Plasma – 2012

27th National Symposium

on

Plasma Science and technology

Challenges of Power Generation & Lighting 21st Century

Organized by

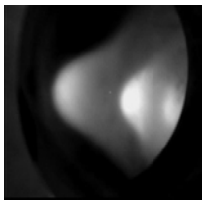
Department of Physics, Pondicherry University, Puducherry – 605 014
&
Plasma science society of India

(10 - 13 December 2012)

27th National Symposium

on

Plasma Science & Technology



10 – 13 December 2012

Book of Abstracts

Compiled By

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PLASMA – 2012

Conference Schedule (10-13-December 2012)

	Time	Time	Min	Time	Time	Min	Time	Time	Min	Time	Time	Min	Time
10-Dec-2012	8:00-9:00	9:00-10:15	1h 15m	10:15-10:45	10:45-13:15	144m	13:15-14:00	14:00-16:06	126m	16:10-16:30	16:30-18:30	120	
	Breakfast & Registration	**Inaugural Function**	Min	High Tea	**Session - 1 (BP)**	Min	Lunch	**Session -2 (NF)**	Min	Tea	**Buti Award Presentations**		Dinner
		Inauguration	30		Invited - BP-I-01	30		Invited - NF-I-01	30		1		
		Keynote address	45		Invited - BP-I-02	30		Invited - NF -I-02	30		2		
					Invited - BP-I-03	30		Invited - NF -I-03	30		3		
					Invited- BP-I-04	30		Oral - NF -O-01	12		4		
					Oral - BP-O-02	12		Oral - NF -O-02	12		5		
					Oral – BP-O-03	12		Oral - NF -O-03	12		6		
					Basic Plasma			**Nuclear Fusion**					

	8:00-9:00	09:00-11:06	126m	11:10-11:30	11:10-13:00	13:00-14:00	14:00-16:00	15:45-16:15	16:15-17:52	126m	18:00-19:00	19:00-20:30	
11-Dec-2012	Breakfast	**Session - 3 (IP+PP)**	Min	Tea	**Poster Session - 1**	Lunch	**Poster Session - 2**	Tea	**Session - 4 (SA)**	Min	**Parvez Guzdar Award for Young Scientist – 2012**	**PSSI –GBM**	Dinner
		Invited –IP-I-01	30		**BP + AO**		**PD +CM + EP+ LP**		Invited - SA-I-01	30		**PSSI Elections**	
		Invited -IP-I-02	30						Invited -SA-I-02	30			
		Invited -IP-I-03	30						Invited -SA-I-03	30			
		Oral - IP-O-01	12						Oral - SA-O-01	12	**Award ceremony and Invited talk**		
		Oral - IP-O-02	12						Oral - SA-O-02	12			
		Oral - IP-O-03	12						Oral - SA-O-03	12			
		Industrial Plasma + Plasma Processing			**BP + AO (102)**		**PD + CM+EP+LP (83)**		**Space & Atmospheric Plasma**				

	08:00-09:00	09:00-11:06	126m	11:10-11:20	11:10-13:00	13:00-14:00	14:00-16:06	126m	16:10-16:25	16:25-18:31	126m	19:00-20:00 20:00-21:00
12-Dec-2102	Breakfast	**Session - 5 (LP)**		Tea	**Poster Session - 3** **IP** **+** **SA**	Lunch	**Session - 6 (EP+CM)**		Tea	**Session - 7 (PD)**		**Cultural Programme** **+** **Conference Dinner**
		Invited – LP-I-01	30				Invited -EP-I-01	30		Invited - PD-I-01	30	
		Invited -LP-I-02	30				Invited -EP-I-02	30		Invited -PD-I-02	30	
		Invited -LP-I-03	30				Invited -EP-I-03	30		Invited -PD-I-02	30	
		Oral - LP-O-01	12				Oral - EP-O-1	12		Oral - PD-O-01	12	
		Oral - LP-O-02	12				Oral - EP-O-2	12		Oral - PD-O-02	12	
		Oral – LP-O-03	12				Oral - EP-O-3	12		Oral PD –O-03	12	
		Laser Plasma										
					IP + SA (102)		**Exotic Plasma + CM**					

	08:00-09:00	09:00-11:06	126m	11:10-11:20	11:10-13:00	13:00-14:00	14:00-14:30
13-Dec-2012	Breakfast	**Session - 8 (OA)**		Tea	**Poster Session - 4** **NF**	Lunch	**Concluding Session** **&** **Tea**
		Invited - OA-I-01	30				
		Invited -OA-I-02	30				
		Invited -OA-I-03	30				
		Oral - OA-O-01	12				
		Oral - OA-O-02	12				
		Oral -OA-O-03	12				
		Other Areas			NF (85)		

10-Dec-2012	KN-01	Keynote Address	Avinash Khare	
10-Dec-2012	SESSION – 1 : BASIC PLASMA (BP)			Abstract number
Session Chair	Professor Amita Das (IPR, Gandhinagar) & Professor K Porsezian (Pondicherry University)			
BP-I-01	Invited - 1	25+5	A Ganguly, IIT Delhi	
BP-I-02	Invited - 2	25+5	Sudeep Bhattacharjee (IIT Kanpur)	
BP-I-03	Invited - 3	25+5	Prabal Chattopadhyaya (IPR, gandhinagar)	
BP-I-04	Invited -4	25+5	Anitha V P (IPR, Gandhinagar)	
BP-O-01	Oral - 1	10+2	Sudeshna Lahri	BP-04
BP-O-02	Oral - 2	10+2	Shekar Goud	BP-10
10-Dec-2012	SESSION – 2 : NUCLEAR FUSION (NF) + COMPUTER MODELING (CM)			
Session Chair	Dr. Vipin Yadav (IISST) & Professor N Satyanarayana (Pondicherry University)			
NF-I-01	Invited - 1	25+5	Arun Chakraborty (ITER India)	
NF-I-02	Invited - 2	25+5	T Jayakumar (IGCAR, kalpakkam)	
NF-I-03	Invited - 3	25+5	Shashank Chaturvedi (BARC Vizag)	
NF-O-01	Oral - 1	10+2	Udaybir Singh (CEERI Pilani)	NF-02
NF-O-02	Oral - 2	10+2	Basanta Kumar Das (BARC Vizag)	NF-05
NF-O-03	Oral - 3	10+2	Sijoy C D (BARC Vizag)	CM-02
11-Dec-2012	SESSION – 3 : INDUSTRIAL PLASMA & PLASMA PROCESSING (IP+PLP)			
	Professor A. Ganguly (IIT, Delhi) & Professor G Govindaraj(Pondicherry University)			
IP-I-01	Invited - 1	25+5	S Mukherjee (FCIPT, Gandhinagar)	
IP-I-02	Invited - 2	25+5	S K Nema (FCIPT Gandhinagar)	
IP-I-03	Invited - 3	25+5	C H Subramaniam (IIT Hyderabad)	
IP-O-01	Oral -1	10+2	Amreen Hussain (IASST, Guwahati)	IP-10
IP-O-02	Oral -2	10+2	Rajib Kar (BARC)	IP-27
IP-O-03	Oral- 3	10+2	Rajani Menon (VECC)	IP-38
11-Dec-2012	SESSION – 4 : SPACE PLASMA (SA) + PULSED POWER (PP)			
	Dr. R. Jitesh Batt (PRL, Ahmedabad) & Dr Ramprakash (CEERI, Pilani)			
SA-I-01	Invited - 1	25+5	Abhay Kumar Singh (BHU)	
SA-I-02	Invited - 2	25+5	Anurag Shyam (IPR, Gandhinagar)	
SA-O-01	Oral - 1	10+2	A K Saxena (BARC Mumbai)	IP-35
SA-O-02	Oral - 2	10+2	Archita Pandey (IIGM, Mumbai)	SA-42

SA-O-02	Oral-3	10+2	Vipin Yadav (IISST, Trivandrum)	SA-02
12-Dec-2012	SESSION – 5 : LASER PLASMA (LP)			
	Dr. Abhaya Kumar Singh (BHU) & Dr. V.V. Ravikant Kumar (Pondicherry University)			
LP-I-01	Invited - 1	25+5	R K Thareja (IIT Kanpur)	
LP-I-02	Invited - 2	25+5	Y B S R Prasad (RRCAT)	
LP-I-03	Invited - 3	25+5	Hem Chandra Joshi (IPR, Gandhinagar)	
LP-O-01	Oral - 1	10+2	Prateek Varshney (Jaypee Institute of Tech)	LP-24
LP-O-02	Oral - 2	10+2	Shivanand Chaurasia (BARC, Mumbai)	LP-09
LP-O-03	Oral - 3	10+2	Deepty C K (ISP, CUSAT)	LP-28
12-Dec-2012	SESSION – 6 : EXOTIC PLASMA (EP)			
	Professor Shashank Chaturvedi (BARC Vizag) & T Jayakumar (IGCAR, kalpakkam)			
EP-I-01	Invited - 1	25+5	Sambaran Pahari (BARC, Vizag)	
EP-I-02	Invited - 2	25+5	Jitesh Bhatt (PRL)	
EP-I-03	Invited - 3	25+5	R Ganesh, (IPR Gandhinagar)	
EP-O-01	Oral - 1	10+2	B Kakati (CPP, Guwahati)	EP-17
EP-O-02	Oral - 2	10+2	Sudeep Garai (SINP, Kolkata)	EP-08
EP-O-03	Oral - 3	10+2	Mridul Bose (Jadavpur University)	EP-07
12-Dec-2012	SESSION – 7 : PLASMA DIAGNOSTICS (PD)			
	Dr. Y B S R Prasad (RRCAT, Indore) & R K Thareja (IIT Kanpur)			
PD-I-01	Invited - 1	25+5	S V Kulkarni (IPR Gandhinagar)	
PD-I-02	Invited - 2	25+5	Ram Prakash (CEERI Pilani)	
PD-I-03	Invited - 3	25+5	Kumudini Thahilyani (IPR Gandhinagar)	
PD-O-01	Oral - 1	10+2	ATT Mostako (IIT Guwahati)	PD-08
PD-O-02	Oral - 2	10+2	U Chakravarty (RRCAT)	PD-26
PD-O-03	Oral - 3	10+2		
13-Dec-2012	SESSION – 8 : Solar Cell OTHER AREAS (OA)			
	Professor G Chandrasekaran (PU, Pududchery) & Dr. S. Mukherjee (IPR, Gandhinagar)			
OA-I-01	Invited - 1	25+5	R Murugan (PU)	
OA-I-02	Invited - 2	25+5	Suresh babu (PU)	
OA-I-03	Invited - 3	25+5	Vibhu Tripathi (MOP Delhi)	
OA-O-01	Oral - 1	10+2	M Tamilselvan (PU)	AO-43
OA-O-02	Oral - 2	10+2	P. Tangadurai (PU)	AO-15
OA-O-02	Oral - 3	10+2	Pramod K (PU)	AO-06

CONTENTS

KEYNOTE ADDRESS & INVITED LECTURES

Keynote Address

Invited Lectures

Basic Plasma [e.g. including Fluid Mechanics, EMT, MHD, EMHD etc] (BP)

Nuclear Fusion and Technology (NF)

Exotic Plasma, Dusty Plasma, Quark and Gluon Plasma etc. (EP)

Application of Plasma Based Technologies (IP)

Plasma Diagnostics (PD)

Space & Atmospheric Plasma (SA)

Any other relevant topic (OA)

KEYNOTE ADDRESS & INVITED LECTURES

Keynote Address

Plasma Science in the 21st Century

K. Avinash

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University of Delhi, Delhi

Email:ojavinash@yahoo.co.in

In the new century, the humankind will face some of the greatest challenges related to energy, interplanetary and beyond space travel and exploitation of exotic but very useful properties of nanomaterials. Fossil fuel reserves will become severely depleted towards the end of this century while chemical based propulsion systems are unsuitable for interplanetary and longer flights. Plasma sciences and related technologies e.g., magnetic and laser fusion, nuclear and plasma propulsion, plasma based processing and nano sciences are likely to play a very important role in alleviating some of the problems related to these challenges. The talk will focus on elucidation of these issues and ways by which plasma science will help us to solve them.

BP-I-01

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BP-I-02

Sudeep Bhattacharjee
(IIT Kanpur)

Email: sudeepb@iitk.ac.in

BP-I-03

Prabal Chattopadhyaya
(IPR, gandhinagar)

Email: pkchatto@ipr.res.in

BP-I-04

SYstem for Microwave Plasma Experiments (SYMPLE)

Anitha V.P.

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It is well established that an unmagnetized plasma does not support propagation of low frequency ($\omega<<\omega_p$) e.m waves. However, depending on the intensity of the incoming wave, several interesting linear and nonlinear interactions occur between the wave andan inhomogeneous plasma at the critical layer ($\omega=\omega_p$), leading to the absorption of the wave in the plasma. The exact interaction mechanism depends on various factors such as the magnitude, frequency and polarization of the incident wave field, the duration of the em pulse, the scale length of plasma etc. In the range where the wave intensity is moderate ($\vec{E}_{em}^2/4\pi nkT_e$) ~1), the absorption is by parametric instabilities as observed experimentally. In certain cases, these instabilities lead to strong ion density fluctuations and a considerable enhancement of the high frequency resistivity around the plasma frequency. Observations also exist on mechanis where a resonant wave electric field and a density cavity grow simultaneously through mutual enhancements. When the wave intensity is very high ($eE_{e.m}/m\omega \sim c$) a yet another mechanism is theoretically predicted where the energy transfer from wave to plasma occur through generation of fast electrons at the location of wave plasma interaction. However, there are no detailed experiments in this regime, to understand the nature of absorption, generation of fast electrons and their propagation in the ambient plasma and associated instabilities.

Interaction of intense electromagnetic radiation with plasma is a subject of great interest, in the context of investigation of nonlinear processes in laser fusion. In particular, the loss of energy of the fast electrons during their propagation in the ambient plasma is a key issue in Fast Ignitor scheme of inertial fusion. Understanding of the energy loss mechanism requires detailed experimental studies on wave-plasma interaction. The major challenges in carrying out experiments with lasers arerelated to the diagnostic access. The plasma that should remain over-dense to the laser frequencies is nearly solid-dense (n_e 10^{27}-$10^{28}/m^3$), leading to fast time scales (a few Femto seconds) and small scale lengths (~ a few μm) of instabilities, difficult to diagonise. The advent of high power sources, with power ranging from a few MW to a few GW levels, a new arena of experimental investigations are now possible, on HPM – plasma interaction. Here, the resolution of appropriate length and time scales are not as stringent as in case of lasers. A system named SYMPLE (System for Microwave PLasma Experiments) is being developed at IPR for HPM-plasma interaction studies. Depending on the experimental plan, the HPM source for this study includes a pulsed (~ 4μs) high power (~2 MW) magnetron or a pulsed (~30 ns) VIRCATOR (~1 GW) both of frequency ~3.5 GHz. The latter is being developed in-house. As for the plasma, the requirement of the sharp gradient at the regime of wave interaction has necessitated the choice of a washer–gun based (integrated 4-gun), pulsed (100 μs), moving plasma. A brief account of the model calculations to determine the system parameters, development and characteristic of the plasma source, and initial test results of the HPM source will be discussed in the talk.

CM-I-01

Shashank Chaturvedi
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NF-I-01

Indian programme in R&D on Negative Ion Neutral Beams for Fusion devices

A.K.Chakraborty

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Neutral Beam Injection (NBI) is the cornerstone of a high performance fusion device. They support plasma heating, current drive and diagnostics. Novel regimes of higher confinement of Tokamak plasmas are primarily through Neutral Beam Heating (NBH). Injectors having beam energy in the range of 50 – 80 keV/amu are based on positive ion sources and have established their operational reliability over the past 2 decades and have met the requirements for the devices adequately. In comparison, for the upcoming devices, the demand on the beam energy and power required for plasma heating and current drive is nearly 5-10 times higher and for diagnostic purposes it is a factor of 2 higher. Principles of production of Neutral Beams (NB) stipulate that NB systems for the upcoming devices need to be necessarily based on negative ion sources, including those for the diagnostics. This requirement needs to considered with the constraint that production efficiency of negative ion beams (~ 30 mA/cm^2) are at least an order of magnitude lower than what is achievable for the positive ions. An immediate impact of this is the requirement of a larger surface area for ion extraction, which ultimately requires plasma source of large dimension. Typical ion-extraction cross-section is ~ 1.5 m x 0.8 m and development of reliable and high performance RF based ion sources with similar extraction area is therefore the thrust area of R&D on NB systems for the upcoming devices. Indian participation in this R&D is in the form of establishing a full scale test facility – Indian Test Facility (INTF) - for the production and characterisation of an ion source where 8 RF antennas couple ~ 1 MW of RF power produced from 4 RF generators operating at 1 MHz. Each RF generator couple ~ 250 kW of power to a set of 2 antennas. The accelerator system is designed for acceleration of 60 A of ion beam at 100 keV. The parameters of the ion source and accelerator conform to that of Diagnostic Neutral Beam Injector (DNB), a system deliverable to ITER. The IN-TF houses a full length transport section of 20.7 m, thereby imparting an unique attribute of performing studies on NB transport and characterisation for the longest length in a test facility.An added attribute therefore is to establish the performance for ITER DNB. This R&D mission complements the other global effort – the Neutral Beam Test Facility (NBTF)- upcoming in Consorzio RFX, Padova, Italy where the objectives are to characterize a similar source in a 100 keV facility and to subsequently extract 40 MW of D beams at 1 MeV and thereby establish the performance of ITER heating beam. A technical perspective of the mission involved in IN-TF, technology challenges in IN-TF, challenges involved in integration and operation and the alignment of present R&D program on negative ion beams to the IN-TF shall be presented.

NF-I-02

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EP-I-01

Sambaran Pahari
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EP-I-02

Role Of Shear And Bulk Viscosity In Relativistic Heavy-Ion Collisions

Jitesh R. Bhatt

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Abstract

Measuring the coe_cient of shear viscosity _ in relativistic heavy-ion collisions is one of the most intriguing problem. Analysis of RHIC and LHC experiments suggest that the thermalized strongly interacting matter created in these experiments (temperature T >200MeV) has the lowest possible observed value for the ratio of _ to the entropy density i.e. $\eta/s \sim 1/4\pi$. No other fluid found in nature can have such a low value of η/s. In this work we show that the determination of η may be strongly influenced by presence of _nite bulk viscosity. We also discuss novel instabilities generated by _nite viscosity in baryon free quark-gluon plasma.

EP-I-03

R Ganesh

(IPR Gandhinagar)

LP-I-01

Laser Ablated Plume Dynamics And Clusters Formation

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Abstract

The talk will sum up some recent work on the behavior of laser ablated plume in various ambient conditions like liquid, magnetic field and gas. The role of various diagnostics like optical emission spectroscopy, two dimensional imaging of plume and shadowgraph imaging to understand the nanoparticle formation in the plumes will be discussed. Dynamic laser light scattering is used to confirm in situ formation of nanoparticles. The morphology of the inverse plume deposited particles is shown to depend on the nature of the ambient used. The possibility of enhanced deposition rates in combined ambient gas and a magnetic field has potentials of industrial applications of the process.

LP-I-02

Time Resolved Optical Probing Of Laser Produced Plasmas

Y.B.S.R. Prasad, S. Barnwal, P.A. Naik, J.A. Chakera, and P.D. Gupta

Laser Plasma Division, Raja Ramanna Centre for Advanced Technology, Indore 452 013, M.P.

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Abstract

The extreme spatial and temporal characteristics of the laser produced plasmas pose an interesting challenge to study the interaction processes. While these plasmas are of hundreds of microns in size, the interaction time scales are in fs- ns regime depending on the laser pulse duration. In order to study these plasmas, special diagnostic techniques like snap-shot probing and special instruments like optical (S-20) and x-ray streak cameras are used. However, the temporal resolutions are limited to few picoseconds in these techniques. The chirped pulse amplification (CPA) technique used in the table top terawatt laser systems to enhance the laser pulse energy, offers a novel opportunity to probe plasmas at much shorter time scales. Popularly known as frequency domain or spectral interferometry (FDI or SI), this technique involves using a portion of the chirped pulse from the femtosecond laser system to probe the laser produced plasmas. The temporal information is retrieved simply from the wavelength versus time (λ-t) relation, by recording the spectrum of the transmitted probe beam passing through the plasma. The temporal resolution can be varied from hundreds of fs to few ps, simply by adjusting the stretcher parameters.

The presentation will cover our experiments on time resolved interferometry using streak camera and chirped pulse shadowgraphy / interferometry. Using these techniques, the temporal variation in the plasma expansion velocities (peak velocities ~10^7 cm/s) and plasma densities was estimated with few ps resolution. Few details about FDI/SI work carried out in other laboratories for achieving time resolutions of few fs will also be discussed, in addition to the advantages and limitations of the different time resolved techniques.

References

[1] Prasad *et al*., ***Rev of Sci. Instrum***. **77**, 093106 (2006).
[2] Geindre *et al*., ***Opt. Lett.*** **26**, 1612 (2001).
[3] Prasad *et al*., ***App. Phys. Lett***. **96,** 221503 (2010).
[4] Chien *et al*., ***Opt. Lett.*** **25**, 578 (2000).
[5] Prasad *et al*., ***J. of App. Phys.*** **110,** 23305 (2011).

LP-I-03

Laser Produced Plasma: An atomic Analysis Perspective

H. C. Joshi

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Abstract

Optical emission spectroscopy (OES) is an important and simple tool to study the laser produced/laser blow-off plasma. It is used for the estimation of plasma parameters as well as for the knowledge plasma composition. However, the atomic processes underlying with the emission processes are to be treated carefully to arrive at the parameters and estimations. In this talk I shall describe the role of atomic processes in laser produced plasmas for a better understanding of the results obtained from OES.

IP-I-01

Role Of Plasma Technologies In Harnessing Solar Energy

S Mukherjee

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Abstract

The demand of today is CO_2 free energy and this is only possible if energy is derived from sources other than fossil fuels. There are broadly two ways of doing it, using nuclear reactions or renewable sources. Among renewable sources, solar energy is a prospective candidate. Solar energy reaching the earth's surface comprises primarily of

visible and infrared region, and a little fraction in the UV region. Its average power density is ~ 1.4 kWh / m^2. Places near the equator and between Tropic of Cancer and Tropic of Capricon have 50% more average solar energy. A great effort is made globally in harnessing this clean energy. In 2011, the International Energy Agency said that solar energy technologies such as photovoltaic panels, solar water heaters and power stations built with mirrors could provide a third of the world's energy by 2060. India being largely placed between Tropic of Cancer and the equator, can take advantage of harnessing solar power. Plasma technologies can be used in developing special materials and coatings, and controlling particle dimensions generating nanoparticles. In the field of photovoltaic applications, where solar energy is directly converted to electrical energy, plasma techniques play a major role in thin film solar cells. Gradually bulk Si-based solar cells are getting replaced by Si based thin film solar cells and non-Si based thin film solar cells. Efficiencies between 10-15 % have been achieved in thin film based solar cells. Solar concentrators using reflector and absorber thin films are being developed. The concentrated solar energy heats up flowing liquid medium, and heat is extracted to electricity using heat exchangers. In both these technologies, the various types of thin films used are deposited using plasma technologies.

Having nanometers level coatings, usually comprising of Ag or TiO_2 nanoparticles, inside the PET plastic bottles can be a very effective way of water purification. In this technique, non-potable water is first cleaned with normal household filters and then filled in these PET bottles. The filled bottle is kept in direct sunlight for few hours and it turns potable. Extending this technique is the subject of photoelectrochemistry; here complex multilayered electrodes can be made using plasma techniques, and this in the presence of water and sunlight can generate hydrogen as a source of energy. The presentation will highlight developments in the above areas and special role by plasma technologies. Some of the developments in FCIPT will also be discussed.

IP-I-02

Plasma Surface Modification of Metals and Polymers

S. K. Nema

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Using non thermal plasma one can modify the surface of metals, polymers, textiles, and biomaterials. At FCIPT, Institute for Plasma Research, various plasma technologies have been developed for variety of applications which include plasma nitriding to increase surface hardness of steels, physical vapor deposition to coat metallic coatings on polymers, ceramics and metals, plasma polymerization and plasma enhanced chemical vapor deposition, plasma surface modification of polymers and textiles, thermal plasma technologies for metallurgical and waste disposal applications etc.
The presentation will cover non thermal plasma technologies and applications developed for processing of metals and polymers (textiles) which are mentioned below:

- Angora wool treatment to enhance cohesion among fibers using Atmospheric pressure air plasma (Dielectric barrier discharge)
- Plasma surface activation of polymers to enhance adhesion
- Plasma surface modification of Brass valves to improve rubber to brass bonding

The presentation will include the results obtained in different plasma processes and proto-type reactor developed for some of the applications. It will also cover the present status in the world and future growth directions.

IP-I-03

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PD-I-01

Role of Pre-ionization in superconducting Steady State Tokamak Operation

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Abstract

It is well known that for fusion reactor, one needs to have a steady state operation of the tokamak for at least 1000 seconds. The superconducting magnets and central solenoid with cryostat are required for steady state tokamak. The applied loop voltage from ohmic system, deceases drastically due to cryostat and also gets delayed in the vacuum vessel due to which plasma production becomes difficult because of in-sufficient loop voltage. In order to overcome this problem, different pre-ionization techniques such as ECRH and ICRH type pre-ionization schemes are being investigated. The advantage of these schemes is that one can use same RF system for pre-ionization which is being developed for plasma heating, current drive and start-up experiments. In presence of pre-ionization, the initial number of electrons is easily available in the tokamak and hence current ramp up with ohmic transformer becomes easy, volts-seconds of ohmic system are saved to have longer discharge and also current ramp-up becomes highly reproducible and repeatable from plasma shot to shot. Pre-ionization system using electron cyclotron resonance layer in the tokamak is a well established technique. However, in a steady state superconducting tokamak once the toroidal magnetic field is established, it cannot be brought down easily and hence ICRH wall conditioning system is well accepted for vessel cleaning between shots. Due to this advantage of ICRH system recently pre-ionization using ICRH system is being tried and seems to be quite successful in many tokamaks. Pre-ionization using ICRH can be done at any magnetic field and the presence of resonance layer in not necessary. This is a major advantage of ICRH system for pre-ionization. The details of different pre-ionization experiments done for steady state operation and the results of the pre-ionization experiments done on tokamak Aditya are presented. In tokamak Aditya pre-ionization experiments are carried out at different magnetic fields, gas pressures, loop voltages and rf powers at 24.8 MHz using 200 kW RF generator. We could produce plasma with RF power under different conditions and also could ramp up the plasma current at very low loop voltage when it was not possible to produce normal plasma using Ohmic system. The planned activity for steady superconducting tokamak SST-1 along with merits and demerits of different systems will also be discussed.

PD-I-02

Collisional-Radiatve (Cr) Model Analysis For Simultaneous Estimation Of Plasma Parameters From Spectroscopic Observations

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Abstract

A method on the basis of experimentally observed intensities of a number of spectral lines of helium in the visible region has been developed to infer large number of plasma parameters simultaneously from a Penning discharge (PD) source. The collisional-radiative (CR) model of ADAS (atomic data and analysis structure) code and database [1] has been used for this analysis. With an approximation of optical thin plasma, the electron density, electron temperature, ground-state atom and ion densities and also the triplet metastable state ($2\ ^3S$) density are the parameters thus estimated. The derived plasma parameters are then used to obtain the absolute intensities of a few lines in the vacuum ultraviolet (VUV) region. This has been compared with the observed VUV spectral lines, recorded simultaneously with the visible lines, using a VUV spectrometer for which intensity calibration was not available. This facilitates to determine the calibration factors for a few VUV spectral lines that could be highly useful for tokamak plasmas. Nevertheless, it is to be mentioned that under the optical thin plasma condition the estimated plasma temperature from the penning plasma discharge source was found rather high [1]. It is seen that the inclusion of opacity in the observed spectral lines through CR-model based photo emission coefficients (PECs) and addition of diffusion of neutrals and metastable state species in the CR-model code improves the electron temperature estimation in the simultaneous measurement [2]. The description of CR-model analysis and results of these efforts will be presented.

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PD-I-03

Radiation Power Loss Measurement in Tokamaks

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Abstract

A tokamak plasma emits electromagnetic radiation from low energies upto energy almost equal to the temperature of the plasma. This radiation loss fraction can vary from 0.1 to 1 depending on several factors like the operation regime, plasma parameters and its size. It is generally desirable to obtain plasmas that have less radiation power loss. But the same is not true for D-T plasmas like the one in ITER. There, a large fraction of the power from alpha particle heating must be radiated to limit the power falling on the divertor plates. So it is essential to estimate and control the power radiated from the plasma. In addition to this control, measurements of the radiated power are required for evaluation purpose, in particular, spatially resolved measurements are required in studies of power balance.

Bolometer diagnostic measures the radiation power loss and its spatial variation. Wide-angle-viewing single bolometers are used to estimate the total radiated power. The measurement from a single bolometer is only adequate to estimate the total radiated power when the radial and poloidal emissivity distributions are known reasonably well. However presence of high-Z impurities and certain instabilities could lead to localized peaks in the emission profiles, necessitating collimated bolometer measurements along several lines of sight. The collimated measurements are then inverted using tomography algorithms to obtain the radiation emission distribution in the plasma.
This talk will provide background on bolometry, discuss the bolometer detectors and techniques for tomographic inversion, summarize the important bolometric results from fusion devices including Aditya tokamak and project requirements for next generation devices.

SA-I-01

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Pulse Power -I-01

Pinches for Inertial Confinement Fusion

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Abstract

Pinches were the first attempt to make thermonuclear fusion reactors. Initial attempts to use Z and pinches did not succeed due to instabilities, their refined version -Reverse Field Pinches are still being investigated. Another form of pinch – Dense plasma focus was considered as an intense neutron source, but failed to scale. Pinches are currently being used to implode liners. In magnetized target fusion schemes, liner, imploded by pinch effect, are used to compress and heat magnetized plasma. Very low mass liners, formed multiple thin wires array, are imploded/pinched by terra-watt electrical pulses. This results in generation of several hundred terra-watt of soft x-rays pulse. These pulsed X-rays can be used for inertial confinement fusion.

OA-I-01

Recent Trends In Electrical Energy Storage Devices

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Abstract

Integration of electrical energy generated by wind or solar technologies in to grid depends heavily on the availability of adequate high capacitive electrical energy storage devices. Batteries and supercapacitors are key electrical energy storage technologies in modern society. The great demand for batteries with high power and energy densities promotes the need for advanced lithium-ion and lithium air battery technologies. Solid electrolytes promise the potential to replace organic liquid electrolytes and thereby improve the safety of next generation high energy batteries. Although the advantages of non-flammable solid electrolytes are widely acknowledged, their low ionic conductivities and low chemical and electrochemical stabilities prevent them being used in practical applications.
The design of lithium batteries having a lithium anode and water or air cathodes for storage of electrical energy requires a solid electrolyte stable in contact with lithium and room temperature ionic conductivity greater than 10^{-4} Scm^{-1}. In the last few years, a series of garnet-like structural compounds have been investigated as a novel family of fast lithium ion conductors. Among them, $Li_7La_3Zr_2O_{12}$ (LLZ) have been paid much attention because of their stable nature against Li metal [1]. The total (grain+grain boundary) conductivity around 10^{-4} Scm^{-1} at 25 ^oC (Ea~0.3 eV at 18–300 °C), good thermal stability and chemical stability against molten lithium and high densification of cubic $Li_7La_3Zr_2O_{12}$ (LLZ) suggested that this zirconium containing lithium garnet is a promising solid electrolyte for Li^+ rechargeable batteries [1]. The stable lithium ion conducting solid electrolytes in aqueous solutions is necessary for

application as a protective layer in lithium-air battery. Preliminary investigations reveal that LLZ may be a promising electrolyte for Li-air/water battery application. In this lecture the recent developments in electrical storage devices and the present status of all solid state lithium and lithium-air rechargeable batteries based on garnet structured solid electrolytes will be discussed.

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OA-I-02

Plasma based metal oxide catalytic coatings for high temperature oxidation protection

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Abstract

Production of sub-nanometer powders and subsequent efficient coating of these precursors pose a challenge governing many important and new applications. Plasma based production of powders and coatings remain as one of the solutions for many functional coatings that include thermal barrier coatings in gas turbines, jet engines etc., The talk focuses on the aspects of solution precursor plasma spray coating as a single step preparation and coating technique for nano metal oxides and its potential high temperature oxidation protection of components.

OA-I-03
Journey of Electron from Generation to Consumption (Lighting 21st century: A general treatise of Indian Electricity Sector)

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Abstract

Synthesized Energy is available in the form of fossils. Energy transport due to geo-climatic variations make available PE and KE of water, wind and thermal forms which are harnessed for use. The transport cycle manifests energy conversion in natural forms. The most suitable and useful forms of energy is electrical energy. All forms of energies available put electrons into motion during electromechanical conversion acting as energy transport agents from distant placed to distant places. The electromotive forces push electrons to move at the generators to carry energy. The electrons move through the grids, at various voltage levels, through long distance conductors, force themselves through windings, push through semiconductor devices, pass through filaments, drive heavy machines delivering energy at various levels and in various forms. As a main transporter, electrons move from generators to grid to transformers to our appliances completing the journey. With a promising future of fusion energy and the

legacy of generation, the elements of generation, transmission, substations, distribution, consumption, metering, control etc, are covered to present an overview of whole electrical system in a simple way. Attempt is made to describe the Indian electricity sector and systems of electrical engineering in place through exciting journey of electrons. Latest advances in ICT, GIS etc and their application to Indian power sector in particular to smart grid and smart metering is also presented. Attempt is also made to explain the complexities of Load control, frequency control, demand side management, load forecasting, peak load management for consumer awareness.

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CONTRIBUTED PAPERS

BP01

An Analytical Understanding Of Plasma Surface Interaction In N_2-H_2 Discharges

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Abstract

Glow Discharge Plasma Nitriding (GDPN) is done in pressure range of 1-10 mbar. In GDPN the correlation between process atmosphere and formation structure of the nitrided layer, is a well established fact. Generally, a single phase nitrided layer of α *-Fe(N)* phase is formed when the partial pressure of H_2 in N_2-H_2 gas mixtures is higher than ~70%, For lower partial pressure of H_2 in the process atmosphere the nitrided layer formed is multi-layered and each of these layers may consists of more than one phase and may have different thickness. These layers with mixed structures of ε+ γ'+α*-Fe(N)* has been reported in several investigations with different N_2-H_2 gas composition. The result of the present work proved that in the conditions of the investigated processes the structure of nitrided layer depends on the number density of nascent nitrogen and hydrogen atom available on the substrate surface. Moreover, this investigation concludes that for 30%N_2-70%H_2 gas composition probability of availability of nascent atomic nitrogen and hydrogen at substrate surface is equal i.e. $\left([N]/[H]\right)=1$. Nevertheless, this can also be achieved for other N_2-H_2 compositions by appropriately varying operating parameters such that transport of N_2^+ and H_2^+ ions via collisional sheath results in equal concentration of nascent nitrogen (N) and hydrogen (H) atoms. Thus, this result supports the concept of hydrogen assisted diffusion of nitrogen into the substrate surface and the diffusion of the atomic nitrogen is most efficient for $\left([N]/[H]\right)\leq 1$ and no compound layer is formed for this condition.

BP02

Dr. Jyotirmoy Pramanik

BP03

Growth Of A Spike On A Laser Beam In Magnetized Homogeneous Plasma

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Abstract

This paper deals with the growth of a Gaussian spike superimposed on a Gaussian laser beam of angular frequency ω in homogeneous magnetized plasma along the static magnetic field coincident with z axis. The nonlinearity arises through the nonuniform heating of electrons due to nonuniform intensity distribution of main beam and spike and has a saturating behaviour. The spike gets focused when the initial power of the spike is greater than the critical power of focusing. The focusing is also considerably affected by the power of main beam, the strength of the magnetic field and the phase difference between the electric vectors of the main beam and the spike.

BP04

Quasiperiodic To Chaotic Transition In A DC Glow Discharge Plasma

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Abstract

The dissipative physical systems like plasmas are one of the most attractive non linear media capable of sustaining a wide variety of waves and instabilities. The nonlinearity in plasma systems is well recognized, arising from the most fundamental processes, namely, the wave-wave and wave-particle interactions [1]. In the present study, the temporal dynamics in the fluctuations of the plasma floating potentials from cylindrical dc glow discharge argon plasma at an intermediate gas pressure of 0.056 mbar and at the range of discharge voltage (300-700 volt) are investigated to probe the nature of the complex system dynamics. The system observable, i.e the electrostatic floating potential was measured using a Langmuir probe. The experiment was performed keeping the neutral pressure and electrode configuration constant, and discharge voltage (DV) was the control parameter. Over several regions of the discharge voltage, the floating potential fluctuation time series data exhibits periodic oscillations, and irregular fluctuations.

A long standing fundamental issue in non-linear time series analysis is to determine whether a complex time series is regular, deterministically chaotic or random. The vast majority of these efforts are based on such characteristics as the Largest Lyapunov Exponent and correlation dimension calculation. In the present study, the time series data of the floating potential fluctuations have been analyzed. The presence of long range correlation in the time series data was estimated by calculating the Hurst exponent and the presence of chaos by the Largest Lyapunov Exponent. The Hurst exponent was estimated by using rescaled-range statistics(R/S).The method was proposed by Hurst [2] and well established by Mandelbrot and Wallis [3]. The largest Lyapunov exponent was calculated according to Rosenstein[4]. The system observable, i.e the correlation dimension of the attractor is measured according to the correlation method suggested by Grassberger and Procaccia [5].

This paper gives a significant insight into the dynamical behaviour of a non linear dissipative glow discharge plasma system.. The discharge voltage has a discernible effect on the behaviour of this complicated system As the discharge voltage increases, the system follows a quasiperiodic route to chaos. The onset of chaos is associated with a large jump in the positive value of the largest Lyapunov exponent and a sharp fall in the numerical value of Hurst exponent. This is perhaps the first time in a chaotic plasma system a correlation has been shown between the Lyapunov exponent and the Hurst exponent in a transition from regular to chaotic behaviour.The results from the real time signals, the power spectrum, the phase space plots also show the same trend. In future we are planning to set up a model by computer simulation to explain the present experimental scenario.

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BP05

Effect of Magnetization and Hall Current on The Jeans Instability Of Quantum Magnetohydrodynamic (QMHD) Fluids

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Abstract

The combined effects of Hall current and intrinsic magnetization due to collective electron spin is investigated on the Jeans instability of quantum magnetohydrodynamic (QMHD) fluids. The general dispersion relation is obtained with the help of linearized perturbation equations using normal mode analysis. The effect of Hall parameter and magnetization is studied on the condition of Jeans instability and critical Jeans wave number expression. The dispersion relation is solved analytically to see the effect of Hall parameter, quantum corrections and magnetization on the growth/decay of Jeans instability in the core of white dwarf star.

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BP06

Effect of Radiative Condensation On Jeans Instability Of Self-gravitating Magnetized Dusty Plasma With Polarization Force

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Abstract

We investigated the effect of radiative condensation on the Jeans instability of self-gravitating magnetized dusty plasma including the effect of plasma-particle polarization interaction. The electron and ion densities are given according to Maxwell-Boltzmann distribution and the electron temperature perturbation is considered. The dynamics of the dust particle is considered in the presence of magnetic field and polarization force. A general dispersion relation is obtained with the help of linearized perturbation equations using the Fourier transformation of all the perturbed quantities. The condition of Jeans instability and critical Jeans wave number expression are obtained which depend upon polarization force and radiative effects. It is found that in the absence of electron perturbed density the condition of Jeans instability depends upon polarization force and ion-electron temperature ratio. The formation of photo-association regions separating HII regions from dense molecular cloud is discussed. The numerical calculations have been performed to show the effect of various parameters on the growth rate of Jeans instability. It is found that polarization force and ratio of radiative heat-loss functions have destabilizing while magnetic field and dust temperature have stabilizing influence on the growth rate of Jeans instability.

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BP07

Study of Hall Thruster Performance Due to Magnetic Mirror Effects

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Abstract

A one-dimensional (1D) fluid model is developed to study the effect of electron-wall collisions on electron transport in a Hall thruster. It is found that the inclusion of this phenomenon predicts lower operational temperature as observed in experiments by enhancing the cross-field electron transport. This model has been further extended to study the effect of magnetic lens configuration on thruster performance. The magnetic mirror effect is found to alter the electron transport by modifying the potential distribution. It is also shown that such a magnetic configuration improves the thruster performance and modifies the profiles of plasma parameters. This model has been applied to predict the experimental observation where the channel width is varied and found to explain reasonably well. In this configuration, the magnetic field along the field line varies and is minimum at the channel center and maximum at the wall.

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BP08

Experimental Investigation For Trapping of Electrons in the Potential Troughs of a Standing Wave that has Been Formed in a Minimally Magnetized Plasma Column

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Abstract

Microwave excited Plasmas was formed and confined by a static, multicusp magnetic field so that along the axis of the plasma column the plasma is minimally magnetized. It was observed that microwaves of 2.45GHz form a Standing Wave pattern along the axis of the plasma column. This was explained by superposition of multiple waves which were formed by repeated reflections from plasma-Vacuum boundary. The plasma floating potential was also measured along the axis of the plasma column. It was observed that the floating potential profile nearly follows the Standing Wave profile. It indicates some degree of localization of electrons of electrons at the potential troughs of the Standing Wave.
We are investigating for more confirmation of the phenomena. Along the axis of the Plasma column we are measuring the optical intensity for a particular line of Argon (our experimental gas). It is recommended to take the Ar II line, which

is the most intense in the visible region. It is hoped that the intensity of radiation for that particular wavelength should be higher near the potential minima. Then we can be able to tell about the electron trapping in the potential troughs of the Standing Waves of Electromagnetic character. The results will be reported at the time of stmposium.

IV. References

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BP09

Two-Dimensional Dust Acoustic Solitary Waves with Kappa-Distributed Ions and Electrons

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Abstract

It is known that the envelope dust acoustic solitary waves (DASW) in one dimension are governed by the nonlinear Schrödinger equation. By taking into account the transverse perturbation, this type of nonlinear wave can be described by the general form of the Davey-Stewartson (DS) equation. In this study, modulational properties of DASW in dusty plasmas with cold negative dust grains and kappa-distributed ions and/or electrons are discussed. When positively charged cold dust instead of negatively charged cold dust is considered, then the modulational properties are modified accordingly depending upon the parametric regime. The effect of spectral index of ions, electrons, and *f* on the stability of DASW is studied and it is observed that dust-acoustic solitary waves are very sensitive to variation of spectral index of ions. Further for positive dust, dromion solutions are also obtained in a limited region of parameter space.

BP10

Generation of Fluctuations And Intrinsic Flows In A Simple Toroidal Plasma

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Abstract

Plasma produced in a pure toroidal magnetic field does not possess a magneto-hydrodynamic equilibrium due to the particles loss towards outer wall [1]. The experimentally observed confinement time in such plasmas, however, is an order higher than that estimated from theoretical calculations [2]. The fluctuations are found to play an important role in the cross-field charge transport and hence the improved confinement. It has been demonstrated through simultaneous measurements that the generation of significant poloidal flows is associated with the onset of large fluctuations [3]. The fluctuations are generated due to free energy sources in the plasma, such as gradients in plasma parameters etc [4]. The mean electric field driven poloidal flow, fluctuation driven poloial flow and net poloidal flow are obtained using suitable diagnostic methods and compared for varying discharge conditions. The present work demonstrates that in a toroidal compressible plasma, an intimate relationship exists between the fluctuations, self-consistently generated flows and enhanced confinement.

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BP11

Studying Bohm Criterion in Two Ion Species Plasma

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Abstract

The thin region of strong electric fields formed by space charge that joins the body of the plasma to its material boundary or to any material inserted into the plasma is known as 'Sheath'. Although the ion velocities in sheath and pre-sheath boundary are well understood in case of single species, only a limited understanding exists in multi-ion species plasma. Recent experiments [1] show the cases in two-ion-species plasma where both ions reach the sheath with equal velocity identified as the system sound velocity. An attempt to describe this was made by Lee *et al.* [2]. In this paper, we generalize the treatment by Lee *et. al* to the limit $\left(\lambda_d/L\right) \neq 0$, where L is the scale length of space charge region, which is more relevant to experimental conditions. Furthermore, we will present the design of the experiment to measure the ion velocities at the sheath pre-sheath boundary using Laser induced fluorescence (LIF) technique. LIF remains the best possible diagnostics for the measurements of individual ion velocities in small plasma systems.

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BP12

Samiran Chatterjee

BP13

Comparative Study On Nonlinear Dynamics Of Magnetized And Un-magnetized DC Glow Discharge Plasma

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Abstract

Various nonlinear dynamical behaviors are experimentally observed to exist in magnetized dc glow discharge plasma. Nonlinear plasma fluctuations are seen evolving when the initial parameters such as discharge voltage, filling pressures etc. are changed in presence of external magnetic field. A transition pattern of periodic to chaos through quasi-periodicity is experimentally observed when magnetic field is applied which is not the case in un-magnetized one. Hence, a comparative analysis is being carried out for both the cases of magnetized and un-magnetized plasma. The nonlinear behavior of the plasma oscillations are diagnosed by different techniques viz., Power spectrum, Phase space plotting, Correlation dimension, Liapunov exponent, Fractal dimension and Hurst exponent. Further, it is noticed that with increasing discharge voltage, the glow emerges from cathode, slowly moves toward anode and finally sinks into the anode in ballooning manner.

BP14

BL Meena

BP15

Imaging Of X-Ray Emitting Zone Of Plasma Focus Device By Simple Triple Pinhole Camera

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Abstract

The pinched plasma column of plasma focus device exhibits various interesting plasma phenomena such as formation of sausage and kink instabilities, Raleigh Tailor instabilities, hotspots and so on. Besides, it is a rich source of various electromagnetic radiations starting from IR to X-ray, charged particles and neutrons. Therefore, to capture images of pinched plasma column, a simple triple pinhole camera have been developed, which gives over all idea of the location of the X-ray emitting zone as well as approximate size and qualitative idea of radiation density of the X-ray emitting plasma column. In addition, the triple pinhole camera has the advantage to capture three images of a single shot X-ray event with different cut-off energy of the radiation with the use of three different filters. The dimensional structures of the three X-ray images of the plasma column, captured by putting filters of same thickness (2 μm Al) in front of each pinhole found to be identical, which indicates that the each pinhole views almost the same region of the plasma column. The pinhole images of plasma column in one shot, captured with Al filters of thickness of 2 μm, 4 μm and 6 μm in front of pinholes show three distinct X-ray emitting zones, which emit X-ray of different photons energy namely anode edge region, central core region and surrounding region irrespective of all anode tips. The formation of instabilities (m=0,1) and hotspots are also observed in the images.

BP16

Anita Tiwari

BP 17

Nonlinear Amplitude modulation of Electron-Acoustic Waves in Relativistically Degenerate Quantum Plasma

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Abstract

The matter in some compact astrophysical objects such as white dwarfs, neutron stars, magnetars etc. exists in extreme conditions of density. In such situation the average inter-Fermion distance is less than the thermal de Broglie wavelength and hence quantum degeneracy effects become important. Also at such high densities the electron Fermi energy E_{Fe} [$= \hbar^2 \left(3\pi^2 n_e\right)^{3/2} \Big/ 2m_e$] may become comparble to the electron rest mass energy and the electron speed can approach the speed of light in vaccum. Thus plasma in the interior of such compact astrophysical objects is both degenerate and relativistic. Regarding the electro-acoustic waves in degenerate plasmas only a few works have been reported in non-relativistic case. The purpose of the present paper is to investigate the amplitude modulation of electro-acoustic waves taking into account both quantum and relativistic effects. Using the Quantum hydrodynamic (QHD) model the modulational instability of electron-acoustic waves (EAWs) have been examined by deriving a nonlinear Schrodinger equation in a two-electron-populated relativistically degenerate super dense plasma. It is shown that the relativistic degeneracy parameter significantly influences the stability conditions and the formation and properties of the envelop solitons. The results presented here may be helpful in the understanding of the basic features of the envelope solitary structure formation in relativistically degenerate superdense quantum plasmas as can be found in white dwarfs, neutron stars and intense laser-solid plasma experiments.

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BP 18

Harmonic Generation by Electrostatic Surface Waves on a Quantum Plasma Half-Space

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Abstract

In recent years quantum effects in plasmas have attracted considerable interest due to its relevance in superdense astrophysical plasmas, nanodevices and intense laser-solid plasma experiments. The surface waves propagating along the interface between a vaccum and a quantum plasma has attracted much attention because of its wide applications in many areas such as laser-plasma interaction, plasma spectroscopy, plasma technology and surface science. Recent development of surface wave phenomena in quantum plasma is mostly limited to linear theory. In the present paper we examine the nonlinear self-interaction of an electrostatic surface wave on a semi bounded quantum plasma by using quantum hydrodynamic (QHD) model and Poisson's equation. The model includes quantum diffraction as well as quantum statistical effects. The boundary conditions used are the continuity of electric potential and normal displacement across the plasma-vaccum interface. Also the normal component of electron flow velocity is assumed to be zero on the interface. Ions are assumed to form a uniform neutralizing background. Using standard perturbation technique we show that a part of the second harmonic generated through self-interaction does not have a surface wave character and represents a wave propagating obliquely away from the plasma-vaccum interface into the bulk of plasma. The result indicates that any instability appearing in the carrier wave will have to grow in competition with the continuous energy interaction by a part of the second harmonic generated through self-interaction. As the strength of this part of the second harmonic depends on the amplitude of the original carrier wave as well as the plasma parameters it may provide us with useful information about the nonlinear evolution of surface wave and possible plasma diagnostic technique.

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BP 19

Linear and Nonlinear Behaviour of Electron Plasma Waves in a Finite Temperature Quantum Plasma

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Abstract

The quantum hydrodynamic (QHD) model as derived by taking the velocity space moments of the Wigner equations has been widely used to study quantum effects in plasmas. The QHD model modifies the classical fluid model for plasmas with the inclusion of quantum diffraction and quantum statistical effects. A survey of the available literature shows that most of the works done on nonlinear wave phenomena in quantum plasma uses this model which is valid in the ultra low temperature approximation. But in most practical cases the temperature is not zero but finite. The purpose of the present paper is to study the modulational instability of electron plasma waves including finite temperature effects. We have used a finite temperature quantum model recently developed by Eliasson and Shukla. Based on the 3D equilibrium Fermi-Dirac distribution for electrons at an arbitrary temperature a set of fluid equations are derived under the assumptions that the electron phase fluid is incompressible and the chemical potential (μ) remains constant during the nonequilibrium dynamics of the plasma. Using the quantum hydrodynamic (QHD) model thus developed for quantum plasma at finite temperature the modulational instability of electron plasma waves is investigated by deriving a nonlinear Schrodinger equation. It is found that the electron degeneracy parameter significantly affects the linear and nonlinear properties of electron plasma waves in quantum plasma. The electron degeneracy parameter (G) is found to increase the wave frequency for a given wavenumber (k). It is shown that in the high k-region quantum diffraction term dominated and the group velocity is almost independent of G. In the small wavenumber region the G term dominates thus contributing to the nonlinear effect due to degeneracy pressure. In this region group velocity increases with increase in G. Through numerical computations of the nonlinear and group dispersion coefficients for different values of k in terms of the system parameters we find that the wave under study is modulationally unstable in low and high k-regions separated by a

stable region in k-space. The stability region in k-space increases with increase in the degeneracy parameter G but it decreases with increase in the quantum diffraction parameter H. The dependence of growth rate of instability on G depends on the region of instability in k-space. In the low k-region the instability growth rate is higher for higher G but in the high k-region the instability growth rate decreases with increase in G. The investigation presented in the paper may be helpful in the understanding of the basic features of electron plasma waves in dense and hot plasmas such as can be found in white dwarfs, neutron stars and intense laser-solid plasma experiments.

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BP20

Kinetic Energy of Ion and Electron in Magnetized Plasma Sheath

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Abstract

The electron and ion kinetic energy distribution in the magnetized plasma sheath region, formed in front of an absorbing material wall, for different orientation and magnetic field strength has been studied. For given ion and electron density distribution at the sheath entrance we use a kinetic trajectory simulation model to obtain the solution to a non-neutral, time independent, collisionless plasma sheath. It has been observed that the kinetic energy of ions reaching the material wall is influenced by the strength of applied magnetic field and orientation but there is no influence of magnetic field and orientation in the electron kinetic energy at the wall. Kinetic energy of ion increases as we move towards the wall where as the kinetic energy of electrons decreases, which becomes prominent as the strength as well as obliqueness of the field increases.

BP21

Kannan

BP22

Non-linear Study in a Cold Cathode Glow Discharge.

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Abstract

The positive column of glow discharge plasma proves to be an apt candidate to probe many non linear phenomena because it is non isothermal plasma far-off from equilibrium. The dynamics of various glow discharges is examined by calculating the Lyapunov exponent spectrum (LES) and correlation dimension (D_{corr}) from the experimental time series. The analysis refers to periodic, chaotic and quasi-periodic attractors. The results obtained are confirmed using Fourier power spectrum and autocorrelation function. The experiments are carried out in Hydrogen, Argon and Neon gases. In the experiment the discharge current is measured at different supply voltage and pressure. Preliminary result indicates presence of chaos in the system.

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BP23

Bright and Hole Peregrine Soliton in a Multicomponent Plasma with Negative Ions

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Abstract

Rogue wave is a unique wave event observed naturally in deep ocean and sea. It appears suddenly with amplitude nearly three times the background wave height and disappears without a trace. Peregrine soliton is commonly considered to be a prototype of rogue wave in deep water [1]. It is a rational solution of the nonlinear Schrodinger equation (NLSE) localized both in space and time [2]. It has been mentioned that the solution can appear as an isolated high crest (bright) or a deep trough (hole) depending on the phase of the underlying carrier wave [3]. Rogue wave hole has been described by Osborne *et al* as deep trough occurring before/after large crests [4]. For rogue holes the depth from crest to trough can reach more than twice the significant wave height which makes it equally dangerous as the normal rogue wave.

The first observation of Peregrine soliton has been reported in a nonlinear fibre optics experiment [5]. Later on it has been observed in a water wave tank [6] and in a multicomponent plasma with negative ions [7]. Recently, rogue wave hole has been observed for the first time in a water wave tank and described in terms of rational solution of NLSE [8]. Here in this work we present the observation and evolution of bright and hole Peregrine soliton in a multicomponent plasma with critical concentration of negative ions. The experiment is performed in a double plasma device with Argon and SF_6 gas discharge [7]. The ratio of F^- ions to that of Ar^+ ion is fixed at 0.1 (critical negative ion density).

A slowly amplitude modulated perturbation gives rise to a localized pulse appearing as a high crest in between two troughs representing a bright Peregrine soliton as shown in figure 1(a) when the envelope maximum coincides with the carrier maximum $\phi = 0$, where ϕ represents the carrier-envelop phase. Conversely, a deep hole/trough appears in between two crests representing a hole Peregrine soliton when the maximum of the envelope coincides with the minimum of the carrier $\phi = \pi$ as shown in figure 1(b).The observed waves are compared with the rational solution of the NLSE derived for multicomponent plasma with negative ions [7,8]. The frequency spectrum of the observed wave profile has also been studied.

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BP24

Characteristics of Electron Free Plasma Produced by using CUSP Magnetic Filter

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Abstract

A low density and low temperature plasma is produced in target section of a double plasma device using a magnetic filter in between source and target section where plasma is produced only in the source section only [1]. The electron temperature is 0.15 eV and ion temperature (~0.1 eV) is nearly equal to the electron temperature. The plasma density is 10^5 -10^6 cm^{-3}. Positive ion negative ion plasma is produced by injecting SF_6 gas into the plasma. SF_6 negative ions are produced by attachment of low energy electrons into SF_6 molecules. The main negative ion species is SF_6^- .Presence of negative ions is detected with the help of plannar Langmuir probe from the reduction of electron saturation current. The lowest value of the ratio of electron to positive ion density has been measured to be 10^{-3}, when the positive ion and negative ion saturation current becomes nearly equal. An emissive probe is used to measure the plasma potential. The floating potential is found to be more negative with increasing negative ion concentration *r*. However, the floating potential reaches a minimum at $r \sim 0.6$ and increases with further increase of *r*. The experimental plasma parameters are very close to that encountered in nature (low earth orbit *e.g.* D-layer of ionosphere) [2, 3]. These results suggest that such a low density plasma is transiting from a distinct behaviour associated with discharges with low and medium values for electro negativity to a negative ion dominated regime (ion–ion plasmas) when the electron fraction is less than 2% of the negative ion density. This value for electronegativity can be regarded as a requested parameter for applications that involve negative sheaths and negative ion etching at heat fluxes comparable to those by positive ions.

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BP25

Study of Helix Water Pulse Forming Line for Generating Longer Duration Rectangular Pulse for Compact Pulsed Power Drivers

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Abstract

A compact pulse forming line using helical water line is designed and experimentally investigated for the generation of longer duration rectangular pulses. The helical PFL inner conductor is made of SS-304 strip rolled on delrin cylinder and outer conductor is made of SS-304 cylinder. The length of the PFL is 800 mm. The PFL inner strip is 0.5 mm thick and 39.5 mm wide rolled on the 168 mm delrin cylinder. 13 turns are wounded on delrin cylinder and the inter turn gap is 20.5 mm. The outer cylinder is 2mm thick and has internal diameter of 232 mm. The volume between the inner strip and outer cylinder was filled with deionised water circulated through a pump and deionizer unit. The impedance of the helical PFL is 22 Ω. The compactness is achieved in terms of reduction in length of the PFL by a factor of 5.5 using helical water PFL as compared to coaxial water PFL of same length [1, 2]. The helical PFL was pulsed charged to 200 kV using a high voltage pulse transformer in 4.5 us and discharged into the matched 22 Ω resistive load through a self breakdown pressurized spark gap switch. The rectangular voltage pulse of 100 kV, 260 ns (FWHM) is measured across the load. The effect of reduction in water temperature on the pulse width is also studied experimentally. The increase in pulse width up to 7 % more is observed by reducing the temperature of the deionised water to 5 ^{0}C. It will further reduce the length of the PFL and make the system small for compact pulsed power drivers [3, 4].

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BP26

Characterization of Plasma Treated TiO_2Nano Composites Polymer Membranes

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Abstract

Using solution casting and spin coating method, nano composite polymeric membranes in the range of 20–40 micron were prepared. Nitrogen ion plasma treatment was done for the membranes. Variable treatment time was used to modify the membrane surface and its characteristics. These membranes were characterized before plasma treatment and after plasma to make comparative study by different technique such as optical microscopy, SEM- Scanning electron microscope, UV-Vis Spectrometry, Fourier transform infrared spectroscopy, I-V measurement. Results of gas permeation shows improvement in porosity N_2 plasma treated Membrane. The permeability of these membranes also depends upon thickness, ion energy and etching time. These results are discussed in this paper.

BP28

Ion-acoustic Shock Waves in Beam Plasma Interaction

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Abstract

Electrostatic solitary waves have been observed by the satellites in the auroral region of Earth's magnetosphere. A large number of investigations have been reported to study the dynamics of electrostatic solitary waves and shock waves in Maxwellian and nonthermal plasmas. Superthermal particles are believed to exist in most of the space and astrophysical environments. Over the last three decades, there have been a much interest in studying the linear and nonlinear properties of solitary waves and shocks in different plasma systems. We consider a plasma comprising of ions, two types of electrons (say cold and hot) and electron beam. We have used Reductive Perturbation Method (RPM) to derive Korteweg-de Vries- Burgers (KdV-B) equation. From the solution of KdV-B equation, we have studied the effects of superthermality, concentration of hot electrons and beam concentration on the amplitude and width of solitary waves. It is observed that both negative as well as positive potential solitary structures exist in the given plasma systems.

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BP29

Correlation Of Neutron With Deuteron And X-ray Emission From 2.2 kJ Plasma Focus Device

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Abstract

Experimental studies on the neutron emission and its correlation with the corresponding deuteron and X-rays emission from a 2.2 kJ Mather type Plasma Focus device is carried out. The temporal evolution of neutron emissions are carried out by employing photo multiplier tube positioned at both axial and radial direction. Faraday cup and Vacuum photodiode are employed for the time resolved study of deuteron and X-ray emission along with neutron emission. The time resolved studies of deuteron and X-ray emission shows that neutron emission is influenced by deuterium ions. Neutron pulses of few tens of nanoseconds and with a maximum energy up to 3 MeV has been observed. In addition, a bubble dosimeter has been used to measure the number of neutron emission from the Plasma Focus device and the measured neutron yield is found to be around 10^7 neutron/shot in axial direction.

BP30

Prateek Varshney

BP31

An Integrated Four-Gun Plasma Source for SYMPLE

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Abstract

It is well established that an unmagnetized plasma does not support propagation of low frequency (($\omega << \omega_p$) electromagnetic (e.m) waves with amplitude such that $eE_{e.m}/m\omega << c$. However, the high amplitude waves, with their relativistic parameter $\nu = eE_{em}/m\omega c \sim 1$ have been shown [1] theoretically to penetrate as well as get absorbed inside a plasma. Experimental investigation of issues related to the transfer of energy from the wave to plasma have implications in fast ignitor fusion research. In this regard, an experimental system SYMPLE (System for Microwave and Plasma Experiments) is being developed in order to investigate interaction of very high power (1GW, $f_\mu \sim 3$ GHz, $t_\mu \sim 15$ ns) microwave with an overdense ($f_{plasma} > f_{\mu wave}$) plasma. Estimation of desirable plasma parameters show that the plasma ($n_e \sim (1\text{-}10)x10^{18}/m^3$) should have a steep axial n_e gradient ($L_n \sim \lambda_{HPM}$) at the wave interaction regime, followed by a uniform axial extent of ~ 1m and a radial extent ~ 10 cm.

The requirement of the sharp gradient at the regime of wave interaction has necessitated the choice of a washer – gun based, pulsed, moving plasma. Here, L_n / plasma velocity $>> t_{HPM}$ so that the plasma front appears static to the incoming wave. Density ~ $1x10^{18}/m^3$ is attained with ~ 20 MW input to the gun using a pulse forming network. A washer gun assembly is specially designed to integrate four guns in a single unit, sharing the same gas plenum. This four-gun assembly ensures the required radial uniformity of the plasma. By optimizing parameters such as gas throughput, magnetic field and ambient pressure, a parametric regime is identified in the post pulse regime where the required axial uniformity and the density gradient ~ 10 cm is attained. The present paper discusses the development and parameter optimization of the plasma source suitable for the HPM-plasma interaction experiments.

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BP32

On Unstable Electromagnetic Radiation in Inhomogeneous Plasma Driven by Nonlinear Dissipative Force

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Abstract

A theoretical investigation on the generation of electromagnetic radiation in inhomogeneous plasma in presence of drift wave turbulence has been presented in this paper. Based on a nonlinear wave-particle interaction process called plasma maser effect, the growth rate of an electromagnetic wave has been estimated in this investigation from the consideration of the associated nonlinear dissipative force. The result predicts electromagnetic instability in a spatially inhomogeneous plasma. The effect of associated nonlinear force in nonlinear wave-particle interaction process for generation of enhanced radiation in inhomogeneous plasmas has been analyzed.

BP 33

Effect of Ionic Temperature on Ion-Acoustic Solitons in Warm Plasma Consisting of Positive Negative Ions with Electrons Featuring Tsallis distribution

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Abstract

Plasmas containing electrons, along with negative and positive ions have a great importance in different fields of plasma science and technology. Positive-negative ion plasmas are encountered in various environments (e.g., Earth's ionosphere, cometary comae, plasma processing reactors, in neutral beam sources, and in low-temperature laboratory experiments). Ion-acoustics solitary waves in a warm electronegative plasmas composed of positive ions, negative ions and nonextensive electrons are investigated. Reductive perturbation technique is used to derive the Korteweg-de Vries equation. Stationary solution of this Korteweg-de Vries equation is obtained. Tthe combined effects of ionic temperature and other plasma parameters on ion-acoustic solitons are investigated. It is also found that for certain values of the negative to positive ion density ratio, the positive to negative ion mass ratio and the nonextensive parameter, the solitons amplitude and width are significantly modified.

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BP 34

Shock Dynamics in Nonextensive Electronegative Plasmas

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Abstract

Shock wave structure, in a warm electronegative plasmas composed of positive ions , negative ions and nonextensive

electrons are investigated. Reductive perturbation technique is used to derive the Korteweg-de Vries Burger (KdV-B) equation. The Nonlinear and dispersive coefficients of KdV-B equation are a function of ion temperature, negative to positive ion density ratio, the positive to negative ion mass ratio and the nonextensive parameter. It is investigated that the shock dynamics is significantly modified by these parameters.

BP35

Effect of the Asymmetric Ion flow on Dust Crystallization in Magnetized Complex plasma

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Abstract

Isotropic interaction potential like Debye-Huickel leads to the formation of coulomb crystals of FCC, BCC or Hexagonal geometries in complex plasma, while asymmetric ion flow near the sheath region gives rise to an anisotropic long range wake potential. This newly generated wake potential provides a vertical alignment to the regular orientation in the horizontal plane and thus affects the crystal geometry to certain extent. For this article we have studied the 2D coulomb crystallization in presence of magnetic field and strong anisotropic ion flow near the sheath region using Molecular Dynamic (MD) simulation. We would like to investigate the effect of strong ion flow in magnetized dusty plasma on coulomb crystallization near the sheath region.

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BP36

Electrostatic Ion Waves in a Magnetized, Collisional Multi-ion Plasma

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Abstract

The stability of the electrostatic ion cyclotron waves has been investigated in a collisional, magnetized multi-ion plasma of hydrogen ions, oxygen ions and electrons. We assume that the hydrogen and oxygen ions drift respectively with velocities V_{0H} and V_{0O} perpendicular to the magnetic field; the electron temperature is not assumed a constant and hence we consider the heat conduction due to a temperature gradient perpendicular to the magnetic field. The derived dispersion relation is shown to reduce to simpler ones for various limiting conditions. The magnitude of the growth rate is dependent on the electron ion collision frequency. We find that the wavelength range of growth rate decreases with increasing oxygen ion densities while its magnitude decreases with increasing drift velocities. These results can qualitatively explain a few of the experimental observations.

BP 37

Drift Wave And Its Stability Analysis In ECR Produced Plasma Of MaPLE Device at Saha Institute of Nuclear Physics

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Abstract

Cross-field transport due to the low frequency drift modes destroys the plasma confinement [1]. It is one of the main barriers to achieve thermonuclear power in nuclear fusion. In this experiment, excitation of drift wave and its stability analysis are done. Modulation of density at 300 Hz excites the drift wave in its second harmonic at MaPLE (Magnetized Plasma Linear Experimental) device [2], in which plasma is produced by Electron Cyclotron Resonance (ECR) method using 2.45 GHz microwave and 875 Gauss magnetic field. Stability analysis shows that parallel electron flow is needed to excite this mode. Growth rate also depends on magnetic field value. At a critical magnetic field value, the growth rate is maximum. Experimentally the critical magnetic field value is also observed. Details results will be presented.

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BP 38

Wave Breaking Phenomenon of Lower-Hybrid Oscillations Induced by Background Inhomogeneous Magnetic Field

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Abstract

In a fluid description, space-time evolution of lower hybrid modes in a cold quasi-neutral homogeneous plasma in presence of an inhomogeneous magnetic field is analyzed by using Lagrangian coordinates. An exact solution is obtained in parametric form. Within a linear analysis a dispersion relation with inhomogeneous magnetic field shows phase mixing of such oscillations. A manifestation of 'phase mixing' is shown in 'mode coupling'. It is demonstrated that lower hybrid modes break via 'phase mixing' mechanism in presence of an inhomogeneous magnetic field. Breaking of oscillations is revealed by the appearance of spikes in the plasma density profile. These results may have some bearing with the laboratory / space plasma situations where the external magnetic field is inhomogeneous.

BP39

Magnetized Quiescent Plasma Device for Wave Studies

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Abstract

The plasma characteristics of a newly developed magnetized plasma device will be presented. It is a versatile laboratory plasma device designed and fabricated in house at Institute for Plasma Research for wave studies. The machine is primarily a cylindrical device with provisions for a uniform axial magnetic field using electromagnets. Plasma is produced by hot cathode. Collisionless plasma can be produced over a large temperature and density range in this device. An initial plasma density of 5 x 10^8 cm^{-3} and temperature around 6 eV has been observed in the system. Details of the experimental set up and initial results will be presented.

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BP40

Current Free Double Layer Study in a Low Pressure Helicon Discharge

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Abstract

Current Free Double Layers (CFDL) are localized potential structures having spatial dimensions ~ Debye lengths and potential drops of more than local electron temperature across them. CFDLs do not need a current for them to be sustained and hence they differ from the current driven double layers. Helicon antenna produced plasmas in an expanded chamber along with an expanding magnetic field have shown the existence of CFDL near the expansion region. A helicon plasma device has been designed, fabricated and installed in the Institute for Plasma Research (IPR), India to study the role of maximum magnetic field gradient as well as its location with respect to the geometrical expansion region of the chamber in CFDL formation. We have observed and characterized a CFDL I our system. One important feature of this CFDL is that it is maintained without any net current. The current through a potential drop is always an electron current because of the electron and ion mass ratio. So for the current free condition to be satisfied, there should be another source of electrons in direction opposite to the electron current through the double layer. We will present this source of electron current which is observed in our system for the first time.

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BP41

The Low Magnetic Field Density Peak in a Helicon Discharge

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Abstract

In a normal Helicon discharge, density varies linearly with applied magnetic field. For magnetic fields below 100 Gauss, however the density does not vary linearly rather shows a density peak. Numerous theoretical and experimental works are reported earlier. Much of the explanation comes from coupling of Helicon and cyclotron Trivelpiece-Gould modes at these critical fields. Reflection of Helicon waves from axial boundary and subsequent interference has been also proposed. We observed and characterized the density peaks by electric probe measurements and antenna plasma coupling measurements for different powers and argon neutral pressures. The experiments are carried out in a diverging magnetic

field configuration with a helicon m=+1 half helical antenna powering the plasma source. Density and light intensity are measured on both sides of the antenna, the characteristics of which are observed to be different. By changing the magnetic field direction, we have shown that the density peaking is on the m=+1 wave propagation direction i.e. peaking happens on that side of the antenna which sees the magnetic north. The magnetic field dependence of plasma resistance (which is a parameter defining the coupling strength between the antenna and plasma) can only be explained if the density variation on both sides of the antenna is taken into account.

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BP42

Ion-Acoustic Solitons In Inhomogeneous Plasma In Presence of Weak Ionization

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Abstract

The properties of ion-acoustic solitons in weakly inhomogeneous plasma in presence of weak ionization are studied. For this study fluid model of plasma is considered and reductive perturbation method is employed to the basic set of fluid equations. In this formulation process a space time stretched co-ordinate is used. The system of equations has been reduced to a modified Korteweg - de – Vries (mKdV) equation and solved for obtaining the expressions of amplitudes and widths of the solitons. The soliton solutions are found to be affected by plasma inhomogeneities. The effective conditions for soliton propagation in weakly inhomogeneous plasma in presence of weak ionization have been analysed.

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BP43

Self-gravitational Instability of Two-Component Radiative Plasma with Hall Current and Electron Inertia Flowing through Porous Medium

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Abstract

The self-gravitational instability of two-component plasma is discussed to investigate the effect of the radiative heat-loss function, thermal conductivity, collision frequency of neutrals, Hall current, finite electron inertia, finite electrical resistivity, viscosity, porosity and permeability of the medium on the Jeans instability. The usual Magnetohydrodynamics (MHD) equations are used for the present configuration with radiative heat-loss function and thermal conductivity. A general dispersion relation is obtained from perturbation equations using the normal mode analysis method. We find that the Jeans condition of self-gravitational instability is modified due to the presence of radiative heat-loss function, thermal conductivity, finite electron inertia and neutral particle. Numerical calculations have been performed to show the effect of the various parameters on the growth rate of the self-gravitational instability.

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BP44

Analysis of EMHD Wave Propagation in Radially Nonuniform Magnetic Configuration

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Abstract

The propagation of EMHD waves is analyzed theoretically in a set up with radially varying ambient magnetic field. The wave magnetic field can be localized to finite radial extent by the magnetic field as the asymptotic solutions of the corresponding eigen value equation limit the wave propagation at larger radii. The critical radius for propagation of a helicon like bounded EMHD mode is found to be determined by the radial scale length of variation of the ambient magnetic field in combination with the parallel wave vector. The results potentially explain the bounded propagation of the EMHD waves observed [1] in the experimental conditions assumed in the present analysis.

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BP45

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BP46

Modified jeans instability of quantum plasma with resistive effects and intrinsic magnetization due to electron spin

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Abstract

The paper examines jeans instability of quantum plasma considering simultaneously the effect of resistive effects and intrinsic magnetization due to electron spin. The linearized perturbation equations are constructed using QMHD model and dispersion relation is obtained using normal mode analysis. The numerical calculations have been performed to show the effects of various parameters on the growth rate of jeans instability. The present work is applicable to the interior of the white dwarf star, neuron star as well as low temperature laboratory plasmas.

BP47

Maxwell Formulation For Equations Of Quantum Plasma

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Abstract

The full description of, and the solution of the equations for ,a plasma present a formidable due to the complexity of the electromagnetic and flud phenomena and their interaction within the same domain. The most accurate physical description of a plasma is fashioned by kinetic theory, in which a distribution fuction possesses the information regarding

the plasma state. Recent investigation in both theoretical [1,2] and computational application [3-6] of the two fluid theory of plasmas have been successful in demonstrating the utility of the two-fluid models. In the present paper, we present a detailed formulation of the two-fluid equations of a quantum plasma into a form remarkably similar to set of Maxwell equations. An analogy in the structure between electrodynamics and hydrodynamics allows the equations of motion for a new fluid to be rewritten as a set of Maxwell equations in a new choice of dynamical variables[7-9]. Our aim is to extend this treatment to the two-fluid theory by determinating the Maxwell set governing each species in the quantum plasma. The genaration mechanisms of the behavior of the canonical quantities are then isolated in the source terms.The utility of these new equations lies in the treatment of the source and quantum terms. If empirical models are subsequently developed for the charge and current densities of the new Maxwell set, then solutions can theoretically be determined in much the same way as elecrodynamic solutions are found.

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BP48

Magnetic Field Generation by Propagation of E.M. Waves In Magnetized Quantum Plasma

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Abstract

The interaction of intense laser pulses with plasma can give rise to number of relativistic [1-3] and nonlinear [4] effects such as parametric instabilities [5], generation of intense longitudinal electric and magnetic [6] field and stimulated backscattered harmonic generation [7]. Relativistic plasma dynamics can produce self-modulation, self-focussing and Raman scattering [3,8] of strong electromagnetic waves in plasma. Intense electromagnetic waves propagating through plasma are capable of generating large electric field gradients, useful for electron acceleration [9,10]. It has been reported [11,12] that torroidal as well as axial magnetic fields are generated in laser produced plasma. These spontaneously generated (or externally applied) magnetic fields significantly affect the propagation of laser beam in plasma [13,14]. In recent years the focus is increasing on high density quantum plasma.Quantum plasmas have potential for application to nanoscale systems [15], such as quantum wells [16], ultra cold plasmas [17], laser fusion plasmas [18], next-generation high intensity light sources [19] and plasmonic devices [20]. Quantum plasma effects also appear in ultra small electronic devices [21], nanowires [22], quantum diodes [23], biophotonics [24], cool vibes [25], dense astrophysical environments (such as white dwarfs, neutron stars, etc.) [26] as well as in laser produced plasmas [27]. Other areas of relevance to quantum plasmas include metal clusters, thin metal films, spintronics, nanotubes, quantum x-ray free-electron lasers, etc. In this paper, we present a detailed study of generation of magnetic field as a result of interaction of a linearly polarized electromagnetic wave with magnetized quantum plasma. We show that when an intense linearly polarized radiation passes through inhomogeneous magnetized quantum plasma, magnetic field will be generating due to current density perturbation. At the same time, the plasma electron will trace an elliptical orbit under the combined influence of the magnetic field and linearly polarized radiation. Magnetic dipoles will be set up and a resultant longitudinal magnetic field will be generated. These effect will be absent for a linearly polarized radiation propagating through unmagnetized plasma.

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BP49

Ponderomotive Acceleration In Magnetized Quantum Plasma

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Abstract

Electron acceleration by a laser pulse in magnetized plasma has been a subject of great intrest. Pukhov et al [1] have in their three-dimensional (3D) particle-in-cell simulation of intense short laser pulse interaction with plasma have observed strong flows of relativistic electrons axially comoving with the laser pulse and generating 100MG azimuthal magnetic field. The electron energies are far in excess of ponderomotive potential energy and the acceleration is a consequence of direct exchange of energy between electron and laser via. betatron resonance. Gahn et al.[2] experimentally observed generation of multi-MeV electron beam by direct laser acceleration in high-density plasma channels. Tsakiris et al.[3] developed an analytical theory and a fully relativistic 3D single particle code for direct laser acceleration of electron in radial electrical and azimuthal magnetic fields. Tanimo et al. [4] studied the effect of self – induced azimuthal magnetic field on the direct electron acceleration by laser with stochastic phase disturbance. They found that apart from beam collimation electrons are accelerated to ultrahigh energies that are greater than the pondermotive energy and that the acceleration is enhanced by increasing the strength of magnetic field. Liu et al. [5] showed that the electron acceleration depends on laser intensity and the ratio of cyclotron frequency to laser frequency . Yu et al. [6] examined similar

configuration using linearly polarized laser. They have obtained electron acceleration to relativistic energies using weak magnetic field. During the recent years, the field of quantum plasma physics has a long and diverse tradition [7-10] and is

becoming an area of increasing interest [11,12] motivated by its potential applications in modern technology. The high-density, low-temperature quantum Fermi plasma is significantly different from the low-density, high-temperature "classical plasma" obeying Maxwell-Boltzman distribution. During the last decade, there has been a growing interest in investigating new aspects of dense quantum plasmas by developing the quantum hydrodynamic (QHD) equations [13] by incorporating quantum force associated with Bohm potential. The QHD equations are useful for studying numerous collective effects [14] involving different quantum forces. In this paper, we have examined the possibilities of electron acceleration by a circularly polarized laser pulse in magnetized quantum plasma. The basic mechanism involves acceleration of electron by the axial gradient in the ponderomotive potential of the laser. The ponderomotive force of the laser is resonantly enhanced when Doppler shifted laser frequency equals the cyclotron frequency.

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BP50

Kelvin-Helmholtz Instability Of Two Superposed Viscous Fluids In Porous Medium

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Abstract

The Kelvin–Helmholtz instability of two superposed incompressible viscous streaming fluids is investigated in the porous medium with suspended particles. The effect of FLR (Finite Larmor Radius) correction also considered with uniform horizontal magnetic field. A dispersion relation for such a configuration is obtained by using normal mode analysis and appropriate boundary conditions of medium. The general dispersion relation is modified by the simultaneous presence of porosity, Suspended particles, viscosity and FLR correction. Stability condition of the interface is affected by the parameters of porosity, suspended particles, viscosity and FLR correction. It is analyzed and found that the effect of viscosity, porosity and FLR correction have stabilizing influence on the growth rate of unstable mode of Kelvin-Helmholtz instability.

BP52

Comparative Study on Nonlinear Dynamics of Magnetized and Un-magnetized DC Glow Discharge Plasma

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Abstract

Various nonlinear dynamical behaviors are experimentally observed to exist in magnetized dc glow discharge plasma. Nonlinear plasma fluctuations are seen evolving when the initial parameters such as discharge voltage, filling pressures etc. are changed in presence of external magnetic field. A transition pattern of periodic to chaos through quasi-periodicity is experimentally observed when magnetic field is applied which is not the case in un-magnetized one. Hence, a comparative analysis is being carried out for both the cases of magnetized and un-magnetized plasma. The nonlinear behavior of the plasma oscillations are diagnosed by different techniques viz., Power spectrum, Phase space plotting, Correlation dimension, Liapunov exponent, Fractal dimension and Hurst exponent. Further, it is noticed that with increasing discharge voltage, the glow emerges from cathode, slowly moves toward anode and finally sinks into the anode in ballooning manner.

BP53

Characterization Studies Of Lithium Vapor Generated In The Heat Pipe Oven For The Plasma Wakefield Accelerator Experiment

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Preliminary studies on characterization of lithium vapor by white light as well as UV laser absorption were carried out in the 40 cm prototype heat pipe oven for the generation of photo ionized Li plasma for the Plasma Wake Field Acceleration Experiment. The experiments were carried out using a low resolution (1nm resolution) spectrometer around the 670.77 nm wavelength region. Values of the line integrated neutral density of Li (n_oL) were found to be of the order of 10^{17}-10^{18} cm^{-2} for oven temperature range from 600-800^oC. This values of neutral density is sufficient to generate the required plasma density of (10^{13}-10^{14} cm^{-3}). The dependency of the neutral density of Li on oven temperature and helium buffer gas pressure was also studied.

The emission spectrum of 193nm laser induced plasma of Li vapour was studied in order to establish a correlation between the emission spectra intensity and the neutral density. It was observed that the 610 nm line intensity grows with oven temperature while that of 670 nm decreases. Since Li has a strong absorption in the 670 nm region there is strong re-absorption of the 670 nm emission which is also observed in the white light absorption studies. Preliminary results show a linear dependence of the neutral density on temperature in the temperature range of our interest. The ratio of these

line intensities at specific oven temperature, once calibrated, could be used as a measure for the lithium vapor density and eventually the electron density. Experimental results are currently being validated using a 0.75 m spectrometer having a 0.05nm resolution.

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BP54

Ion-Acoustic Solitary Waves with q-nonextensive Distribution of Electrons

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Abstract

An investigation has been done by taking a two component plasma system consisting of cold positive ions and the q-nonextensive distributed electrons. Using the standard reductive perturbation theory, Korteweg-de-Vries (KdV) equation has been derived. The nonlinearity and dispersion coefficients are found to be the functions nonextensive parameter q. Mainly the effect of nonextensive distribution of electrons on the dynamics of ion-acoustic solitary waves

has been studied and the results of the numerical computations are interpreted in the form of graphs for various parameter regimes.

BP55

Experimental Measurement Of Electron Energy Distribution Function Of Solitary Electron Holes

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Abstract

A metallic disc electrode (exciter) is immersed in a low pressure thermionic argon plasma. When the exciter is positive pulsed biased, nonlinear solitary electron holes (SEHs) are excited [1]. SEHs are identified in plasma as a positive potential hump, where the electrons are trapped and propagate with the phase velocity of fraction of electron thermal speed (v_e) to twice of v_e. Also a certain critical value is required to excite the SEHs. In our case [1], for the applied pulse width less than the thrice of ion response time, initially the SEHs propagate towards the exciter with the speed of less than the v_e and away from the exciter, SEHs propagate in the order of v_e. Such type of nature indicates the presence of virtual source in front of the exciter. For the applied pulse width greater than the thrice of ion response time, the SEHs propagate away from the exciter in one direction only, but with two speeds. For both type of pulse widths, the amplitude

of SEHs decreases with distance from the exciter. So, for the changing in the number of trapping electrons, for both pulse widths, the distribution function of SEHs would be changed. One should incorporate the electron distribution function to learn more about the microscopic details, e.g. the growth of holes in linearly stable plasmas or the microscopic nature of anomalous transport processes, depletion of electrons, non-Maxwellian, temperature and density of trapped electrons moving with the SEHs, etc. We have measured the electron energy distribution function (EEDF) of solitary electron holes for shorter and longer pulse widths compared to ion response time. To measure this EEDF, a disc Langmuir probe is used and the electron and ion currents are obtained for positive and negative bias to the probe respectively. From the *I-V* characteristics of Langmuir probe, we can find the EEDF (first derivative of the *I-V* curve) and the electron energy probability function (EEPF). In EEPF, the peak gives the trapped electron temperature and the area under the curve gives the density. In this way, we have measured the temperature and density of trapped electrons inside the SEHs. The distribution function is changed according to the number of trapped electrons. For the pulse width less than the thrice of ion response time, the distribution function shows bi-Maxwellian and for the pulse width greater than the thrice of ion response time, the distribution function shows Maxwellian.

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BP56

Electron Trapping in Laser Wakefield Acceleration in Plasma

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Abstract

The number of particles in an electron beam from laser wakefield acceleration is determined at the moment of trapping of background electrons. The longitudinal and transverse wave-breaking initiates the electron trapping. After some time, the trapping stops because of the repulsive force by the trapped particles. From many simulations and experiments, it has been well known that trapping of the background electrons begins much below the longitudinal wave-breaking limit. This is related with transverse motion of the electrons. As an ultra-intense laser pulse propagates through a plasma, it pushes out the background plasma electrons and leaves behind a periodically-repeated bubble-like region. Inside the bubble, the electron density is very low, while the electron density at the rim of the bubble is very high. Highly energetic electrons make their trajectories along the rim of the bubble. Though many of such electrons turn around the rim and leave the bubble, some of those electrons are trapped in the transverse direction when their kinetic energies are lower than the depth of the potential well of the bubble.

The idea suggested in this paper is that a magnetic field applied in the longitudinal direction is able to suppress the transverse drift of the electrons so that their trajectories are dragged more inward the bubble. Because of the sensitivity, even a very weak suppression of the transverse drift of the electron may be able to turn the outgoing path into the trapping path. The advantage of this technique is obtaining one more control of the beam charge in the laser-plasma accelerators, while keeping other parameters unmodified. Though the required magnetic field is strong, i.e. like a few tens or one hundred Tesla, magnetization of the plasma is still weak enough to put the wakefield uninfluenced.

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BP57

Comparison of Langmuir probe characteristic of argon and oxygen plasma in presence of external magnetic field

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Abstract

In the recent years electro-negative plasmas has drawn significant interest due to various applications arising from low temperature plasma processing of semiconductors, negative ion plasma thrusters and for neutral beam heating in fusion devices. The Langmuir probe is the most basic plasma diagnostic tool used for characterizing negative ion density. The information of negative ion density and electro-negativity can be obtained from electron saturation current of the Langmuir probe. However interpretation of plasma parameters in presence of negative ions can be highly complex in magnetized plasmas as the magnetic field attenuates plasma electrons from reaching the probes surface.

In this paper we present a comparative study of planar Langmuir probe characteristics in argon and in electronegative oxygen plasma. The plasma is produced using a cylindrical DC magnetron discharge operated in conjunction with a constricted anode. The plasma is characterized by an intense annulus glow adjacent to the cylindrical cathode. The density is found to be dropping sharply towards the centre of the plasma column (figure-1) with application of magnetic

field. The above feature is due to limitation in cross field diffusion of plasma electrons radially towards the centre of the plasma column. However the characteristic diffusion length for the negative oxygen ions is much greater than electrons. Comparison of probe characteristics for electro-positive argon discharge and electro-negative oxygen plasma shows that the Langmuir probe characteristic in oxygen tends to be symmetric around the floating potential as the magnetic field was increased (figure-2). This preliminary result indicates that the central region is likely to be composed of mainly negative ion and positive ions species in a quasi-neutral equilibrium.

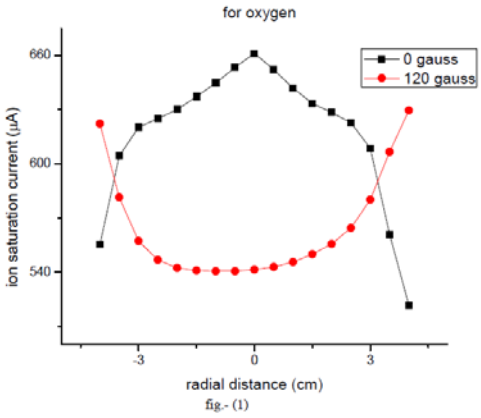

fig.- (1)

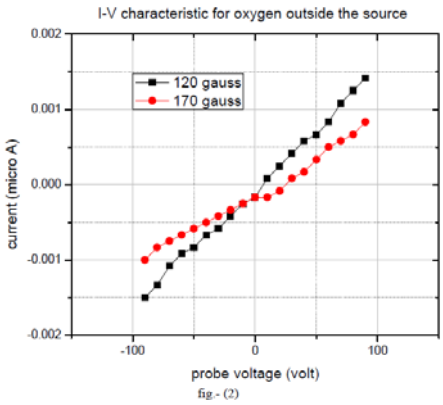

fig.- (2)

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BP58

Biased Electrode Experiment in Aditya Tokamak

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Abstract

To carry out biasing experiments in Aditya tokamak by introducing a biased electrode in the edge region, an electrode-assembly and a pulsed power supply (PPS) have been designed and fabricated. Experiments have been carried out by inserting a movable molybdenum electrode from the top port of the Aditya tokamak and placing it at different radial locations inside the limiter. The electrode is biased positively and negatively with respect to the vacuum vessel. Substantial changes in loop voltage, H-α, Ly-α, line average density, visible continuum, CIII, OI, OVII, Langmuir probes signals has been observed during biasing the electrode positively. Experimental results show particle and energy confinement time improvement in typical Aditya tokamak discharges. Detailed experimental data and analysis will be presented during the symposium.

BP59

Observations of nonlinear structures in LVPD Plasma

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Abstract

The energy and particle transport in plasmas are very crucial areas of research in both plasma physics and fusion science as confinement of plasma depends on the control over the transport caused by the gradients in the profiles of various plasma parameters and the magnetic field. The collective modes are excited to achieve a state of equilibrium in plasma at the cost of free energy associated with the gradients and thus enhance the resultant plasma transport. These growing modes saturate through nonlinear processes and generate vortices of different scales in plasma. The typical size, lifetime and dynamical characteristic of vortices are decided by the evolution of background turbulence. Investigations of these structures become important because of their role in transport.

In finite beta plasma of LVPD, investigations are carried out in the target plasma where the free energy source exists only in the radial gradient of electron temperature. The density fluctuations (δn_e) are measured from a movable array containing eleven numbers of cylindrical Langmuir probes of size ($\phi \sim 1$mm, L~ 5 mm). A reference probe(similar size and shape) is also mounted in the same poloidal plane as that of movable array from another probe shaft. The data is]

acquired in a rectangular grid of size (10cm x 50cm) with a spatial resolution of $\Delta x = \Delta y = 1$cm. The correlation and conditional averaging techniques are used to obtain the correlation length and selection of similar eddies. Radially extended structures are observed in poloidal plane perpendicular to the ambient magnetic field at different grid locations by suitably satisfying the condition imposed on the amplitude ($\delta n \geq 1.5\sigma$) and slope ($dn_e/dt > 0$) of the reference probe where ' σ ' is standard deviation of the fluctuations. The probability distribution function of density fluctuations exhibits a deviation from Gaussian profile, thus exhibiting signature of non-linearity. Initial results obtained shows the existence of radially extended structures with spatial scale lengths of 50 and 6 cm and of typical life time of ~ 20 μs in both the radial and poloidal directions. The typical correlation lengths obtained are 30 cm and 15 cm respectively. A theoretical model incorporating non-linearity is also developed. The detailed comparison of experimental results with theory will be presented in the conference.

BP60

Novel method for scavenging of energetic electrons by pulse modulation of discharge supply

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Abstract

Control of energetic electrons in LVPD attains significance as the measurement of electron temperature, the gradient of which provides the very source of free energy for the excitation of Electron Temperature Gradient (ETG) turbulence gets corrupted because of the presence of energetic electrons in the plasma produced. Although, we have successfully produced plasma free of energetic electrons by making use of a specially designed large aspect ratio Electron Energy

Filter (EEF) but the difficulty it poses is in the form of sharp reduction in the volume of plasma available for making turbulence study. A motivation is thus derived for finding different mechanism for producing plasma free of energetic electrons where no loss of plasma volume should occur.

A plasma is thus produced using a discharge power supply with a larger transient voltage(~ 70 V) for striking discharge but the arc is then sustained at lower discharge voltages(~40V). Initial results obtained from its application to plasma are indicative of its success as significant scavenging of energetic electrons is observed. The measured values of electron temperature are also found comparable to the plasma produced with EEF. The only unexpected result is obtained in the form of reduction in plasma density. We believe that this reduction is plasma density may be because of insufficient time given to the ionizing primary electrons as they are removed in a transient time of (10- 30 μs), sufficiently small in comparison to the confinement time of plasma produced (~ 1ms). We have therefore made suitable provisions in power supply for addressing this problem by modulating the transit time of discharge supply. The transient time of discharge pulse is now controlled for ≤ 3 ms before it gets forcibly reduced to 40 V.

In this paper, both the design features of pulsed discharge power supply, capable of two-step pulse modulation of the output voltage and the results obtained by its application in LVPD plasma will be presented from the perspective of both, the scavenging of energetic electrons and the production of plasma of suitable density for carrying out ETG studies.

BP61

ETG Turbulence in Finite Beta Plasma of LVPD

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Abstract

The paper presents first controlled observations on electron temperature gradient (ETG) driven turbulence in high beta plasma of Large Volume Plasma Device (LVPD). The observed instability is investigated in the core region of target plasma when a ~ 2m diameter magnetic Electron Energy Filter (EEF) is used. The instability observed in finite beta, $\beta \sim 0.6$ plasma is electromagnetic in nature and is characterized by broadband spectra with central frequency, $\omega \leq 10$kHz, wave number, $k_\perp$=0.1- 0.2 cm^{-1} and it satisfies the condition $k_\perp \rho_e \leq 1$ where ρ_e is the electron Larmor radius. By suitably carrying out measurement for parallel wave number, we have shown that the condition $k_{||}/k_\perp << 1$ is satisfied experimentally for the observed modes. The observed lower hybrid instability is electromagnetic in nature and exhibits its direct dependence on electron temperature gradient. A confirmation of it as ETG turbulence is demonstrated by showing its absence when ∇T_e is made insignificant. The results obtained from these investigations will be presented in the conference.

BP62

Observation of Electromagnetic Turbulence in the Energetic Electron Belt region of LVPD Plasma

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The Electron Energy Filter (EEF) distinctly divides plasma in LVPD into source, filter and target regions. The plasma in target region is made devoid of energetic electrons by preferential transport of thermal electrons into target region. The transverse field of EEF ensures that the energetic electrons are either stopped or trapped in the source and EEF region but the exact mechanism involved in their loss is not understood yet. We have traced the trajectory of these energetic electrons by doing 2-D measurements of floating potential in the source and filter regions at different axial locations, maintaining an angular resolution, $\Delta\theta \sim 10$ degrees. The energetic electron follow an asymmetric path beginning right from one filament location to the EEF and closes its trajectory on to a filament placed exactly opposite to it in the same plane. A probe array comprising of 32 numbers of tungsten $\varphi = 1mm$, and $l = 10mm$ Langmuir probes ($\phi \sim$ 1mm, L=10 mm, radial probe separation, Δx=2.5cm).

The measurement of density and magnetic field fluctuation in the energetic electron band region of the source plasma shows an enhancement in their level by a factor of 20. A strong anti-correlation is observed between the density and magnetic field fluctuation. The typical density fluctuations observed in the off band region are ~ 0.1 % but they exhibits a sudden enhancement to 2% in the band region. A similar behaviour is also seen for the δB_z. The density and magnetic field fluctuations exhibits a strong anti-correlation with typical correlation coefficient, $C_{n,Bz} \sim -0.7$. The observed phase

velocity has the same magnitude and direction as that of electron diamagnetic drift velocity. The fluctuation exhibits a broad power spectrum with peak power within ≤ 60 kHz. The phase velocity of density fluctuations is measured using a pair of closely separated Langmuir probes in the radial direction. The propagation is seen towards the energetic band from both sides of it. The measurement of the floating potential also shows a reversal of electric field in the energetic band. Presently, the exact loss mechanism involved for these energetic electrons in the band is not clear. The possibility of excitation of energetic electrons driven Whistler turbulence in the band cannot be ruled out. Detailed results explaining the possible loss mechanism involved and the source for the excitation of turbulence in the band will be presented in the conference.

BP63

Study of Shear Flows in a Strongly Coupled System using a Generalized Hydrodynamic Model

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Abstract

Plasma is a statistical system of mobile charged particle interacting with each other via the electromagnetic forces. We consider spatially homogeneous plasma with dust grains embedded in it. We model only dust component which is strongly coupled i.e ratio of average potential energy per dust grain to average kinetic energy can be large. Such plasma is called strongly coupled plasma. In the past these systems have been studied by both Molecular Dynamic Simulation and phenomenological fluid model such as simple Generalized Hydrodynamic (G-H) model or memory based viscoelastic fluid model [1].

Recently, generic shear flows and their linear and nonlinear phases have been studied using simple GH model and MD simulation respectively. In present work, we study the linear and nonlinear phases of shear flow instability such as Kelvin-Helmholtz instability considering the complete convection in the viscoelastic or memory term i.e., including "Frenkel convective term[2]".

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BP64

Phase Mixing Of Upper Hybrid Oscillations In The Presence Of An Inhomogeneous Magnetic Field

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Abstract

Spatiotemporal evolution of large amplitude upper hybrid oscillations in the presence of an inhomogeneous magnetic field is studied numerically using the Dawson sheet model. It is observed that the inhomogeneity in magnetic field causes the upper hybrid frequency to acquire a spatial dependence, which results in phase mixing and subsequent breaking of the upper hybrid oscillations at arbitrarily low amplitudes. This result is in sharp contrast to the homogeneous magnetic field case where upper hybrid oscillations break, when the perturbation amplitude exceeds a certain critical value, and in a time scale which is a fraction of the period of oscillation [1]. The phase mixing (wave breaking) time scale which is measured by the time of crossing of sheets in the Dawson sheet model, is found to depend on inhomogeneity scale length, strength of the magnetic field and the perturbation amplitude. This result is in agreement with recent nonlinear calculations reported in ref. [2].

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BP65

Characterization of VIRCATOR: An Update

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Abstract

A pulsed power HPM device, VIRCATOR, has been developed at Institute For Plasma Research, Gandhinagar to study the interaction of high power electromagnetic waves with plasma in 'SYMPLE'[1]. There is further requirement of microwave-plasma interaction studies in SYMPLE and that is, coupling of intense microwave power (few Mega-watts) onto the plasma gradient such that microwaves are absorbed, followed by generation and propagation of energetic electrons in the plasma. The study needs pre-knowledge of VIRCATOR[2] output, e.g., power, frequency and modes, prime requisites for finalization of focusing and coupling circuitry. VIRCATORS are wide-band, multi-mode devices and pose a challenge for the detection and focusing of multi-spectral components of its output. Recently, experiments for characterization of present VIRCATOR have been carried out at IPR using transmitting-receiving circuitry, which uses

wide-band antennas along with band pass filters of frequency range 2-10 GHz and wide band diode detectors. Detailed experiments along with results will be presented in this paper.

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BP66

MD Simulational Study Of Driven Yukawa System

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Abstract

Molecular dynamics simulations have proven to be of immense help in understanding the physics of strongly coupled system such as 2D Yukawa or Complex plasmas. To understand the physics of nonlinear wave propagation in Driven Yukawa system, an MD simulation code, earlier reported in has been revamped. Extensive rewriting and additional several new diagnostics, such as self-diffusion coefficient, velocity autocorrelation function, shear viscosity correlation function and correlation function for thermal conductivity have been implemented. Using this new MD code, properties of 2D driven yukawa system is explored.

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BP67

Plasma Diagnostics Of Reverse Polarity Planar Magnetron

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Abstract

DC magnetron system is widely used in thin film deposition and other variety of coating applications. In this work possibility of using planar magnetron as an ion source is being investigated, the idea is to bias the DC magnetron in reverse polarity so 'target' is biased positively with respect to surrounding shield. Magnetron plasma passes through various modes until it behave like and ion source. Magnetic field profile, operating pressure and applied potential plays a

crucial role in the beam profile. Experiment was performed with varying pressure and discharge voltage in the range of 10^{-2} to 10^{-4} mbar of pressure and 150 to 800 volt dc voltage, respectively. It is found that current still increases according to I^n law as observed in normal magnetron mode. The plasma property of the source was measured with the help of cylindrical Langmuir probe. Floating potential profile has been studied and is found to have peak just below the centre of magnetron and then reduces on the both sides. Different target materials were examined to investigate the role of secondary electrons ejected from the target materials. Observed different modes seem to be appear due to different mean free path and gyro radius under various operating conditions. Experiments are in the way to characterize the beam profile using retarding potential analyzer.

CM01

Particle-in-Cell Simulations for a Virtual-Cathode Based THz source: An Exploratory Study

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Abstract

Pulsed, high-power electromagnetic radiation in the Terahertz (THz) range can have several applications, such as the direct excitation of vibrational modes of polar molecules. It is of interest to examine if concepts for conventional high-power microwave sources, operating in much lower frequency ranges, can be adapted to operate in the THz range.

Virtual Cathode Oscillators (vircators) have traditionally been used as pulsed sources of high-power microwaves in the GHz frequency range. In the present work, we use numerical simulations to explore the possibility of vircators that work in the Terahertz (THz) range.

We have performed two-dimensional, relativistic, electromagnetic, particle-in-cell (PIC) simulations of an axially-extracted vircator using a locally-developed particle-in-cell code called MWS. The idea is to see if electromagnetic radiation in the THz range can be generated using such devices. If simulations suggest that such a device is feasible in principle, the next step would be to explore its experimental feasibility. The present paper focuses on the simulations – experimental considerations lie beyond the scope of this work.

A typical vircator with typical dimensions of a few cm and anode-cathode (A-K) gaps of a few mm can produce electromagnetic radiation in the GHz range. For a given A-K voltage, the radiated frequency is a sensitive function of the A-K gap, with smaller gaps resulting in higher frequencies. In vircators, plasma produced by ablation of the anode (mesh or foil) shorts the A-K gap, thereby limiting the pulse duration. A smaller AK gap thus results in shorter durations of the radiation pulse.

Our simulations show that device parameters can be tuned to produce radiation in the THz range. The required AK gaps lie in the range of a few mm, resulting in pulse durations of hundreds of picoseconds.

Details of the simulations, the limitations of the model and the major results will be presented in the paper.

CM02

Rayleigh-Taylor Instability Analysis In A Direct Energy Conversion System Based On Magnetic Flux Compression By Expanding Fusion Plasma

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Abstract

Magnetic flux compression (MFC) inside a solenoid by an expanding diamagnetic inertial fusion plasma sphere, and its use as a direct energy conversion scheme, has been reported in Refs.[1-8]. The basic idea is to use an electrical conductor (a solenoid in Refs. [2,3]) that enclose the plasma expanding in an external magnetic field. In Refs. [2,3], this magnetic

field is provided by the pick-up coil (solenoid) itself. The expanding plasma excludes the magnetic field by the diamagnetic currents produced on its surface. The inductive electromotive force induces currents in the shielding conductor (solenoid). Hence a part of plasma kinetic energy can be converted into pulsed electrical energy. Preliminary numerical studies given in Refs. [2,3], indicate that the proposed system is promising in terms of overall conversion efficiency.

However, such a plasma, expanding across a magnetic field is subject to Magnetic Rayleigh-Taylor (MRT) instability. For efficient operation of the system, the perturbation amplitude must be small that the irregular surface caused by MRT instability does not disturb the smooth compression of the magnetic field between the plasma and the solenoid. The simulation results given in Ref. [3], starting with an unperturbed initial plasma state, indicate the development and evolution of MRT instabilities at the plasma-vacuum interface around stagnation time. However, since the perturbations were only generated numerically, they did not grow to an amplitude large enough to affect operation. In reality, perturbations with different wavelengths and amplitudes would pre-exist on the surface of the plasma sphere. Therefore, detailed analysis is required.

In this paper, the evolution of nonlinear MRT instability in an MFC system driven by fusion plasma is studied for different types of initial perturbations, using a 2D MHD model [3]. The effect of magnetic field amplification outside the plasma, and the geometric divergence due to spherical expansion, are also studied. The paper reports the details of the proposed system, numerical model and the results of instability analysis.

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CM03

First Implementation of 2-D Scrape-off Layer Plasma-Neutral Transport Simulation code SOLPS5.1 to a Double-Null Diverted Plasma-Magnetic Equilibrium

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Abstract

The plasma transport in the open field line region of Scrape-Off Layer of the modern diverted plasma devices has assumed an increasingly detrimental role in the recent times. Given the prohibitingly large power loads on the targets and the challenges associated with effective power and particles exhausts, 2 and 3-dimensional coupled plasma-neutral computer simulations of the plasma transport in the SOL region have emerged as the most dependable basis for, design optimization, predictive modeling, and a successful operation time analysis of the steady-state Tokamak plasmas that last over a few hundreds of seconds and more. Extensive SOL plasma-neutral transport modeling support for both predictive and run time analysis of the plasma operations is envisaged for Tokamak SST-1 using the suit of codes, SOLPS. We report the successful implementation and benchmark of code SOLPS5.1 to SST-1, which is first to a connected double null diverted plasma-magnetic equilibrium set-up. The plasma transport in SOLPS is simulated by the code B2 on an orthogonal 2-D mesh following a multi-fluid equilibrium model incorporating multiple charged particle species. A full

kinetic description is provided by the kinetic code EIRENE of the neutral particle transport in the realistic geometry of the device. An iterative coupling between the plasma and neutral transport calculations is achieved in the SOL region, sampled by an orthogonal 2D mesh in magnetic geometry generated by the conformal mesh generator Carre, and a triangulated neutral particle mesh is generated by the module Triang. The latter allows sampling the distributions of neutral particle species to desired resolution in the rest of the vessel volume housing various plasma facing and first wall components. The contribution will provide details of the implementation on the servers in IPR and ITER-India, and results of the benchmark runs.

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CM04

Electromagnetic Particle-in-Cell Simulation in Three-Dimensions of the Kelvin-Helmholtz Instability in a Plasma

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Abstract

The Kelvin-Helmholtz Instability (KHI) has been the subject of extensive study due to its ubiquitous presence in many physical systems where streaming fluid flows with a velocity shear are involved. In neutral fluids, the nature and mechanism of the instability is well understood [1]. In streaming plasmas, however, the interaction amongst the charge particles via their electromagnetic fields introduces a number of complex issues which are still not clearly elucidated. We report here the development and evolution of the KHI within counter-streaming electrons in a plasma using a three-dimensional, relativistic, electromagnetic particle-in-cell code, *Picpsi3D.*

Fig. 1 below shows the system when it is initialized. There are three cold electron streams, each depicted in a different color. The central stream is flowing downwards along the z-direction, while the two streams at the periphery are flowing upwards. The velocity shear surfaces lie between adjacent streams, and have a sharp discontinuity horizontally along the x-direction.

It is seen that the Lorentz force acting on the electrons due to their self-magnetic field leads to a charge separation transverse to their motion along the x-direction. As a result, an oscillating electric field at the period of the electron plasma frequency is created along the x-axis which leads to a migration of electrons across the shear boundaries. The KHI then manifests itself with its characteristic vortex structures which are the hallmark of the instability.
Fig 2. shows the streaming electrons at a stage where the KHI has developed, and fig. 3 depicts the current density vectors in the central plane.

During the initial stages, there is a periodic exchange of energy between the EM field and the charged particles. Later, there is a redistribution of the particle kinetic energy so that as the energy along the z-direction reduces, it simultaneously increases along the x- and y-directions, with the total remaining constant. The vorticity in the current density also increases. In the last stage, the flow becomes turbulent as the three streams get completely mixed.

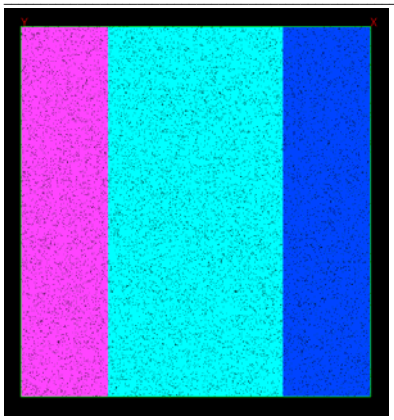
Fig. 1. The initial configuration

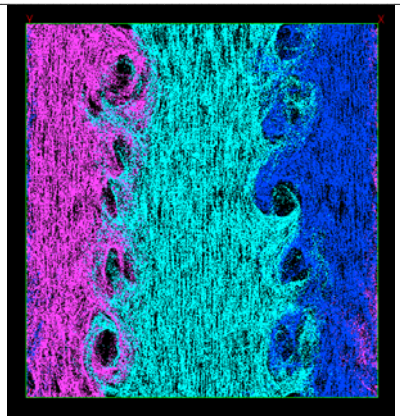
Fig. 2. The developed instability

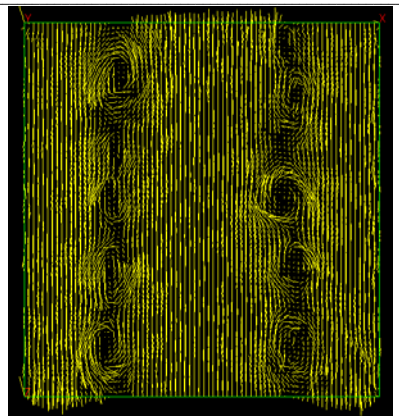
Fig. 3. The central plane current density

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CM05

A Kinetic Trajectory Simulation Model for Magnetized Plasma-Wall Transition

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Abstract

The plasma-wall transition region in presence of oblique magnetic fields has been studied using a kinetic trajectory simulation model. In presence of an oblique magnetic field plasma-wall transition region, which otherwise is purely electrostatic, breaks in two regions: magnetic presheath (dependent on magnetic field) and electrostatic Debye sheath (independent of the magnetic field). The electric field does not show the usual monotonic nature at magnetic presheath region. It has been observed that various plasma parameters reaching the material wall is insensitive to the magnitude and orientation of magnetic field but highly influenced near the plasma boundary. The particle densities and potential decrease as we move towards the wall, which becomes prominent as the strength as well as obliqueness of the magnetic field increase. Our results agree with previous works and hence, we expect our model to provide a basis for studying all types of magnetized plasmas, using the kinetic approach.

CM06

A Synthetic Diagnostic to modeled expected 2-D radiation power loss profile for the Infrared Imaging Video Bolometer of ADITYA tokamak

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Abstract

A "synthetic diagnostic" has been developed to theoretically estimate the radiation from ADITYA plasma using Infrared Imaging Video Bolometer (IRVB). These theoretical results will then be compared with the results obtained experimentally. The IRVB is a two-dimensional (2-D) plasma radiation imaging diagnostic. IRVB is used to measure time resolved 2-D profile of radiation power loss with wide field of view (FOV) [1-6]. The synthetic IRVB assumes toroidal symmetry in the tokamak. In poloidal cross-section it assumes symmetric parabolic profiles of plasma temperature, plasma density and impurity density. The IRVB system is essentially a pinhole camera system. It traces the line of sights of each bolometer pixel through the plasma volume and calculates local power emissivity at each volume element in space using the radiative cooling rates of plasma impurity. Finally line integrated emissivity profile provides a 2-D brightness profile at each bolometer pixel. This brightness profile is the expected IRVB image at foil location. By considering the system etendue the power loss profile can be computed. Using the synthetic diagnostic, spatial response of the experimental diagnostic, FOV, expected signal level and Signal to Noise Ratio can be determined. The synthetic IRVB used to simulate ADITYA-IRVB diagnostic and results were compared with experimental results [7].

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CM07

Collisional Radiative Model For Inert Gases Using Detailed Fine-Structure Cross Sections

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Abstract

The population kinetic models along with the optical emission spectroscopy (OES) measurements provide a widely used method for the plasma diagnostic. Plasma diagnostic yields various parameters like electron temperature, electron density, population of various levels etc. In the low temperature plasmas the dominating processes are due to electron-impact. Hence, the success of these population kinetic models depends on using accurate electron impact excitation cross sections of various fine-structure levels which play a crucial role in these low temperature plasma models [1, 2]. It is therefore desirable to use reliable excitation cross sections data rather than using the usual empirically obtained excitation cross sections which do not distinguish the fine structure levels or treat them in an approximate manner [3, 4]. Our group has studied and reported various electron impact fine structure cross section for inert gases [5, 6] using fully relativistic distorted wave (RDW) approximation method. The studies have also fitted the calculated RDW cross sections to analytic formulae so that these can easily be incorporate in various plasma models.

In order to test the effectiveness of including the detailed RDW fine–structure cross sections and to see the improvement

in plasma parameters we have recently developed a collisional radiative (CR) model for low temperature Ar plasma. In our CR model we incorporated our calculated detailed RDW cross sections. We obtained the population densities of the 1s and 2*p* levels of Ar as a function of electron temperature and electron density and compared them with the recent measurements [7]. Our CR model gave improved results and very good agreement with the experimental measurements [9].

We have further extended our study and develop a CR models for low temperature Kr plasma. We have obtained some preliminary results for the population densities of Kr plasma as a function of electron temperature and density. We will be presenting in the conference our results for Ar along with some results of Kr.

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CM08

Weibel Instability as a Function of Laser Angle of Incidence and Effect of External Magnetic Field

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Abstract

The Weibel instability is caused by anisotropic velocity distribution in plasma constituents and is characterized by the growth of large scale magnetic fields orthogonal to the direction of higher velocity. Due to interaction of ultra intense laser pulse with plasma, anisotropy in the electron velocity space is naturally produced due to the action of the radiation pressure of the laser pulse. In this work, we have presented the growth and saturation of weibel instability as a function of laser angle of incidence. We have observed non linear behavior in the saturation of the instability for laser incident angles other than normal incidence. The kinetic energy of the particles is also affected by the laser angle of incidence. Further we have also observed suppression in the growth of weibel instability due to the application of constant magnetic field parallel to laser beam direction in normal incidence. All the studies presented here is based on our simulation results performed with the help of 3D fully relativistic sequential version of laser-plasma interaction code PICPSI3D developed in L&PTD of BARC. The study of this kind of instability is very important in connection with fusion basically in fast ignition scheme (FIS) where it plays a very crucial role in heat deposition process from laser to fusion source.

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CM09

Dipti

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Rajesh Srivastava

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CM12

Neoclassical closure and the effect of equilibrium flow

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Abstract

In this work, we are reporting, a numerical investigation of different neoclassical closures and the effect on equilibrium flow in current carrying plasmas such as tokamak plasmas. We specifically focus our attention a the poloidal flow damping closure,which leads to damping of the poloidal kinetic energy which is important when we consider momentum deposition through neutral beam injection. We carry out oursimulation with help of the parallel MHD simulation program pNear, based on the generalised reduced MHD (GRMHD) equations.

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CM14

2-D Predictive simulations of Scrape-off Layer Plasma Transport of Phase-1 Divertor Operations in Tokamak SST-1

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Abstract

A 2-Dimensional computational analysis of coupled plasma and neutral transport in the scrape-off layer region is done using the SOLPS5 suite of codes (B2-EIRENE) [1] in order to explore an optimum range of operating parameters for sustainable steady-state discharges during the Phase-1 divertor plasma operation of the tokamak SST-1.With the central objective of achieving an effective control over particle and power exhaust in a double null diverted plasma equilibrium, the Phase-1 operation scenario implemented in the present simulationsindicates access to the sheath and flux limited divertor operation regimes and provides estimate of the degree of control that can be exercised on the differential power loading of targets by controlling the SOL plasma conditions for a range of the net heating power input.

The first detailed characterization of the effect of the external gas puff on the plasma profiles in the SOL of the device shows that with the level of neutral penetration observed in the present simulations, an effective control could be achieved on the core plasma density and temperature, as well as on the associated gradients of the respective parameter profiles in the edge region of the device.

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CM15

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Mahmuda begum

CM17

Numerical Simulation Of Substrate And Coating Temperatures During Plasma Spraying

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Abstract

The substrate and coating temperatures significantly influence quality and properties of the plasma sprayed coatings. It is difficult to measure the temperature of the substrate and coating during spraying. Numerical modeling is one of the proven techniques used to solve such a complex problems quickly and simply. In this work, a one-dimensional computational model is developed to predict the temperature of both substrate and coating during spraying using Finite Volume Method. A transient heat conduction equation is solved in coating, substrate and substrate holding regions with appropriate thermo-physical properties. It is assumed that heat fluxes to the substrate / built coating from the plasma jet and particles are constant during spraying. Temperatures of the alumina coating and copper substrate are predicted for different coating growth rates and spray distances. Predicted results are compared with measurements and results of previous model. The coating temperature predicted by the present model is lower than that calculated by previous model and measurements. The reason for this discrepancy is scientifically explained and results predicted by the present model are as expected.

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CM18

Numerical Simulation Of Non-Transferred Arc Plasma Torch Built At IPR

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Abstract

Facilitation Centre for Industrial Plasma Technologies (FCIPT) has a plan to design and develop high power plasma torches to produce high heat flux for ITER related activities. At present, a newly designed and developed 40kW non-transferred arc plasma torch is being tested and it is proposed to develop high power torches using the results of numerical simulations of the torch. In this connection, a numerical model of the plasma torch is developed to predict temperature and velocity fields of the plasma inside the torch and electro-thermal efficiency of torch. The design and operating conditions of the 40kW plasma torch are used as input parameters for modeling. The commercial software's

GAMBIT and FLUENT are used to generate 3D computational domain and to solve the set of governing equations respectively. Simulations are carried out for different gas flow rates of nitrogen, and arc currents. The measured electro-thermal efficiency and arc voltage are used to validate the numerical model. The simulation results will be used to modify the torch design to develop high power torch with higher electro-thermal efficiency.

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CM19

Particle in Cell Modeling using XOOPIC to interpret the Experimental Results Of The Axial Virtual Cathode Oscillator (VIRCATOR) Driven By The Compact Pulsed Power Source

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Abstract

The VIRCATOR has found some basic physics related applications in recent past where the high power microwave (HPM) interaction in various media including plasmas need to be studies. HPM generating device like Vircator can be coupled to desired loads for such applications. An axial Virtual Cathode Oscillator was previously reported [1] to be driven by a solid dielectric pulse forming line and a compact pulse transformer which uses its capacitor bank in the shape of its primary. The experimental results of such VIRCATOR have shown a frequency pattern which consists of a low frequency as well as high frequency components when the Fast Fourier Transformation of the radiated microwaves was done. In order to validate the experimental results and to see the propagation of low frequency components through the

drift tube of VIRCATOR a particle in cell modeling of VIRCATOR at the nearly experimental operating voltage was done. The modeling was done on the XOOPIC [2] code, a two and half dimensional particle in cell code freely available in public domain, modified to incorporate VIRCATOR physics [3]. After incorporating the modifications in the code the modeling results of the VIRCATOR were validated with the published results and were found to be matching to a good extent. Interestingly the modeling results of the experiment are very consistent with the experimentally found results. The frequency in the computational results was determined by recording the poynting flux of the radiating port at every computational time step and then the signal was processed numerically to give the Fast Fourier Transform. As the Poynting vector provided the information about the power radiated from the VIRCATOR radiating port, the resultant FFT of the signal has double the frequency of the radiated electric field and hence the FFT scale was halved in order to find the frequency of the radiated output field. The computational results show that the frequency of the observed radiation is nearly matching with the observed frequency exceeding 7GHz.

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CM20

CM21

Study Of Thermal, Fluid Dynamic And Active Species Characteristics Of DC Segmented Electrode Arc Plasma Torches

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Abstract

DC arc plasma jets serve as the key component for numerous industrial applications like spraying, welding, cutting, melting, waste processing, synthesis of new materials, nano-synthesis, chemical conversion etc. For device developments point of view it is very important to know the thermal, electromagnetic, fluid dynamic and species field distribution inside the devices. It is a combination of all these quantities that finally determines the ultimate thermal, physical and chemical properties of the plasma jet emerging out from the device and used in a processing work. However, complete mapping all these parameters experimentally inside the device is not possible due to mechanical obstructions posed by the electrodes themselves. The only way out is appropriate numerical simulation of the device with proper boundary conditions.

The present study concentrates on numerical simulation of a segmented electrode DC plasma torch having seven segments, operating with nitrogen as plasma gas in the current range of 150A to 800A. Under two-temperature consideration the system is described by usual Navier-Stokes equations with source terms appropriately modified by electrically conducting nature of the plasma and the associated electromagnetic body forces. The energy equation is split into two parts: one for electrons and the other for the rest of the particles in the system. A finite volume code [1] in combination with a two-temperature property routine [2] solves the region inside the torch with appropriate boundary conditions. A SIMPLE like algorithm solves the associated Navier-Stokes equations in association with a property routine. Thermodynamic properties are determined considering all electronic, rotational and vibrational energy levels of nitrogen under two-temperature consideration. Chapman –Enskog approach is used to determine the associated transport properties.

Results obtained in the study depend on operating conditions together with degree of thermal non-equilibrium present in various zones of the system. Chemical non-equilibrium is not included in the study. Distribution of electron temperature, heavy species temperature, fluid dynamic flow field, molecular, atomic and ionic species, electric potential, current density and fluid pressure are studied under different operating conditions. Effects of different diameter of the plasma channel and shape of the nozzles are included in the scope of the study. Results obtained are discussed with a focus on the specific requirements in different application areas.

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CM22

Fluid Simulation Of Electrostatic Sheath With Negatively Charged Dust

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Abstract

One dimensional fluid simulation is performed to study the plasma sheath in presence of negatively charged dust particles. Due to the higher thermal speed of electrons under typical laboratory conditions dust particles receive more numbers of electrons and in such a situation one can consider dust particles as negatively charged. The potential profile of sheath and density profile of plasma particles inside the sheath are studied. The effect of dominant forces like ion drag

force and the electric force on the sheath structure are highlighted. However, the effect of gravitational force is neglected.

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CM23
1-D PIC Simulation of Finite-size Transient Photoplasma

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Abstract

A 1-D particle-in-cell (PIC) model has been developed to study the evolution of a finite-size laser produced transient photoplasma in electrostatic field. The photoplasma is created in between two parallel plates with vacuum boundaries on both sides. The photoplasma is replaced by smaller number of super-particles representing both ions and electrons. The computational volume (linear box in one dimension) is discretized into spatial meshes or grids by sets of uniformly spaced points. The charge densities at mesh points are calculated from the particle's positions by applying linear weighting scheme between adjacent points. The Poisson equation is solved using Gauss-Sheidal technique. The forces on the particles are calculated using the Lorentz equation. The velocity and position of particles are estimated by solving Newton's equation of motion using leap-frog method. The iterative execution of the above steps self-consistently calculates the electric field and describes the evolution of photoplasma. The electrons generated by photoionization of atoms are mono-energetic and they are thermalised by e-e collision. The plasma attains a constant potential (~anode potential) within a few cycle of plasma oscillation. The sheath of ions is formed between cathode plate and plasma boundary. The sheath boundary moves accordingly to balance the Child Langmuir current flux. As density decreases with time, plasma is unable to shield the external applied potential and hence behaves like single charge particles. The details will be discussed in the paper.

CM24

Simulation of High Power Microwave Source – a Vircator for SYMPLE.

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Abstract

SYMPLE (SYstem for Microwave and PLasma Experiments) is an experimental system already developed at IPR in order to investigate the nonlinear absorption of very high power (1-3 GW, f_m ~ 2-10 GHz, t_m ~ 15 ~ ns) microwave (HPM) in an overdense plasma (plasma frequency f_p > microwave frequency f_m). Here, the HPM source is a Virtual cathode Oscillator (VIRCATOR). Initial passive tests as well as diode detector measurements on the VIRCATOR presently developed have confirmed the microwave generation. Detailed characterization is under way.

In order to gather a deeper insight to the physical mechanism governing of the microwave generation in this nonlinear HPM device, simulation studies using a Numerical tool called MAGIC is taken up. Using this tool we are able to find out the expected frequency and power of the microwaves generated from the VIRCATOR. The initial phase of the simulation study shows the expected dominant frequency ~ 8.4 GHz and power ~ 25 MW. The EM field distribution in the device indicates possibility of TM mode excitation. A detailed analysis of the influence of various critical design parameters of the system on the output characteristics is presently being carried out. Important observations made till date on the expected HPM output, using the simulation studies is reported here.

Acknowledgement: We acknowledge Dr V. V. P. Singh, Dr. L.M. Joshi & Dr. S.N. Joshi of CEERI, Pilani for allowing us to use their MGIC tool facility for simulation.

CM25

Computational Fluid Dynamic and Magneto Hydro Dynamic Simulations Of The Transferred Arc Torch Based Nanoparticle Production System

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Abstract:

In recent years, new and advanced applications like, arc generation of novel nanostructures has been of great interest due to their bulk generation capacities. To produce inter-metallic nanopowders, two plasma torches have been used to evaporate two different metals. These metal vapors mix with each other and flows with the plasma gas. As the plasma gas cools, condensation of metal vapors results in formation of inter metallic nanoparticles. This paper reports the results of CFD simulations of plasma arc based system used for nano-synthesis of oxide products in our laboratories. The system is a cylindrical chamber with two transferred arc torches mounted on opposide side of the chamber. Two different metals ingots are placed below these torches. These two ingots acts as anode for the two torches. Metal evaporated from the two ingots and the plasma gas flows through a quartz tube placed along the axis the chamber. Walls of the tube are heated and temperature is controlled using a temperature controller. Particles are formed inside the quartz tube and collected at the water cooled dome located at the top of the chamber. For controled formation of nanoparticles, it is important that plasma gas flows through the quartz tube and is not diverted towards the walls of the chamber. Flow near the zone of interest is not only driven by thermal gradients, but also by the presence of electromagnetic forces resulting

from high current electrical arcs. Thus both CFD and MHD equations must be solved to arrive at the currect understanding of the flow behavior. The Flow and heat transfer in the reactor have been simulated using a CFD solver. MHD equations are solved by writing the User Defined Functions and coupling them with CFD solver. Argon is used as plasma gas and treated as an ideal gas. Variation in transport and thermal properties of the argon with temperatture was taken from [1]. Radiation loss is accounted using net emmision coefficient method. Emmision coefficint of the argon are taken from [2]. Value of electrical current was specified at the torch cathode. Base of the metal ingot was speecified zero voltage. The electrical and thermal coupling between anode and the arc was achieved using equation (1) and (2). Figure (1) and Figure (2) shows the computed profiles of current density and temperature.

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CM26

Computational Studies Of The Effect Of Power Variation On Velocities Of The Particles In The Single Wire Arc Spray System

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Abstract

Plasma spray is commonly used to develop corrosion and wear resistant coatings. In a Single Wire Arc Spray System (SWAPS) a wire is continuously fed into the plasma. SWAPS torch is a transferred arc torch in which high current arc is sustained between a continuously fed metal wire and cathode of the torch.The wire is consumed by the arc and is converted into micron size molten particles. These molten particles are carried by the high velocity plasma gas and bombard on the substrate to be coated. It is important to have an estimate and control over the velocities of the generated particles. Fast photography techniques have been used to determine the velocity of the particles in a SWAPS system [1]. It was observed that particles that are generated at different time are having different velocities. It was also observed that electrical power fed into the SWAP system varies due to variation in main electrical supply line. In this paper we have reported the computational fluid dynamic simulation of the SWAP system. The aim of the simulation is to establish the correlation between power variation of SWAP system and the particle velocities.

Electric arc was modeled as an equivalent heat source of 2 mm radius cylinder from the cathode to wire. Argon was taken as the carrier gas and treated as ideal gas. Variation in transport and thermal properties of argon with temperature was taken from [2]. Radiation transport was solved using Discrete Transfer Radiation Model. Gray model was used for the values of radiation absorption coefficient. Temperature variation of radiation absorption coefficient was taken from [3]. Particles were treated as inert and the particle fluid coupling was assumed to be one way. Particles of size 100 µm and 200 µm were considered. Power cycle was assumed to vary with a time period of 20 ms. Computation were initially done to obtain a steady state solution at time t=0. Subsequently transient simulation was done for 30 millisecond second with a time step of 0.1 millisecond. Graph 1 shows the variation in computed values of axial velocity of gas with the distance from the torch nozzle. As can be seen, though in general the velocity of the gas increases with power, it can be different for the same power depending on whether the power is in up cycle or down cycle. This is due to the finite response time of the fluid dynamics to the variation in power. Graph 2 shows the variation in particle velocities as they move downstream. Particles were assumed to start from rest at a location of 5 mm from the torch nozzle. It is evident from the graph that particles emanating at different time will have significantly different velocities.

CM27

Simulation Of Pyrolysis Of Wood In Thermal Plasma Torch Based Plasma Pyrolyser

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Abstract:

With rapid urbanization of population, management of waste has become important. Pyrolysis of waste materials has been suggested as an energy efficient and clean alternative method to handle these waste materials. A high temperature, chemically clean environment is required for pyrolysis. Several pyrolysis reactors have been designed using thermal plasma torches as a heat source for the reactor. Efficient use of the energy and creation of a controlled temperature field inside the reactor are among the most important issues related to a reactor design. Computational Fluid Dynamic simulations can play an important role towards evolving an efficient design of the reactor. In this paper we have presented the work related to CFD simulations of a pyrolyser. The pyrolyser is L-shaped reactor with rectangular cross section. Two plasma torches are mounted on the horizontal arm of the reactor. The waste is introduced from the top. The waste passes through a differential zone enabling it to go through various stages of waste treatment including pyrolysis. Simulation of the reactor was done using commercial CFD solver. Air was taken as the carrier gas and treated as ideal gas. Temperature and mass flow rates of the gas were specified at the torch outlet. Variation in transport and thermal properties of argon with temperature was taken from [1]. Radiation transport was solved using Discrete Transfer Radiation Model. Gray model was used for the values of radiation absorption coefficient. Temperature variation of radiation absorption coefficient was taken from [2]. Waste is introduced in form of spherical wood particles. Particles were treated as devolatizing and combusting particles. Species resulting from wood pyrolysis are given in table 1. Particle fluid coupling was assumed to be two way. Pyrolysis is modeled through a decomposition reaction (1).

$$\text{Wood} \qquad 4CO_2 + CH_4 + 4CO + H_2 \qquad (1)$$

Wood particles first go through devolatization in the lower temperature zone and pyrolysis takes place as they pass through a zone of higher temperature. Simulations have been done for 60lpm flow rate of plasma gas (air) and at 20kw torch power. We have presented the profiles of temperature, velocity, mass fraction of wood and pyrolysis products. Figure 2 shows the temperature distribution of plasma gas in the flow field. As air flows further the system, its temperature goes on reducing uniformly. However, temperature drops abruptly in the region where pyrolysis of wood takes place.

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CM28

Analysis of 3-Dimensional Characteristics of Simulated Scrape-Off Layer Plasma Transport in Tokamak Adiya

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Abstract

The scrape-off layer (SOL) region of the plasma in tokamak Aditya, limited by a poloidal ring limiter, shows characteristics including, considerable variations in distributions of flow velocity and parameters of plasma in all 3-dimensions, and temporal fluctuations that respond to stimulus, like an external gas-puff which was recently observed to suppress the fluctuations in plasma floating potential [1]. Since the experimental observations remain limited to probe measurements at a few spatial locations, recently, complete 3D simulations of the SOL plasma transport were done using the code EMC3-Eirene revealing interesting 3D flow pattern and parameter distribution of the SOL plasma in the device. We have analyzed the simulation data further to estimate the impact of the 3D gradients on the plasma equilibrium and their correlations with spatiotemporal fluctuations measured in the device. Current perturbations capable of affecting the plasma equilibrium have been estimated.

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NF01

Design of Magnetic Focusing System for 0.26 THz Sheet Beam Traveling Wave Tube

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Abstract

Sheet beam TWTs have been emerging for generation of high power terahertz radiation[1]. However, stable transport of sheet electron beam is the main issue due to diocotron instability and edge effect which arises due to E×B/B2 velocity drift, where E is space charge field and B is applied axial magnetic field[2, 3, 4]. Recently it is shown by us that closed short PCM can be suitable for stable transport of terahertz sheet beam[5]. This paper describes the design of suitable closed short PCM to transport sheet beam suitable for 0.26 THz sheet beam TWT which can be used for DNP NMR applications. For this purpose beam of size 2 mm(width)×0.1 mm(height), current density 100 A/cm2, kinetic energy 12 keV can be suitable. Matching of horizontal component of space charge field and magnetic force in horizontal direction shows that magnetic period should kept possibly minimum to provide suitable vertical focusing. Aspect ratio of magnetic tunnel should kept at two to provide suitable vertical magnetic force. Numerical analysis using CST Particle studio and OPERA 3D shows that closed short PCM with magnetic period 3.4 mm, magnetic tunnel size 6.2 mm×3 mm, transverse thickness of magnets 25 mm, axial thickness 1 mm can be suitable to transport aforementioned sheet beam. Simulated value of magnetic field is which is 0.15 T which is slightly greater than theoretically required magnetic field. Numerical analysis by CST Particle studio shows that aforementioned sheet beam transports upto 100 mm distance through suitable ridged wave guide type interaction structure under magnetic tunnel of aforementioned closed short PCM without any instability.

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NF02

Design of 84 GHz, 500 kW Gyrotron for ECRH Application

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Abstract

The gyrotron is a high power, high frequency (millimeter/sub-millimeter wave range) vacuum device based on the phenomenon called Cyclotron Resonance Maser (CRM) instability. The electron Cyclotron Resonance Heating (ECRH) in magnetically confined plasma fusion requires the high power gyrotrons operate at different frequencies like 170 GHz,

140 GHz, 110 GHz, 84 GHz, 42 GHz, etc. 84 GHz is used as the ECRH frequency in various tokamak systems including Indian tokamak SST-1. In this paper, the design of 84 GHz, 500 kW gyrotron is presented for the ECRH application. The design and numerical simulation of the 84 GHz gyrotron are performed for first harmonic operation. The operating mode selection is performed considering the various mode selection parameters such as voltage depression, ohmic wall loading, start oscillation current, etc. TE10,4 is selected as the operating mode after the rigorous analysis of several TE modes. Then the interaction cavity geometrical parameters are optimized on the basis of cold cavity simulations and Q factor calculation. The Start Oscillation Current (SOC) study is performed for the operating mode to analyze the mode competition with the neighboring modes. The electron beam parameters are optimized in the beam-wave interaction simulations using Particle-in-Cell (PIC) code MAGIC. The triode-type magnetron injection gun with the accelerating voltage 70 kV, the beam current 10 A and the maximum transverse velocity spread less than 5% is designed. The initial gun parameters, namely, the cathode radius (rc), the cathode-modulating anode spacing (dac), the emitter current density (Jc), the electric field at the cathode (Ec), the cathode angle (ϕc), etc. have been obtained from the analytical trade-off equations. The commercially available code EGUN is used for the design optimization of the electron gun. The beam tunnel connects the electron beam source with the interaction cavity and designed specifically considering the maximum absorption of backward RF and suppression of spurious modes during the electron beam transportation. CST-Microwave Studio is used in the S matrix analysis of beam tunnel. To enhance the overall efficiency of gyrotron tube, depressed collector is designed considering the maximum spreading of the electron beam. Plasma Assisted Chemical Vapor Deposition (PACVD) diamond material is used in the designing of RF window. PACVD diamond material is the best choice for high power microwave tubes due to excellent thermo-mechanical and dielectric properties. The design results confirm more than 500 kW of output power at 84.5 GHz of operating frequency.

NF03

Design Study of 170 GHz, 1 MW Gyrotron for Electron Cyclotron Resonance Heating in Plasma Fusion

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Abstract

Considering the increasing demand of energy and the regular depletion of the conventional energy sources, the research work on the various novel renewable energy sources is going on worldwide intensively. Among the various renewable energy sources, the energy generation by plasma fusion is getting popularity due to its various advantages over conventional and non-conventional energy sources. Various research groups including IPR Gandhinagar are involved in the research in the feasibility of efficient energy generation by magnetically confined nuclear plasma. International Thermonuclear Experimental Reactor is an international effort in the direction of energy generation by plasma fusion. The similar effort has also been initiated in India on the name of ITER India. 170 GHz is considered the electron cyclotron resonance heating (ECRH) frequency for ITER and total 24 MW power will be pumped into the plasma chamber to heat it up to the fusion reaction level. Gyrotron oscillators are the only device at present which are capable to deliver MW RF power in the millimeter wave band and thus are used as the RF power source in almost all plasma fusion reactors including ITER. Considering the importance of 170 GHz frequency, the design of gyrotron oscillator at this frequency with 1 MW or more RF power is performed and presented in this paper.

The design work is started with the high order mode selection and in-house developed code GCOMS is used in mode selection. TE34,10 is finally selected as the operating mode and the interaction cavity dimensions and electron beam launching position are calculated on the basis of selected operating mode. Particle-in Cell (PIC) code is used further to optimize the electron beam parameters, RF power and frequency. On the basis of the optimized electron beam (beam

voltage=80 kV, Beam current=40 A) and interaction cavity geometrical (Cavity radius=21 mm, cavity length=13 mm) parameters, the triode type Magnetron Injection Gun (MIG) is designed. The commercially available trajectory code EGUN as well as indigenously developed codes MIGSYN and MIGANS are used in the MIG designing. The designed MIG delivers 3.2 MW beam power with electron beam ratio (α) of 1.35 and velocity spread of 3.28 %. The design of MIG is also validated with another code CST-Particle Studio. Further, the electron beam collector and RF widow are designed considering the 1 MW RF power and 170 GHz frequency. Depressed type of electron beam collector is designed to enhance the overall efficiency of the device. The CVD diamond material is considered in the window design due to its excellent thermo-mechanical and dielectric properties. The design of the gyrotron oscillators shows 1.17 MW RF power at 170.03 GHz frequency with more than 50 % efficiency including collector efficiency.

NF04

Non-Linear Design Code for Gyrotron Oscillators

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Abstract

Gyrotron is a vacuum based microwave generation device based on the phenomena called CRM (Cyclotron Resonance Maser) instability occurred during the beam-wave interaction. At present, gyrotron is a signature device for ECRH in magnetically confined plasma fusion. Several electromagnetic design tools based on the various types of numerical algorithms are used in the design of gyrotron oscillators. The commercially available design tools are very generalized and non specific for the gyrotron oscillators. The exclusive design codes for the gyrotron oscillators are developed by various research groups and not available commercially. Considering the unavailability of specific design tools for gyrotron, the development of design code for gyrotron interaction cavity is started. Initially, the single mode code is developed, in which, mode selection, cold cavity analysis and beam-wave interaction efficiency computation are included. Initially, the velocity spread in the electron beam is not included in the calculations due to the sake of simplicity. In the next phase, the multimode code will be developed considering the electron beam velocity spread also.
The gyrotron theory is well developed and described by many researchers in different ways. The theory developed by Fliflet et al, Denly et al, Borie et al, Nusinovich et al, etc are used in the development of design code for interaction cavity. Various numerical techniques such as Numerov method, Runge Kutta method, etc are implemented for the solution of coupled differential equations and integration. The developed code is implemented in the design of interaction cavity and efficiency computation for two gyrotrons namely 42 GHz, 200 kW and 95 GHz, 100 kW. The obtained results from the developed code for these two gyrotrons are further compared with the commercially available PIC code MAGIC and the design data of interaction cavity for these two gyrotrons available in literature. The results obtained from the developed code show good similarity with the PIC code and the design data available in literature.

NF05

Indigenous Development of Compact Neutron Generator

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Abstract

In recent years, due to specific features of compact neutron generators, their demand in elemental analysis, detection of the illicit materials, characterization of materials related to fusion grade devices has been increased in scientific community. Compact in size, controlled operation and radiation safety like features of neutron generator is suitable for research work with illicit materials. An accelerator based neutron generator can be operated in steady mode as well as in pulse mode. The main embodiment of this type of generator includes ion source, ion acceleration system and target. We are developing such type of neutron generator. This consists of one in-house developed penning ion source, a single electrode acceleration gap and one deuteriated titanium target or virgin titanium target. The neutron generator was operated at 80 KV acceleration potential, a deuterium pressure of 0.1 mtorr and ion source potential at 1 KV. The neutron generation was confirmed by the solid state nuclear track detector CR-39. In this presentation, we will discuss various physics and technical issues related to the important components of this generator, operation of the generator, production and detection of neutrons.

NF06

Molybdenum Limiter for Aditya Tokamak

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Abstract

Limiter protects vessel wall surface exposed to tokamak plasma. The hot plasma interacts with the inside vessel wall which may introduce impurities and also get damaged. The limiter controls impurity generation due to plasma wall interaction. ADITYA Tokamak is a medium size ohmically heated tokamak. Aditya has a set of three types of limiters (i) Safety limiters (ii) a Poloidal limiter and (iii) a set of Movable limiters. The safety limiter protects the vacuum vessel and the assemblies mounted in the vacuum vessel, while the poloidal and movable limiters function as the working limiters. The poloidal limiter is the working limiters in Aditya, which is subjected to very high particle loads (1024 m-2s-1) and heat ux (6 MWm-2) during the discharge. Aditya limiters are made of shaped carbon tiles fixed on stainless steel base plates. Aditya discharges of 50 to 75 kamp and 100 to 200 millisec are achieved successfully. During the discharges, carbon impurities are observed. It is well known that the reduction in impurities helps to improve the plasma discharges. In order to reduce carbon impurities in Aditya tokamak, we decided to get rid o the graphite limiter. We have designed new poloidal limiter with molybdenum tiles. The design of the new molybdenum for Aditya Tokamak is presented here.

NF07

Wire Burn Test of Multi Mega watt Regulated High Voltage Power Supply for NBI, LHCD and ECRH

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Abstract

This paper discusses the wire burn test setup, experiment and its results of Multi Mega watt Regulated High Voltage Power Supply (RHVPS) for various plasma heating systems like NBI, LHCD and ECRH. Wire burn test is a validation test of power supply for the safe uses at RF and NB Loads. RF and NB Loads demands very low storage energy (10J) of power supply system. The conventional high power microwave tubes should be protected from arc fault. If the stored energy of the power supply is greater then some critical limit (10 J) of tube then it may damage the microwave tube. This test is performed prior to connect the actual load. The RHVPS with rating 80kV, 75A is design and developed for such critical RF and NB loads. This power supply has ability of deliver mega watts of power during the normal operation and store & deliver very low energy (<10J) during fault condition to protect the critical load like NB and RF loads.

To conduct the wire burn test ~10J energy wire is used as a load and successfully completed the wire burn test with full voltage rating up to 80kV. The power supply delivered <10J energy so load wire is intact after fault creation. On successful completion of test wire can be replaced with actual load.

NF08

Electronic Database Code Upgradation For ADITYA Experiments

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Abstract

Aditya is a medium size Tokamak (Ro = 0.75 m, a = 0.25 m) is operational since 1989 and nearly 25,000 numbers of shots have been fired till now. In order to keep track of such a large shots database, having varieties of operational as well as plasma parameters, and comparing them within a minimum possible time, an electronic database was developed in 2003, using Matlab programming tool. Sufficiently large numbers of plasma parameters as well as some of the control parameters (input) were chosen for comparing shots and they were recorded in a file. While using this database over a period of time, we realized some of the shortcomings of the database software. The major problems were identified as (i) any change in physical channel number for particular signal would require change in the software program (ii) change in hardware, such as amplifier gain would again require change in the program etc. In order to eliminate those problems and make the software more reliable, efficient and user friendly, we have recently modified the code by (i) introducing logical channel number instead of earlier physical channel number to avoid any problem related to change in digitizer or channel of a particular signal (ii) replacing constant values, used for some important input parameters as well as calibration factors with variables to improve performance and flexibility. In addition to that recently shot to shot information regarding calculated value of edge safety factor (q) was also introduced in the electronic database. The input parameters of edge safety factor like minor and major radius of the plasma was obtained from plasma position measurements. The modified program has been successfully tested for comparing a large number Aditya discharges for various plasma parameters such as maximum plasma current, duration, flat-top plasma duration, average loop voltage at Ip flat-top, plasma resistance during flat-top, minimum edge safety factor (q), hard X-ray status according to their energy level etc for particular shot. The details of the program development, testing procedure and finally comparison list for some Aditya discharges will be presented in this work.

NF09

A Comparative Study of Ion Trajectories between a Two and Three Electrode System of a Positive Ion Source

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Abstract

We present here a comparative study of two types of ion extraction system namely a two Electrode (diode) and a three Electrode (Triode) for a slit grid type +ve ion Source. Two electrodes system is consists of two grids (electrodes) first is acceleration grid which is positively biased (with +V) and other is earth grid (with V=0). The three electrode system consists of three grids, a third grid which is placed between acceleration and earth grid. This grid is known as suppressor grid which is negatively biased (with –V) with the reference of earth grid. The placement of this grid substantially improves the focusing property of the electrostatic lens system. This helps in suppression of secondary electrons that are produced between earth grid and plasma box of ion source this suppression compensate for the space charge and thereby reduce angular divergence of the beam. We present the results of a simulation study carried out by an ion trajectories simulation code.

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NF10

Effect of 30keV Deuterium Ion Beam onto Pulsed Laser Deposited Rh/W/Cu Multilayer

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Abstract

Thin films of heavy metals of Rh, W, Mo, Cu have been looked upon as a simple alternative for the first mirror (FM) application in the optical diagnostic of a fusion device. The durability of these thin film FM can be enhanced by depositing the the multilayers of these mirrors in proper sequence. In the present paper, the effect of 30keV deuterium ion beam on multilayer Rh/W/Cu mirror like thin film is reported. The multilayer thin film was fabricated on to a polished SS substrate via pulsed laser deposition technique. The UV-visible and FIR reflectivity was measured before and after irradiation of D ions. It was observed that rms surface roughness changed from 12 nm to 15nm after irradiation. The post irradiation changes in the UV-visible and FIR reflectivities were 3% and 1% respectively. The FIR spectrum showed a broad peak at 15μm corresponding to the scissor vibration mode of D-D confirming the implantation of D ions into the film during irradiation of D ion beam. The details shall be discussed during the conference.

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NF11

Preliminary Fusion Reactor Performance Analysis For The Radial Build-up Of Reactor Components

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Abstract

Fusion reactor involves major components like breeding and shielding blankets, plasma facing components, superconducting magnetic coils and vacuum vessel. The choice of concepts for these components and materials will decide the performance of any fusion reactor. Fusion reactors can be built to provide facility for fulfilling various objective or a set of objectives such as testing materials, evaluation of components performance under irradiation, study of issues related to burning plasma, fuel cycle, etc.. The objectives of fusion reactor will decide the choice of particular design. In this work, a study on the preliminary design of self-sufficient fusion power reactor with D-T plasma and tritium breeding blanket will be carried out. In particular, it is planned to consider various concepts and materials for the reactor components as well as to vary choices of plasma parameters like aspect ratio, safety factor, operational density, fusion power, etc. A one dimensional physics and neutronic analysis is carried out for a set of obtained sizes of reactor components using engineering constraints.

The study has been carried out with main objectives of obtaining attractive Tritium Breeding Ratio (TBR) along with the protection of Vacuum Vessel and TF magnet from radiation. The radial build-up obtained by this study will ensure these objectives. The Vacuum Vessel and shield will be made of water and SS-316. Nb3Sn and other possible materials will be assumed as candidates for material of TF coils. The different concepts for breeding blankets will be considered. This study will be carried out based on the cylindrical model of the reactor's preliminary radial build-up. Intersection of cylinders will define the different zones of the fusion reactor. The widely used radiation transport tool and nuclear cross-section data library is used to calculate the TBR, gas production in Vacuum Vessel, peak nuclear power density in TF coil and dpa in the coil. Several design iteration by changing the various zone thickness, shielding material composition, Li-6 enrichment will be carried out. This will allow the optimization of the radial buildup of machine so that TBR is adequate and Vacuum Vessel and TF coils are safe for the reactor operation. The performance of having solid breeder at the inboard side and other breeding concepts like LLCB (liquid and solid breeder placed side by side) at outboard side will also be evaluated. The main results of this design study will be presented in this paper.

NF12

Pratibha Gupta

NF13

Conceptual Evaluation of Digital Integration using DSP for SST-1 Plasma Position Control System

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Abstract

Magnetic probes are used for estimating the position of plasma column within vessel. Plasma position control [PCS] algorithm running on a DSP will use this data from the position probes and calculate the required actuation signal for the power supply of PF coils to restore the position of plasma column. SST-1 PCS system will be using 48 position probes arranged in pair around the plasma to measure tangential and normal component of magnetic field. The pickup signal in this position probes are derivative of magnetic field, so to get magnetic field it requires to do a numerical integration of this position probes signals. Various methods for integrations of magnetic coil signals are studied for this application and considering the limitation and advantages of each; digital integration method is selected for the SST-1 PCS application. This paper will present the details of the Hardware implementation and the results showing the performance of the DSP based digital integrator for the position probes signals. For measuring plasma current rogowski coils will be used on SST-1. Rogowski coil signal also need numerical integration to get the plasma current. So in this existing setup rogowski coil signal were also used to test the digital integration. In final implementation the tested digital integration will be a part of the PCS algorithm running on DSP, so the existing PCS hardware is used to test the concept of digital integration. PCS hardware is consist of PMC based DSP module which sits on the VME SBC's PMC site. The other PMC site of VME SBC is occupied by RFM module used for communicating the control signals to the PF coil power supply. Magnetic probe signals will be digitized by Pentk6802 ADC card which is 32 channels simultaneously sampling ADC. For 96 channels three such cards will be used. Digitized data from ADC is transferred over FPDP interface from ADC to DSP. DSP is using this data for doing the digital integration and transfer the raw data along with the digitized data using the RFM card to the other VME machine with SCSI Hard disk, where it will be stored on SCSI Hard disk.

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NF14

Simulation of Wire-Burn Test On 30kV, 600kW DC Power Supply for High Power RF Generators Using Tetrodes

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Abstract

The experimental activities of IPR involve development of High Power RF and Microwave sources for fusion related heating and current drive applications. High power RF tubes like Triode, Tetrode, Klystron and Gyrotron are in general operated with High Voltage DC power supplies. These HVDC power supplies must be equipped with necessary arc fault protection in addition to over-current and over-voltage protections.

The arc fault protection must act with-in few micro seconds to prevent permanent damage to the RF tube. When an arc fault is detected, in order to protect the load, output voltage of the DC power supply is short circuited using a crowbar device (generally Ignitron, Thyratron, thyristor, rail-gap etc.) that operates in few microseconds. This diverts the fault current from the load to crowbar device, thereby protecting the load. This is necessary as conventional protection in the power supply input takes ~100mSec to switch-off. The crowbar device must be able to take the fault current till the circuit breaker, placed at power supply input, is switched off.

A 30kV, 600kW DC power supply is used for the high power tetrode operation at 91.2 MHz, for Ion Cyclotron Resonance Heating experiments. The arc fault protection is tested for its effectiveness by "wire-burn" test at various voltages up to 15kV.

Full power short circuit of 600kW DC power supply puts enormous stress on the power supply, utility and the crowbar, therefore frequent wire-burn testing is to be avoided. A simulation model is developed using PSIM software to reproduce the results obtained during wire-burn test conducted up to 15kV. The same is also used for predicting the results of the test at 27 kV, as required for the next stage amplifier. The results would be useful for optimization of the component values without conducting actual wire-burn test.

NF15

Development Of Hydrogen Isotopes Recovery System Using Gas Adsorption Method For Tritium Extraction System Of LLCB-TBM

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Abstract

In the Nuclear fusion technology, the most challenging part in the design of the fuel cycle lies in the proper recovery and purification of tritium before being sent back to the fusion reactor. Test Blanket Modules (TBM) developed by different countries would breed tritium, which has to be recovered. Indian Lead Lithium Cooled Ceramic Breeder (LLCB) TBM would extract tritium in two steps – removal of tritiated water through Atmospheric Molecular Sieve Bed (AMSB) adsorption and recovery of hydrogen isotopes through Cryogenic Molecular Sieve Bed (CMSB) adsorption. So, the proper process design of subsystems in Tritium Extraction System becomes important for maintaining fuel cycle self-sufficiency and safety.

Tritium extracted from the breeder zones of LLCB TBM is loaded with impurities like H2O, O2, N2 along with tritium in combined form as HT, HTO, DT, T2O. It is necessary to remove all the impurities from tritium and recover tritium from its isotopes before it is refueled back to the reactor. A prototype hydrogen isotopes recovery system is being developed to validate theoretical design concepts for tritium extraction by both pressure swing and temperature swing adsorption methods.

This paper would discuss the conceptual design of the hydrogen isotopes recovery system.

NF16

Permeation Calculations for A Hydrogen Isotopes Sensor in Liquid Lead-Lithium

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Abstract

In the Lead Lithium cooled Ceramic Breeder (LLCB) Test Blanket Module (TBM) for ITER, correct and reliable management of tritium is of basic importance, both for safety and fuel cycle reason. In LLCB – TBM, Liquid PbLi is used as tritium breeder material in addition to its use as neutron multiplier and coolant. Tritium bred in liquid PbLi stream has to be recovered by Tritium Extraction System. Thus the need for a reliable sensor with quick response time for measurement of hydrogen isotope is evident.

A hydrogen isotope sensor is designed which utilizes permeation of hydrogen isotopes through the sensor material. This sensor can be considered as a hollow capsule permeable to hydrogen isotope, immersed in liquid PbLi where hydrogen isotope is dissolved at certain concentration in equilibrium with some pressure. Measurement of permeated gas pressure inside the capsule can be correlated with the concentration/ pressure of the hydrogen isotope dissolved in liquid PbLi.

This paper would discuss about the numerical calculations for the permeation considering hydrogen recombination on both surfaces and diffusion in the bulk. This calculation would be used for refining the conceptual design of the hydrogen isotopes sensor.

NF17

Yogesh Govind Yeole

NF18

Preparation Of High Power CW Klystron Test Bed

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Abstract

The multi-megawatt Lower Hybrid Current Drive (LHCD) system, designed to drive and sustain plasma current in Super-conducting Steady-state Tokamak-1 (SST1) for continuous wave (CW) operation is one of the most important and crucial system. The system is designed for 2MW CW of rf power at 3.7GHz, and is sourced by four high power CW klystrons, each rated for 500kW of rf power. Two additional klystrons have been recently procured to run LHCD system to its full capacity. Before putting these klystrons into the main system, the klystrons need to be tested in laboratory at the rated power for CW operation.

To carry out above task, a high power CW klystron test bed is prepared. One of the old klystron is installed and configured with various sub-systems. The sub-system mainly consists of auxiliary power supply system (like filament power supply, magnet power supply, anode modulator power supply, ion pump power supply, etc.), active thermal management system (like collector cooling, upper/lower body cooling, magnet cooling, waveguide system cooling, high

power water load cooling, etc.), pressurization system, fast protection system, slow protection system, data acquisition and control system, input rf system, etc.

After initial conditioning of the klystron, the tube is subjected to maximum cathode voltage (~65kV) and operated in diode mode for more than 1000 seconds. Typical beam current of ~19A is obtained during the diode mode testing. Since no rf power is extracted from the tube in diode mode, the entire electrical power is dissipated in the collector and the same is reflected in the temperature rise in the collector outlet water temperature. A train of rf pulse (50ms ON, 50 ms OFF) is given to the tube input and 500kW rf power is extracted from it in pulsed manner (50% duty cycle). In this case, the collector dissipation decreased, since substantial amount of rf power is extracted from the tube. Subsequently the water outlet temperature of water load increased. The successful operation of the tube establishes the test-bed capability for testing the newly procured klystrons.

This paper describes the experimental setup in detail and presents the experimental results obtained during this experimental campaign. It also highlights the challenges faced during this campaign. Further, it also focuses on the preparedness towards testing of newly procured klystrons for CW operation at rated power.

NF19

Klystron Operation At Rated Power With Regulated High Voltage Power Supply

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Abstract

The multi-megawatt Lower Hybrid Current Drive (LHCD) system, designed to drive and sustain plasma current in SST1 tokamak for continuous wave (CW) operation is sourced by several high power CW klystrons, each rated for 500kW of rf power at 3.7 GHz. Each of these klystrons typically operates at 65kV/20A and demands for 1.3MW of input DC power. In SST1 LHCD system, these klystrons would be powered and operated with a single 80kV/75A, multi-megawatt Regulated High Voltage Power supply (RHVPS). The LHCD system installed on ADITYA tokamak also gets rf power from similar klystron.

Recently, one of the klystron has been successfully configured and operated at maximum cathode voltage (65kV) with RHVPS for configurations, relevant for experiments on SST1 and ADITYA tokamak.. For above requirements, RHVPS is used for driving the klystron for short durations. The klystron system is actively cooled and connected to auxiliary power supplies, necessary for klystron operation. The klystron system is operated remotely by data acquisition and control system based on VME system. Data logger is used to monitor and acquire online cooling parameter. Waveguide system is pressurized with dry nitrogen to enhance its power handling capabilities and the same is monitored/acquired using data logger. After initial conditioning of the klystron, its operation with RHVPS is successfully demonstrated at ~65kV for about 300ms. A beam current of ~17A is drawn during loaded condition. Since the operation is pulsed in nature, no appreciable change in the outlet water temperature of the collector and water load is observed.

The experimental results obtained in the above experimental campaign is presented and discussed in this paper. The plan to operate more than one klystron with the same RHVPS is also discussed towards the preparation for achieving multi klystrons operation with single RHVPS.

NF20

Data Acquisition For Long Pulse High Power Operation Of Klystron Test Bed

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Abstract

The high power CW klystron test bed is a very complex system. It interfaces with several subsystems like high voltage power supply system, auxiliary power supply system, anode modulator power supply, active thermal management system, waveguide pressurization system, fast protection system, slow protection system, data acquisition and control system, input rf system, waveguide network system, etc. It is needless to iterate that the system demands for monitoring and acquisition of large channels of data. The streaming data not only gives the status of various signal but also stores data for post processing for further data analysis.

Normally, VME based data acquisition and control system is employed during operation of high power klystron test bed. However, for long pulse operation, where data is enormous, it is advisable to transfer some of the slow signals on another platform so as to off load burden from VME system, which may be used for more critical and fast signals.

In the present setup, all the cooling parameters have been transferred on APLAB data logger. It has 96 analog input channels (4-20mA signals), 16 analog input channels (0-5V), 4 analog output channels (0-5V), 16 digital input channels (PFC) and 4 Relay outputs. The data from the field is fed to the data logger. The datalogger is connected to PC through serial port interface and through this communication data is read and stored in file. A GUI based program is developed to display the streaming data. The streaming data for flow, temperature rise, etc. is manipulated to display the power dissipated in various sub-systems like collector, water loads, upper/lower body etc.

This paper describes the salient features of the developed GUI based software and its capabilities. It also discusses its application and importance in klystron test set-up, especially during long pulse operation.

NF21

ARC Detection And RF Inter-Lock For High Power Operation Of CW Klystron Test Bed

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Abstract

A new arc detection and RF interlock system for the LHCD system has been developed. The system is required to turn off the RF drive in the event of (1) arcing in the RF transmission line components, (2) Reflection in transmission line crosses the set limit (3) Air pressures within transmission line is below set limit and (4) transmission line cooling water flow is below set limit.

RF interlock system comprises of six numbers of infrared phototransistors signals, two numbers of AFT make arc detector units, two numbers of reflected power (analog signals) from RF detectors, one water cooling flow switch (for transmission line) and one transmission line pressures transducer. Infrared phototransistors are directly mounted on the RF transmission line, to see RF arcing light through a hole. Two arc signals are carried through optical fibers to AFT make arc detector unit and converted into open collector digital signals. After detection of any fault RF input drive is switched off in less than 5μs.

This paper describes the interlock system in detail and presents the experimental results obtained during klystron operation. It will also describe future improvements that can be done on present interlock system.

NF22

Testing of Water Dummy Load for CW High Power RF

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Abstract

High power rf dummy load forms the basic unit for high power CW klystron test bed. The klystron under test would dissipate power in the water load and its capability to handle the rated CW power needs to be established. These loads also find its application in high power circulators and power dividers which forms the basis for multi-megawatt Lower Hybrid Current Drive (LHCD) system, designed to drive and sustain plasma current in Super-conducting Steady-state Tokamak-1 (SST1) for continuous wave (CW) operation.

To meet the above requirements, a high power (250kW CW) rf water dummy load at frequency of 3.7GHz has been tested and calibrated with VNA for important rf parameters like VSWR (better than 1.1). Since the load is actively water

cooled therefore its coolant section and input/output coolant line is tested for water leaks with sufficient margin. Similarly the waveguide section is tested for gas leaks as this section would be pressurized up to 3 bar to improve its breakdown strength. After qualifying the cold tests, it is subjected to CW high power rf testing.

This paper describes the experimental setup in detail and presents the experimental results obtained during the high power testing of water dummy load followed by conclusions.

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NF23

Validation of various subsystems of Upgraded SST-1 Central control System (CCS)

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Abstract

The Central Control System (CCS) of Steady State Superconducting Tokamak (SST-1) is based upon distributed hierarchal control system. It consists of machine, experiment & discharge control, timing and a SAN (Storage Area Network) based centralized data storage system. CCS system controls and monitors various SST-1 subsystems like water-cooling, power supplies, cryogenics, vacuum, superconducting magnets and auxiliary-heating sources located remotely within the campus. All SST-1 subsystems and CCS are connected with a backbone of high-speed 24-core fiber optic network; the backbone contributes to the underlying network of Timing Signal network, Ethernet, GPS IRIG network, Safety Interlocks, Machine Audio-Vision network and Feed-back control network. The SST-1 control room is the place where all the activities like session announcement, machine control, experiment control, discharge control and monitoring is to be performed.

The CCS has been upgraded to cater the requirement of first plasma by strengthening its subsystems capability of dealing with any abnormal condition arising during the operation. With the up-gradation of CCS, the ability to monitor & control various SST-1 subsystems' health in terms of statuses & conditions from the control room has greatly improved. The improved capability means less down time and higher number of shots per operating cycle. Also upgraded CCS can helpful to diagnose system behaving abnormal and causing problems in machine operation. Various validations tests were carried out with all the components of CCS to prove it as stable & reliable. All the upgraded/modified and newly developed system (Time Synchronization System, Central Storage System, Machine Monitoring & Control System, Experiment Management System etc.) have undergone intensive rugged testing and honed to meet the desired results to the utmost expectations.

This paper discusses the validation test carried out & its results with the upgraded Central Control System components to cater the requirement of first plasma in SST-1.

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NF24

Temporal Measurement of Ion Flux Emitted at Different Filling Gas Pressures in a 4.7 kJ Plasma Focus Device

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Abstract

Plasma Focus (PF) device is a cost effective pulsed source of radiations like ions, electrons, soft and hard x-rays etc. and especially neutrons if deuterium is used. These pulsed sources of radiation find applications in various emerging fields like pulsed activation analysis, thin film deposition, lithography, micro-lithography etc. Emission of these radiations also

helps in understanding the dynamics of plasma focus. In our experiment, we have studied deuterium ion beam emission at different filling gas pressure in the range of 1-5 mbar. PF device has been developed in this division [1]. Capacitor bank consists of four single capacitors, each of 10.6 μF, 25 kV, 30 nH. We operated capacitor bank at 15 kV. An anti conical Faraday Cup has been designed to detect ion flux. Inner core of detector is of graphite to reduce secondary electron emission and outer core shield is of brass with Teflon separating inner and outer core. FC dimensions have been designed to give characteristic impedance of 50 Ω for impedance matching with co-axial cable through which output is taken. It is biased to -145 V to collect ions and kept at 220 mm from anode top. FC signals have been recorded oscilloscope at different pressures in the range of 1-5 mbar. In these Signals, two peaks have been observed corresponding to lower energy (eVs) and higher energy (tens of keVs to few MeVs) ions. Amplitude and FWHM of high energy ions peak decreases with increasing pressure. Lower energy ions flux seems to increase with increasing pressure. More energetic ions (tens of MeVs) are produced at lower pressure. This temporal study of deuterium ions with different filling gas pressures support the evidence of anomalous resistance in PF device [2]. This ion emission study could help in optimizing conditions for desired range of energy of ions. Work is in process for further investigation for finding correlation between ions and neutron emission with filling gas pressures at other operating voltages.

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NF25

Interfacing of VME Based Ohmic And VF Power Supply Control System With SST-1 Central Control System

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Abstract

SST-1 is having water cooled Ohmic and Vertical Field Coils. While the Ohmic transformer system is provided to initiate the plasma and sustain the current for initial period, a pair of vertical field coils is provided for circular plasma equilibrium at the startup stage of the plasma.

A VME based Power Supply Control System (PSCS) monitors and control the power supplies of the Ohmic Transformer (OT) and Vertical Field (VF) Coils of SST-1. The power supply for each of these coils receives an analog reference, updated at around 1ms interval. OT current is ramped up to a preset value and maintained flat for about 200ms. A command is sent to open Vacuum Circuit Breaker (VCB) through Digital Out (DO) channel and Digital In (DI) channel is polled to find out when VCB is open. Opening of VCB triggers a sequence of trigger pulses through the timer card

channels, which are used to fire-in a predetermined sequence to a set of ignitrons in the OT and VF circuits. When the VCB trigger-in signal received, two more analog out channels are used to issue references for the plasma current and a simulated plasma current. The control system not only generates the analog references but also passes commands to the power supply controllers through Digital In/Out (DIO) card and also detect the alarms. A Graphics User Interface (GUI) application running on Linux Host worked as operator console to set the references and to pass the commands to the power supply through VME.

This paper will present the programming of VME application and development of GUI in Tcl/Tk for the Linux Host machine, which provides the interfacing of the VME PSCS with Central Control System (Main Control System and Timing System). The selection of the Slave Mode option on the local host, enables the remote operation of the OT and VF Power Supplies from the Central Control System. In the remote mode operation all the references and the commands will be passed from MCS to the PSCS. The Timing System interface will enable the power supply to be synchronized with the other sub-systems and to start the discharge phase of OT, after getting Master Trigger from the Timing System.

NF26

Deepak Sangwan

NF27

Design of the Thermal Shielding & Routing of cryoline for cryopumps of SST-1 Neutral Beam Injection System

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Abstract

Cryopumps are used in SST-1 NBI system for handling high Hydrogen gas throughput of ~10-20 Torr.L/sec. This paper describes a newly developed concept of the thermal shield for the Liquid Helium transfer line using the Aluminum thermal anchoring blocks. The ANSYS CAE (Computer-Aided Engineering) software program was used in conjunction with 3D CAD (Computer-Aided Design) solid geometry to simulate the behavior of Temperature distribution under thermal loading conditions. Distance between the adjacent anchoring blocks has been simulated with the help of Ansys Software, considering thermally Steady state condition. Results of the simulation are validated with the analytical approach and optimized distance between the adjacent anchor blocks finalized.

NF28

Ram Niranjan

NF29

Sequence Detection And Display Electronics Card For The Analysis Of Fault Sequence In The RF-ICRH System

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Abstract

Sequence Detection and display Electronics card may be used as an essential part of the system having many critical fault signals and knowing the sequence order (in terms of time sequence) of the fault signal is necessary to prevent the systems damage. e.g. High power RF Accelerator, Triode, Tetrode tubes, where they have to operate with multi power supplies likes filament, control grid, screen grid, cooling, crow bar etc. The main purpose of this card is to monitor the correct time sequence order of the arrival of inputs at the channels and display the order number of the same.

Knowledge of the order of sub-system failure may be useful to make it safe and accident proof. Sequence order will help in identifying the first trigger fault, which causes the system collapse. Sometimes two or more fault signals come within the microsecond's interval, and it's very difficult to detect which of them initiated crowbar first. For that purpose this electronics card has been designed, developed and tested keeping following objectives.
Records the order sequence in which the fault signal comes to the respective channels.
The circuit is sensitive enough to be able to resolve the difference of two inputs timing difference of less than microseconds.

Once the hit of a channel is registered, that channel should disable automatically (Latch Features).
The circuit works both for TTL trigger mode and contact based (PFC signals).
A master Reset buttons reset the circuit for new round of the experiment.
Card support the features having to put LED displays away from the main board.
Number of input channels should be expandable from the present four channels (if needed), without disturbing any of the present channel and components (modular type).

This paper will discuss about design details, cards features, testing results and cards interfacing with ICRH system [1][2] in details.

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NF30

Design and development of a 3-db ultra wideband high Power hybrid coupler

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Abstract

A ultra-wideband 3-dB tandem high power hybrid coupler of 1.0MW, 72±40MHz has been designed for the ion cyclotron heating (ICRH) in Tokamak. The 3dB hybrid coupler divides the input power to output and coupled ports equally with 90° out of phase. This may be used as combiner or to protect the source by coupling of mismatched reflected power to the isolated port. It has very useful applications in the ICRH of plasma related experiments. The outputs of hybrid coupler can drive two antennae in the known phase or can be combined to drive one antenna whereas rf power output from one amplifier chain is not sufficient. The need has been felt to understand, design, optimize and indigenously develop the hybrid couplers for the plasma experiment. Initially, a 2.5kW, 91.2±15MHz, 3dB hybrid coupler is developed and tested for the satisfactory performance. This prototype is aimed to create concept and a process of indigenous fabrication.

The ion cyclotron resonance heating of plasma uses cwrf of 100kW onwards in the frequency range of 10 to 100MHz depending upon geometry of the tokamak and desired plasma parameters. Therefore, the up gradation of the developed prototype is required, in terms of power as well as in terms of frequency bandwidth. In addition to the requirement a novel ultra wideband 3±0.2dB hybrid coupler is indigenously designed at 72±40MHz for 1.0MW power handling capability. The designed model is simulated on HFSS and verified for satisfactory performance.

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NF31

Electronics for Quench Detection System of SST-1 TF Magnets

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Abstract

Steady State Superconducting Tokamak-1 (SST-1) at Institute for Plasma Research (IPR), India is now in engineering validation phase. Precision electronics has been developed for detection of quench phenomena in Toroidal field (TF) and poloidal field (PF) magnets of SST-1. This Quench Detection (QD) system continuously monitors the magnets and detects the initiation of normal zone during the magnet charging operation. Quench Detection system is an essential and integral part of any superconducting magnet system, since any irreversible off-normal scenario leading to the magnet quench must be promptly detected and the energy from the magnet must be extracted with equal promptness to protect the magnet within the defined dump time, avoiding thermal stresses in the winding pack.

An active fail proof electronics QD system is installed and is in operation for the detection of resistive transitions in any part of the SST-1 TF coils. The Difference Configuration Method has been adopted and exploited in the QD system for comparing the voltage drop measured in each of the double pancakes and inter-pancake joints of the TF coil. This paper describes the scheme of the QD system, precautions taken to ensure enhanced reliability and redundancy and validating test results from the recent experiments.

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NF32

Validation results of VME based Magnet Data Acquisition System for SST-1

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Abstract

The magnet system of the steady-state superconducting tokamak-1 at the Institute for Plasma Research, Gandhinagar, India, consists of sixteen Toroidal field and nine poloidal field Superconducting coils together with a pair of resistive PF coils, an air core ohmic transformer and a pair of vertical field coils. These coils are instrumented with various cryogenic grade sensors to monitor it's operating status and health during different operational scenarios like cryogenic cool down, current charging cycles including ramp up, flat top, plasma breakdown, dumping/ramp down and warm up. Total channel counts for sensor and voltage taps are more than 500. A VME based data acquisition system with remote system architecture is implemented for data acquisition and control of the complete magnet operation. Client-Server based architecture with VxWorks RTOS target application, a Tomcat apache based application server and a JAVA based client application is designed with remote hardware configuration and continuous online/ offline monitoring. A platform independent client application is used for data analysis and data plotting for monitoring purpose. The server has multiple data pipeline architecture to send data to storage database, online plotting application, Numerical display screen, and run time calculation. All the temperature sensor values are calculated for generating minimum, maximum and average temperature data for the cryogenic plant operation. This paper describes software architecture, implementation and it's validation results from the recent experimental campaign from SST-1.

NF34

Design And Development Of Prototype Of FPGA Based 8 Channel Fiber Optics Serial Data Link For Digital Signals

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Abstract

For addressing the R& D activities in area of Negative Neutral Beam Injector, in IPR, Negative Neutral Beam development program has been started. As a part of the program, three test -bed viz [1] ROBIN – development under IPR-IPP (Germany) license agreement, [2] Twin Source (TS) and [3] Indian Test Facility (IN-TF) has been planned. Out of the three, the ROBIN- a signal RF driver based 100 KW, 1 MHz negative ion source test-bed is already commissioned

and in operational stage. Subsequently, a Twin Source- an inductively coupled two RF driver based 180 kW, 1 MHz negative ion source experimental setup has been initiated with an objective of understanding the physics and technology of multi-driver coupling. Twin Source (TS) also provides an intermediate platform between operational ROBIN and eight RF drivers based Indian test facility IN-TF.

The Ion source and related sub-systems (viz. HV power supplies, Gas feed systems, diagnostics systems etc) of all the three test-bed will be floated at high potential (more than 50KV DC) during the beam operation phase; therefore, for interfacing of analog and digital signals of the ion source and HV referenced sub-systems to the Data Acquisition and Control System (DACS), mainly two types of fiber optics (FO) links would be required, depending upon the signal type i.e analog and digital. For catering these requirements, two types of fiber optics links have already been developed in-house, installed and tested in the ROBIN test-bed. These FO links have single channel or multi-channel parallel design because of which there is a large number of interfacing channels from sub-systems to DACS, and for each channel, a separate fiber cable, and transmitter and receiver circuit is required. This increases the complexity and cost. Further the analog signal FO link has limitation of low accuracy i.e 0.5 % only. To overcome this limitation and to reduce the complexity and cost, new in-house development of fiber optics links, based on digital communication technique and advanced FPGA technology has been started. As a part of the development, a prototype of FPGA based 8 channel fiber optics serial data link for digital signals, has been design and successfully tested.

The FO link comprises of transmitter module, receiver module, power supply module and fiber optics cable. Specialty of the link is that it can transmit 8 nos. TTL signals, having a bandwidth DC- 20 KHz, over 300 meter distance via single fiber cable. In the link eight digital signals are first encoded with proper encoding scheme and then converted to serial data. The serial data is framed in proper framing bits to transmit it over the single fiber optics (FO) cable. In the receiver, received data is first used to recover the clock by the clock recovery unit. The recovered clock is then used to generate the actual data from the received signal. The received data in synchronization with the recovered clock is first de-framed. This de-framed serial data is then converted to the parallel, and then decoded as per the encoding scheme. Finely, this decoded parallel data is made available at the 8 nos output. For meet the bandwidth requirements, XILINX SPARTAN-3E FPGA has been selected. 8B/10B block coding and Unipolar NRZ Line Code technique has been selected for the asynchronous communication. In receiver module, Edge detection method is used for clock recovery. Fast prototyping has been done using Papilion One 250k FPGA development boards having a 32MHz on board oscillator.

The paper describes in detail about the design, implementation and test result of the FO link.

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NF35

Recent Improvements Of The Cryogenic Components Of The Neutral Beam Injection System Of SST-1

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Abstract

Neutral Beam Injection System of SST-1 at IPR has indigenously developed cryopumps as one of the key components. These cryopumps are designed for hydrogen and deuterium gas condensation at temperature down to 3.8 K for which

there is a dedicated Helium refrigerator/liquefier which can produce and circulate liquid helium (LHe) at 3.8 K. Liquid nitrogen (LN2)-cooled thermal shielding and baffles are used to reduce external heat loads on LHe system. All these cryo-components necessary for operations had been established and commissioning was completed in 2007. During the operations of LN2 distributions, it was observed that, the required LN2 flow rate, when all cry-components are in operation, was hard to achieve in the present configuration. The root cause was systematically diagnosed and removed which improved the flow rate significantly. Both LN2 and LHe transfer lines inside the cryopump vacuum chamber developed significant leaks during the operations, which made further operations difficult. The root causes have been diagnosed and improvements in the design have been done considering simplicity for fabrication, reliability for long time leak-proof operation and easiness for maintenance and repair. This paper will discuss all these aspects.

NF36

Assembly And Test Results Of The Accelerator System For ROBIN At IPR

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Abstract

An inductively coupled single driver RF (100kW, 1MHz) based negative hydrogen ion source program has started off with the commissioning of ROBIN [1] at IPR under IPR-IPP (Germany) license agreement. The operation of ROBIN has been planned in two phases. In the first phase the plasma production and in second phase the beam extraction has been planned. During first phase of experiments (without accelerator system), the plasma has been produced and desired plasma density has been achieved successfully at IPR. Now the experimental facility is being updated for beam extraction experiments.

A multiaperture three grid accelerator system [2] (consisting of plasma grid (PG), extraction grid (EG) and ground grid (GG) installed inside a porcelain insulator) is used to extract and accelerate a negative hydrogen ion beam of ~10 A at 35 kV, with a current density of ~30 mA/cm2. The porcelain insulator separates the grid system at high voltage from vacuum vessel and ground potential. The extraction power supply (15kV, 35A) is connected between PG and EG and acceleration power supply (35kV, 15A) is connected between EG and GG [3]. The cooling water channels are provided inside the grids (EG and GG) to flow low conductivity cold water for thermal load protection during beam extraction. All the grids are mounted on individual grid holder boxes (GHBs) having ceramic post insulators in between for high voltage isolation. The GHBs are also cooled by flowing water. The water connections are taken out by using flexible metallic hoses which work as high voltage feeding points as well.

Due to the precise alignment of the grids and involvement of the delicate items like ceramic post insulators, the assembly of the accelerator system demands special jigs and fixtures. These fixtures and jigs were made and then the full accelerator assembly was done at IPR in clean and dust free environment to avoid high voltage breakdowns during operation. The alignments between grids were ensured by special mechanical arrangements in the form of grid to grid and grids to grid holder boxes. The successful assembly of the accelerator system was ensured by acceptance tests like helium leak test, global leak test, pressure test, flow test and high voltage tests.

The source and accelerator description, assembly sequence, acceptance tests and progress in beam extraction experiments will be described in the paper.

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NF37

Low cost Capacitor Bank for the Electromagnet of Compact Plasma System at Ravenshaw University

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Abstract

Plasma filaments, or ''blobs,'' are coherent structures, characterized by enhanced density relative to the background plasma. These blobs are extended along the magnetic field lines and having rather small cross-section in the perpendicular plane. They propagate to the outer wall due to ∇B plasma polarization and associated $\vec{E} \times \vec{B}$ drift. Hence studying the characteristics of these blobs and their motion is very important in understanding and control the fast convective radial transport in tokamaks. For this purpose we need an electromagnet associated with our compact plasma system. We cannot use polar electrolyte capacitors for our capacitor bank since appreciable reverse current will damage the system. We have two options, either energy storage capacitors or metallised poly propylene capacitors. Energy storage capacitors are very costly; hence we have gone for metallised poly propylene type. It is worth noting that use of this type of capacitors is rarely used in plasma experiments in India. The magnetic field strength at the centre of plasma chamber, 0.1 m from the mouth of plasma source is ~ 0.02 T for input current 0.1 kA. The pulse width is ~ 1 ms. The radial profile of field strength at different discharging potential/input current is reported.
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NF38

On the spectroscopic diagnostics of atmospheric gas plasma blob produced from washer stacked plasma gun

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Abstract

Plasma guns have wide range of application in plasma physics and controlled nuclear fusion research. We have designed a plasma gun very similar to washer stacked plasma gun to produce coherent plasma structures. [1] The blobs are produced and contained for ~ 3 ms. [2] The spectroscopic signature of atmospheric gas plasma blob is studied using spectroscope in the visible spectrum. The excited species present in the blob is determined and excitation temperature is estimated using ratio of intensity of spectral lines. We have detected excited states of Carbon, Oxygen, Nitrogen, Hα. The results are reported in this work.

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NF39

Resonant and Non-resonant type Pre-ionization and Current Ramp-up Experiments on Tokamak ADITYA in the Ion Cyclotron Frequency Range

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Abstract

Pre-ionization in ICRF range is an important aspect of steady state tokamak like SST-1 and few experiments are successfully carried out in tokamaks like TEXTOR, TORE SUPRA etc. Here we report the pre-ionization and current ramp-up experiments carried out in ICRF range using poloidal type fast wave antenna, and 200 kW RF system at 24.8 MHz frequency which corresponds to the second harmonic resonance layer at the center of the vacuum vessel of tokamak ADITYA at 0.825 T. The diagnostics used are Langmuir probes, visible camera, spectroscopy, soft X-ray and hard X-ray detection techniques, diamagnetic loop and microwave diagnostics like interferometer and reflectometer.

The experiments are carried out in different phases to have full understanding and control over current ramp-up.In first phase only RF breakdown is produced at 24.8 MHz using a fast wave antenna without toroidal magnetic field and loop voltage at different RF powers.

In second phase, RF plasma is produced in presence of different toroidal magnetic fields varyingfrom 0.825T to 0.075T. For 24.8 MHz RF frequency, the second harmonic resonance layer lies at the center of the plasma at 0.825 T and when the magnetic field is varied, it goes away from the antenna towards high field side and finally vanishes at ~0.5 T inside the vacuum vessel.It is observed that at higher magnetic fields when the resonance layer is present in front of antenna into vacuum vessel, the plasma spreads toroidally all around the vessel but radial spread is mostly limited up to resonance layer. In case of non-resonant plasma, when there is no resonance layer in the plasma volume at the lower magnetic field, the plasma density formed is lower than that of the resonant plasmaThen the experiments are carried out at 0.75 T and the RF power is varied from 20 kW to 120 kW power. Also the pre-ionization is produced at different pressures in the range of 3 x 10-5 torr to 8.0 x 10-4torr. It is observed that plasma density due to pre-ionization is in the range 1010 /cc and that of normal plasma after current ramp-up is in the range of 1013/cc. It is observed that the pre-ionization density increases with increase in pressure as well as with increase in magnetic field.

In third phase, the experiments are carried out with RF power and the full loop voltage of 22 volts. The duration of RF pulse is from -150ms with reference to Ohmic loop voltage starting at 0ms. In this experiment, the over-lapping time of RF power with loop voltage is varied and also the RF power is varied. The adjustment of the vertical field as well as the magnitude, duration and the frequency of the gas puff is done to have normal current build- up of 90 kA plasma current, 90ms duration with electron temperature around 300 eV.

In fourth phase the loop voltage of Ohmic transformer is decreased by decreasing the current through the transformer due to which the available volts-sec also decreases. The pre-ionization and current ramp-up experiments are carried out at

different loop voltage varying from 22 volts to 8 volts. It was observed that at 8 volts loop voltage without RF, we could get only a few kA current for few ms which was not possible to ramp up. However as soon as RF pre-ionization was produced we could ramp-up the plasma current to have normal discharge.
In fifth phase, the resistors in the ohmic transformer are changed to keep available volt-seconds of Ohmic system constant and the current ramp-up experiments are carried out. However, by changing resistors, we could not save appreciable volts-seconds to have longer discharge because of the fast rise time of the loop voltage.
In the last phase the current ramp-up experiments are carried out at delayed 8 volts loop voltage. We could ramp-up current successfully to have normal plasma current.

NF40

Conceptual design of a pellet injection system for the plasma fuelling applications

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Abstract

Conceptual design of a single barrel Hydrogen pellet injection system is proposed for the high temperature plasma fueling applications. A pellet made up of hydrogenic gas below its triple point and injected with hundreds of m/s speed has become the leading technology for refueling magnetically confined plasmas for controlled thermonuclear fusion research [1]. For the fueling scenarios in the Aditya and SST-1 tokomak plasmas, the size and speed of a pellet is calculated to be less than 1.5 mm cylindrical shape and few hundreds of m/s, respectively. This pellet injector is a pipe gun type injector, in which, a pellet is formed in-situ in the formation barrel, and injected into the plasma with the help of high pressure propellant gas [2]. A pellet is formed at a temperature below 10 K by using a Gifford-McMahon (GM) cycle cryogenic refrigerator. In-order to restrict the propellant gas entering into the plasma, a multi stage differential pumping system is employed to the pellet injection line. The light gate system consisting of a laser and photodiode will

be used for measuring the speed of the pellet at the injector exit. For the pellet shape and hence the mass measurement, a shadow-graphic system based on a CCD camera and a nano second light source is planned.

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NF41

Conceptual Design Of Filament Heating And Bias Power Supplies Scheme For Electron Seedling In A Two RF Driver Based Negative Ion Source

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Abstract

A dedicated experimental plan has been initiated in IPR, Gandhinagar; with the objective of understanding the physics and technology of multi-driver inductively coupled rf based negative ion source. The experimental plan is base on two RF driver negative ion source , TWIN source (TS)[1] driven by a single 1 MHz, 180 kW RF generator(RFG). This TS configuring an experimental system consisting of other supporting systems like Heating and Bias Power Supply Scheme (HBPS), High Voltage Power Supply (HVPS), High Vacuum and Cooling System and centralized Control, Data Acquisition and Communication system of Twin Source (TS-CODAC). Plasma of density ~ 1018 m-3, in a volume of ~ 0.5 m3 chamber shall be produced in this experiment from which, extraction of ~ 10 – 12 A of negative hydrogen ion current at high potential - 50 kV, is envisioned. RF Power will be launched through an actively cooled RF coil mounted on each of the driver.

To initiate the RF ignition in the ion source, electron seeding is necessary. For providing the necessary seed electrons, dedicated filament discharge circuitry is placed in each driver. To heat the filaments for electron emission filament heating (16V DC, 10A) power supplies will be connected to two filaments. Filaments will be negatively biased with reference to source for discharge with a filament Bias (128V DC, 1A) power supply. A special circuitry control individual filaments in various operational modes will be implemented in order to reliably operate the ion source. This circuit is also interfaced with the TS-CODAC for remote operation of the HBPS. The HBPS system will be designed to offer high regulation (± 0.01%) and low ripple (0.04%). Since during extraction and acceleration phase, the source will be floating at high potential (~ - 50kV), a special galvanic (using isolation transformer) and physical isolation scheme will be implemented for feeding the AC power to the HBPS rack. As the filament heating and filament bias power supplies are needed to be synchronized for simultaneous turn on and off, which involve switching of DC voltage and current so, a special DC contactor circuitry will be implemented. The output of power supplies will be interfaced through corona free insulated wires.

The paper will discuss that scheme also describe the corresponding conceptual design of filaments heating and bias power supplies and its necessary isolation, control and interconnection scheme in engineering aspect.

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NF42

Recent Technologies For Superconducting Magnets of SST-1

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Abstract

Refurbishment of SST-1 project has been envisaged as the time bound mission at IPR. Magnet systems of this machine are the major critical components. Steady State Tokomak (SST-1) has sixteen (16) numbers of superconducting NbTi/Cu based Toroidal Field (TF) coils, which are designed to produce a magnetic field of 3T on the plasma axis with 10000 A of nominal currents in the conductor. Each TF magnet winding pack comprises of six double pancakes encased in a SS 316LN case. Each TF magnet thus has five numbers of inter-double pancake (IP) joints and two inter-coil (IC) terminations. Nearly one hundred of IP and IC joints have been fabricated to complete TF magnet system in SST-1. New

low DC resistance joints of less than one nano ohm have been fabricated and tested at 5 K, 10KA DC transport current in the spare TF coil and in sixteen SST-1 TF coils. Joint fabrication processes, joint box welding, joint resistance measurements and quality assurance (QA) are discussed in this paper.

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22nd Magnet Technology conference 2011, Marseille, France

NF43

Detection of 4He Generated During the Reaction of 3He (3He, 2p) 4He in a Plasma Focus Device using Lexan Solid State Nuclear Track Detector

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Abstract

The plasma focus (PF) device is a well known laboratory fusion device. It is known to produce neutrons due to DD or DT fusion reaction. Fusion of heavier elements is difficult to achieve in such devices due to high coulomb barrier. Such type fusion was attempted here using an 11.5 kJ (40μF, 24 kV) PF device operated with high purity 3He gas at 3mb filling pressure. The fusion product 4He (α particle, 3.7 MeV) generated during the reaction of 3He (3He, 2p)4He inside the plasma focus device was observed using Lexan solid state nuclear track detector.

Typical 4He tracks recorded during PF experiments are shown in Figure 1. This track detector is sensitive only to high energy (>4Mev/mg.cm2) α particles. The track dimensions are comparable to the tracks of known α source (Americium, 5.5 MeV). The observation unambiguously demonstrates the fusion of 3He in a plasma focus device. This is also supported by the recording of high energy X-rays during the fusion process. Details of measurement and result will be reported.

NF44

Integration of "Regulated High Voltage Power Source" (RHVPS) with LHCD System of SST-1

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Abstract

A Regulated High Voltage Power Source (RHVPS) and its results are presented for its operation with LHCD system. Experimental results are shown to show the ability of RHVPS as a practical source of electrical power for LHCD. Klystron is operated at 3.7 GHz. with a continuous wave (CW) RF power level of 500 kW with various subsystems. RHVPS has proven its capability for feeding power to klystron with a safe and good level of required quality. Repeatability of operation is shown by successive shot results. Up to 65 kV and a load current in excess of 18 A was imparted to klystron with a trapezoidal pulse of voltage.
RHVPS is explained with its scheme and control system. Basic parameters are fulfilled with a dummy load testing of RHVPS. Test results are illustrated for basic parameters with resistive dummy load. LHCD system operation parameters and experimental parameters of RHVPS for its operation are discussed. A regulation on flat top level of voltage is as per the requirement of LHCD system. Integration of RHVPS has been successful and future plans are mentioned for full-fledged SST-1 operation.

NF45

Wire Burn Test of Multi Mega watt Regulated High Voltage Power Supply for NBI, LHCD and ECRH

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Abstract

This paper discusses the wire burn test setup, experiment and its results of Multi Mega watt Regulated High Voltage Power Supply (RHVPS) for various plasma heating systems like NBI, LHCD and ECRH. Wire burn test is a validation test of power supply for the safe uses at RF and NB Loads. RF and NB Loads demands very low storage energy (10J) of power supply system. The conventional high power microwave tubes should be protected from arc fault. If the stored energy of the power supply is greater then some critical limit (10 J) of tube then it may damage the microwave tube. This test is performed prior to connect the actual load. The RHVPS with rating 80kV, 75A is design and developed for such critical RF and NB loads. This power supply has ability of deliver mega watts of power during the normal operation and store & deliver very low energy (<10J) during fault condition to protect the critical load like NB and RF loads.

To conduct the wire burn test ~10J energy wire is used as a load and successfully completed the wire burn test with full voltage rating up to 80kV. The power supply delivered <10J energy so load wire is intact after fault creation. On successful completion of test wire can be replaced with actual load.

NF46

Jatinkumar

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Nigam Prajapati

NF48

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NF49

Comprehensive Studies on Thickness Measurement of Gold Thin Film Using RBS Method

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Abstract

We present detailed investigation of measurement of gold nano film thickness using Rutherford back scattering method (RBS). A sample of gold nano film is prepared on silica substrate having dimension 10 mm x 10 mm using physical vapour deposition method. Prepared sample is irradiated with the Ar+ accelerated through 150 keV ion accelerator to achieve a uniform film deposition. The prepared sample is allowed to hit by alpha particle accelerated by 1.7 MeV Tandem accelerator and gold atoms scatter the encountered alpha particles backwards. The back scattered particles energy is detected by the Solid State detector and the thickness is determined using the RBS method. A comparative study is also made using the analytically by surface energy approximation method and as well as numerically employing RUMP numerical code.

NF50

A Computational Parametric Study on Effect of Non-Thermal Electrons on Temperature Measurement Using ECE for ITER

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Abstract

In TOKAMAKS, the radial temperature profile can be measured using Electron Cyclotron Emission (ECE) diagnostics . But for high temperature plasmas like that of ITER this method is limited by many factors like presence of non-thermals. In this paper we have estimated effects of a small non-thermal electron population on measured temperature profile for ITER-Scenario 2. For ITER like plasma, radial temperature profiles can be obtained from the first harmonic O mode ECE spectrum. It is possible that, higher harmonics produced from the non-thermals can be relativistically downshifted to first harmonics and introduce error in the measured temperature profile. Generally Non-

thermals are produced from Electron Cyclotron Resonance heating (ECRH), Electron Cyclotron Current Drive (ECCD) , Neutral Beam Injection (NBI) etc. In the present study the non-thermals are assumed to be produced from proposed ECCD, which is being considered for suppressing Neoclassical Tearing Modes (NTM). We have ignored any other source of non-thermals in the present study. All the numerical calculations reported in this paper is performed using NOTEC computer code which is capable of handling non-thermal populations. The locations and spatial extents of non-thermals are taken from previous report on optimization study of the ITER ECRH top launcher. The non-thermals are assumed to be centered around safety points q=1 where the ECCD is expected to be used for suppressing the NTMs. The main results of the present study are summarized below. In the first part of the paper we present the results for temperature measurement with out non-thermal populations for the purpose of validation. Secondly the range of higher harmonic frequencies (due to non-thermals) which possibly reach antenna and induce error in the temperature measurement are identified and the corresponding energies of non-thermal populations are calculated analytically. These calculations are further checked by simulations using NOTEC code. Finally non-thermal populations are seeded in the plasma with fraction and energies of non-thermals are varied in a parametric form. The parametric range of energies is initially bracketed by the analytical calculations explained above. The resultant temperature profiles and error in the measured temperatures will be presented.

NF51

Dac System Software For Fast Ferrite Tuner Operation

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Abstract

Ion cyclotron resonance heating systems on Tokamak include devices for matching the input impedance of the antenna to the generator output impedance. We have implemented real-time feedback control loop for Fast Ferrite Tuner operation, which can work within 5 millisecond timescale for matching source and load impedance. FFT achieves change in reactance by changing permeability of the ferrites just by changing the electromagnet current. So we have implemented algorithm program, which runs on VME processor within required timescale with parameters.

We have used VxWorks real-time operating system software using C/C++ programming with GNU cross compiler. There is a separate process running on VME program which has been governed by standard complex variable algorithm. The algorithm provides required value or current for the power supply by which the feedback control loop works. There are 12 different probe signals on transmission line connected with FFT. We have to find out minimum and maximum value by using runtime value during operation. Finally we got value of current which would be outputted to power supply from VME terminal as analog output. Power supply will generate output according to the value of analog output to electromagnets of FFT. The power supply requires 3 ms to ramp up from minimum to maximum value of current output. For safety reasons and consideration of hardware and transmission delay we are running our feedback control loop within 5 ms timescale. This paper presents an overview of the ICRH DAC control system software based on Real-time feedback control software for operation of Fast ferrite tuner and test results.

NF52

Prototype Of Icrh Data Acquisition And Control Client Software Using Qt Programming

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Abstract

This paper presents an overview of the ion cyclotron resonance heating (ICRH) data acquisition and control system software based on QT programming, which can be run on Linux system. The actual software was based on TCL/TK toolkit with different third party application interface. It is some tedious and time consuming job to make user interface with existing system which requires more attention to build application. Also some of the third party software toolkit versions are not support with TCL/TK. We find QT programming is more suitable to develop and run our application.

We have main three threads having with DAC system software (Monitoring data, Archival of data and real-time control). The client interface mainly works with monitoring and archival of data. The existing version of TCL/TK software toolkit was not compiled or installed with multithreading facility. Due to unavailability of multithreading the user has to run two or three terminal commands to run experiment while given shot in pulse mode operation of heating experiment. Also the vacuum control software has to be run separately while experiment. QT toolkit is based on C/C++ programming

languages and has inbuilt multithread facility. QT programming has wide variety of libraries with easier development. This is new emerging technology, which can also run on Linux as well as windows operating system. We have make QT programming based user interface for monitoring and acquiring data. The server program is based on RTOS with C/C++ programming which provides proper synchronization and easy implementation with QT client. The application software at VME server acquires the signals and through data on Ethernet via socket programming on demand of client software running on Linux work-station. The VME based data acquisition and control system with QT client is commissioned for remote operation of ICRH system.

NF53

Customization In Jscope Tool For Data Visulization And Off Shot Analysis For Archived Data Of Rf Icrh System

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Abstract

The VME based Data Acquisition and Control system is commissioned for remote operation of SST-1 Ion Cyclotron Resonance Heating (ICRH) transmission line system. The transmission line consists of (a) a pressurized 9 inch 50 ohm coaxial line, (b) matching systems at two different time scales and (c) vacuum transmission line called interface, linking the transmission line to the fast wave antennae. One single line transmits the power from the RF generator to the two antenna boxes placed at diametrically opposite radial ports. A high power 3dB hybrid coupler is used to split the power into two transmission line arms. Each transmission line arm has 24 voltage probes, motorized automatic matching network (in ms) and course tuner (in s). Automatic matching network consists of two stubs coupled with stepper motor and two nos. of vacuum variable capacitors coupled with high-speed servomotor. Motorized course tuner consists of one phase shifter and one stub.

The VME based system for monitoring and control is a power PC-604 processor based. The 24 probe signals from RF detector of each arm of transmission line is processed through the signal conditioning rack and connected to VME compatible VGD4 card which is used to digitize the analog I/P signal in ~100 □s timescale. The application software at VME side acquires the signals. To match the antenna impedance to the generator impedance, required parameters,

VSWR and error signals are calculated and control signals are generated through VME digital I/O card (VMIVME-2528) for motor driver/controllers. The Carrier Board AVME 9660 with timer card IP-480 is used for generating different timing pulses & sequences. The real time controlling application software modules are developed on the VME hardware on VxWorks RTOS Tornado environment in C++ with networking and Board Support Package libraries. The Graphical User Interface is developed in TCL/TK on Linux platform on PC for online monitoring and interactive control. The acquired data is archived on Network file system based binary files on Database Server. There are several channel data

archived from VME server which will be analyzed with JSCOPE tool along with comparison. Mainly we have develop 3 major customization with JSCOPE tool which can make automatic build of property file run time. Plot ascii based data from text file of csv. Remote visualization and comparison of data.

NF54

Welding Activities for Superconducting Magnets Systems of SST-1

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Abstract

In SST-1 machine various types of problematic areas associated with superconducting magnet systems had been identified and realized for its refurbishment. Welding technology related with magnet system requires process optimization and expertise for their execution on the actual system. In this machine sixteen numbers of toroidal field (TF) magnets and nine poloidal field (PF) magnets. All TF magnets have inter-double pancake joints and four PF magnets have also inter-double pancake joints. Terminations of all superconducting magnets have been connected with bus-bars and will also cover by joint boxes. Components of magnets fabricated and connected with it using precise welding are joint boxes over all joints, Isolator manifolds, Inlet and outlet tubing, venturimeter welding, inlet and outlet headers welding during magnet test. All types of welding have been tested at low temperature at 5K. Leak tightness of all welded components at functional condition have been found better than 10^-7mbl/s. Various types of welding processes of magnet components will be discussed in this paper.

NF55

Conceptual Design for an Upgraded Version of "Control and Data Acquisition system for NBI Power supply"

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Abstract

A Neutral Beam Injector (NBI) System provides additional heating to the SST-1 Tokomak; it is designed for 1.7 MW power into the plasma. The 1st stage experiment focused on integrated tests of the control and electrical sub-systems has

been completed. Other essential systems made operational are the Vacuum system; Gas feed system, some diagnostics and the data acquisition system.
The present Data acquisition and control system for NBI has been developed using a VME Based system. All power supply signals including the Arc-Filament power supply signals are acquired on the VME system. The VME system is referenced at the accelerator potential, up to 80kVDC. Windows operating system based computers are used for human interface of the VME based control system. The control logic has been developed in VxWorks real-time operating system.

The NBI machine is in now operation mode. This paper explains with the knowledge of initial experiment and using today's technology, conceptual design of the upgraded system. The VME master control system will be upgraded with PXI system. The centralize data management will be imposed. The data sharing and access will be made easier for users.

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NF56

Contingency Plan of LN2 Distribution Network for 80K Thermal Shields of SST 1

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Abstract

The cryostat of steady state superconducting tokamak 1 (SST 1) consists of liquid nitrogen (LN2) cooled 80 K bubble shields. These shields can be cooled by two possible variants, either using high pressure single phase (0.6 MPa) or low pressure (0.25 MPa) two-phase cooling using liquid nitrogen. The single phase cooling can be obtained by using 80 K booster system whereas low pressure cooling can be delivered by simple pressure head available from the main storage tank. As the installation, commissioning and testing of the 80 K booster system is yet to be done at IPR, a parallel contingency plan has been executed. According to contingency plan, the service pressure of LN2 storage tank was used to cool down 80K thermal shield. This paper describe how to configure process and instrumentation diagram for different types of bubble shields, selection of appropriate instruments viz. temperature, pressure, flow control valves as per planned grouping of the 80 K thermal shields were carried out. The balance of hydraulic resistances of individual paths was controlled by looking at the temperature and regulation of flow control valves.

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NF57

Implementation of SST-1 Cryogenics Sub-system Control Application and Network Architecture for Centralized Time Synchronized Data Acquisition

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Abstract

Under the SST-1 mission mandate, the several cryogenic sub-systems have been developed, upgraded and procured in prior to the SST-1 cool-down operation. New developments include 80 K Bubble type thermal shields, LN2 distribution system, LN2 booster system and current feeders system (CFS) for charging the TF and PF coils at their rated current. In-house Graphical User Interface (GUI) program developed in Wonderware SCADA and Schneider make PLC for the above sub-systems. This platform will provide the features of process parameters control and monitoring. Control area network architecture is designed and implemented to have synchronization among each cryogenic sub-system with centralized Industrial SQL server (InSQL) and GPS based SST-1 Control system. Centralized InSQL server configured to acquire and store real time process data from each cryogenic sub-systems and cryogenic process data availability to SST-1 central control room. This paper describes the details of newly developed and upgraded cryogenic sub-system's control system and network architecture. This paper will discuss the performance of this system during the recent cool-down campaign of SST-1.

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NF58

Performance of Cryogenics system during Recent Cool-down campaign of SST-1

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Abstract

Recently, the cool-down attempt of the refurbished SST-1 machines has been carried out as part of the engineering commissioning and preparedness towards getting the first plasma discharge. The SST-1 cryogenics system comprises of the technology of cold helium and liquid nitrogen systems. IPR has an operational 1.3 kW at 4.5 K custom designed cryogenic helium refrigerator-liquefier (HRL), which can cater 650 W of refrigeration power and 7 g-s-1 of liquefaction capacity at 4.5 K. In order to minimize the direct steady state heat loads from ambient (300 K), double embossed type thermal shields system is provided. The major auxiliary cryo systems include the current feeders system (CFS), contingency cooling mechanism of 80 K thermal shields and warm gas managements system. These auxiliary cryo systems have shown their rated performance and compatibility during the recent cool-down of SST-1. This paper will present the observations and highlights of recent cool down of SST-1.

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NF59

Cool-down results of 80 K Thermal shields system for SST 1

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Abstract

The 80 K thermal shields of Steady State Superconducting Tokamak (SST-1) minimize the steady state heat loads on the superconducting magnet system at 4.5 K from ambient (300 K). Uniform temperature, vacuum and cryo compatibility is desired for the 80 K shields. Temperature mapping is one of the key tasks in such complex and distributed system. There are total 130 bubble shields installed in SST-1 machine distributed in five hydraulic paths cooled by liquid nitrogen (LN2). It was envisaged to have accurate and reliable temperature measurement system. The total 104 temperature sensors were mounted on the strategic location of the thermal shields to have overall idea and uniformity of temperatures on 80 K shields surface. In-house developed methodology of temperature measurement was adopted to provide the accurate temperature measurement. In this paper, we discuss about the temperature measurement techniques and some of the relevant experimental results of recent SST-1 cool-down campaign of August 2012 as part of engineering commission of SST-1 tokamak.

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NF60

Integrated distribution network for SST-1 Liquid Nitrogen service

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Abstract

The 80K thermal shields are used to minimize the steady state heat loads on the superconducting magnets system (SCMS) of SST-1 operating at 4.5 K In order to cool these shields down to 80K, the liquid nitrogen distribution network is designed, fabricated, installed and commissioned using vacuum jacket integrated cryo lines (VJICL). In order to achieve the desired leak tightness of 1 x 10-8mbar-l/s, heat load of < 5 W/m, and pressure drop of 5mbar/m an integrated

cryo line (5 supply / 5 return process lines) was designed and installed at IPR. The design procedures, fabrication, installation, commissioning and final acceptance testing are presented in this paper.

NF61

Design and development of water-cooled dummy load for 12 kA, 16 V power supply test at IPR

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Abstract

As a part of final acceptance of 12kA, 16 V switch mode power supply at IPR, the constant voltage (CV mode) performance testing is one of the key parameters to be tested. In order to facilitate this test, we require to design and develop in-house water-cooled high current and low voltage dummy load. This dummy load was used to calibrate the individual sub-converters as well as multiple settings of voltages given to the power supply. In this paper, we report design calculations, in-house development and applications of high current low voltage grade water cooled resistive load. We also present the operation results of CV mode of 12 kA, 16 V DC switch mode power supply.

NF62

Maintenance Experience On Utility Power Distribution

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Abstract

Experiments on high temperature magnetically confined plasmas is being conducted in the Tokamak ADITYA. The SST-1 machine is focusing on the physics and technology issues related to steady state Plasmas. The diagnostics, control and cooling power for these machines are drawn from 11 kV feeders from utility company from an exclusive 132 kV line. The operation and maintenance of the utility distribution power is narrated in this paper. Single Line diagrams of complete distribution network are explained. Safety and signal grounding schemes have been studied and implemented. We have analyzed the good quality power requirement for such experimental machines and incorporated various measures, which are described. Electrical loads like control, diagnostics, air conditioning, pumping, motor and lighting etc. are studied and narrated in this paper.

NF63

Simulation of Eddy Currents in SST-1 startup using FEM

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Abstract

This paper describes the calculation of eddy currents that circulates in the vessel and cryostat structure and its effect on the magnetic null in SST-1 tokamak using 2D axisymmetric finite element model. The varying magnetic flux that forms and maintains the plasma current also induces currents in all the conducting structure of the tokamak, around which the ohmic heating solenoid is tightly wound. During the plasma startup phase the eddy currents strongly affect the performance of the ohmic heating system and must be taken into account.

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NF64

Development of PLC and SCADA Application for SST-1 80 K Control Systems

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Abstract

Steady state superconducting Tokamak (SST-1) is medium size tokamak, which requires liquid nitrogen (LN2) cooled 80 K bubble shields for reducing direct thermal heat load from room temperature to superconducting magnets system. As the LN2 shields and its distribution facility is develop in-house, it is essential to test all the shields to ensure the design performance of each shield and hydraulic balance among all the flow paths. Monitoring and controlling systems require for hydraulically balanced cool-down of SST-1 80 K thermal shields. In order to facilitate this operation a programmable logic developed with the use of ladder language in Schneider make PLC. The front end GUI has been developed for control and monitoring in Wonderware Intouch SCADA. It is a state of art with independent applications developed in Intouch SCADA software for real time data monitoring, control, logging and historical logged data retrieving. The performance of the SCADA based data acquisition and data retrieval system found to be satisfactory during the recent SST-1 cool down Campaign. This paper describes the implementation and the validation results of 80 K shield control system.

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NF65

LOCA and LOFA analysis for Indian LLCB TBM for ITER

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Abstract

Indian TBM program in ITER is one of the major steps in Indian fusion reactor programme towards DEMO and power plant vision. The Lead-Lithium Ceramic Breeder (LLCB) TBM concept is being developed by India for testing in ITER machine. The LLCB TBM consists of lithium titanate as ceramic breeder (CB) material in the form of packed pebble beds, PbLi as the coolant, multiplier and the tritium breeder and Reduced Activation Ferritic Martensitic steel (RAFMS) used as the structural material. Safety analysis of the reference accidental sequence like Loss of Flow Analysis (LOFA) has been carried out for Lead Lithium cooled Ceramic Breeder (LLCB) Test Blanket Module (TBM) system. The safety studies on different accidental scenarios LOFA have been performed using ANSYS. The details of these analyses and its use in deciding the events to be reported to Central Interlock System (CIS) and Central Safety System (CSS) of ITER. will be discussed in this paper.

NF66

NF67

Electronic Database Code Upgradation For ADITYA Experiments

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Abstract

Aditya is a medium size Tokamak (Ro = 0.75 m, a = 0.25 m) is operational since 1989 and nearly 25,000 numbers of shots have been fired till now. In order to keep track of such a large shots database, having varieties of operational as well as plasma parameters, and comparing them within a minimum possible time, an electronic database was developed in 2003, using Matlab programming tool. Sufficiently large numbers of plasma parameters as well as some of the control parameters (input) were chosen for comparing shots and they were recorded in a file. While using this database over a period of time, we realized some of the shortcomings of the database software. The major problems were identified as (i) any change in physical channel number for particular signal would require change in the software program (ii) change in hardware, such as amplifier gain would again require change in the program etc. In order to eliminate those problems and make the software more reliable, efficient and user friendly, we have recently modified the code by (i) introducing

logical channel number instead of earlier physical channel number to avoid any problem related to change in digitizer or channel of a particular signal (ii) replacing constant values, used for some important input parameters as well as calibration factors with variables to improve performance and flexibility. In addition to that recently shot to shot information regarding calculated value of edge safety factor (q) was also introduced in the electronic database. The input parameters of edge safety factor like minor and major radius of the plasma was obtained from plasma position measurements. The modified program has been successfully tested for comparing a large number Aditya discharges for various plasma parameters such as maximum plasma current, duration, flat-top plasma duration, average loop voltage at Ip flat-top, plasma resistance during flat-top, minimum edge safety factor (q), hard X-ray status according to their energy level etc for particular shot. The details of the program development, testing procedure and finally comparison list for some Aditya discharges will be presented in this work.

NF68

Langmuir Probe Diagnostic Electronics For SYMPLE (System For Microwave Plasma Experiments)

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Abstract

A device, SYMPLE, is being developed at IPR to study high power microwave - plasma interaction physics. The plasma that enables the proposed investigation needs to satisfy certain criteria in terms of its density ((1-10)x1018/m3), uniform axial (~1 m) and radial (~ 10 cm) extends and a sharp gradient, with scale length of the order of the wavelength of the microwave, in the microwave-plasma interaction regime. These requirements have necessitated a choice of washer – gun (input power ~ 10 MW) based pulse (100μs) plasma source. One of the prime diagnostic requirements is to identify a right parametric regime where the plasma meets with the required pre-requisites discussed above. For this, Langmuir Probe based measurements need to be routinely carried out to measure various plasma parameters such as the electron density (ne), the electron temperature (Te), the floating potential(Vf), and the plasma potential (Vp).

As operation of SYMPLE involves application of pulsed high voltages to the plasma as well as the microwave sources, utmost care is to be taken to acquire the right signal, not corrupted by high voltage noises, from the probe based diagnostics. We have adopted a Langmuir probe electronics scheme keeping in view of the specific requirements of SYMPLE. This system installed in standard industrial enclosure, which consists of ultra isolation transformer to power the electronics systems, signal conditioning electronics for Langmuir probes, opto isolation cards, power supplies for signal conditioning electronics, high voltage supply for biasing probes. The front end electronics is designed using high common mode differential amplifiers which can measure small differential signal in presence of high common mode dc bias voltage, which is given to the probes. The front end is backed by programmable gain instrumentation amplifier and programmable filter modules. There is a provision to take optically isolated output signal which can be acquired by data acquisition system. The electronics system is tested in both dc bias and sweep bias mode of operation. The paper describes the detail design of the system with experiment results.

NF69

Study of Helium Glow Discharge Cleaning in ADITYA Tokamak

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Abstract

Hydrogen glow discharge cleaning (GDC) is regularly used for wall conditioning of ADITYA tokamak vacuum vessel. The hydrogen GDC is highly effective in reduction of oxygen and carbon (low- Z) impurities on first wall material and metallic vessel wall. However, during the long operation of hydrogen GDC, the retention of hydrogen increases significantly in vessel wall and in-vessel components, which results the higher hydrogen recycling in normal plasma discharges. Helium glow discharge cleaning is beneficial to reducing hydrogen retention in vessel wall and in-vessel components by ion induced desorption phenomena. Helium GDC is also effective for reducing oxygen and carbon impurities from the graphite surfaces such as limiters. Helium GDC has been carried out in ADITYA tokamak and low hydrogen recycling has been achieved in normal discharges. In this paper we will present the advantages of Helium discharges for better operation of ADITYA tokamak.

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NF70

Simulation of Wire-Burn Test On 30kV, 600kW DC Power Supply for High Power RF Generators Using Tetrodes

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Abstract

The experimental activities of IPR involve development of High Power RF and Microwave sources for fusion related heating and current drive applications. High power RF tubes like Triode, Tetrode, Klystron and Gyrotron are in general operated with High Voltage DC power supplies. These HVDC power supplies must be equipped with necessary arc fault protection in addition to over-current and over-voltage protections.

The arc fault protection must act with-in few micro seconds to prevent permanent damage to the RF tube. When an arc fault is detected, in order to protect the load, output voltage of the DC power supply is short circuited using a crowbar device (generally Ignitron, Thyratron, thyristor, rail-gap etc.) that operates in few microseconds. This diverts the fault current from the load to crowbar device, thereby protecting the load. This is necessary as conventional protection in the

power supply input takes ~100mSec to switch-off. The crowbar device must be able to take the fault current till the circuit breaker, placed at power supply input, is switched off.

A 30kV, 600kW DC power supply is used for the high power tetrode operation at 91.2 MHz, for Ion Cyclotron Resonance Heating experiments. The arc fault protection is tested for its effectiveness by "wire-burn" test at various voltages up to 15kV.

Full power short circuit of 600kW DC power supply puts enormous stress on the power supply, utility and the crowbar, therefore frequent wire-burn testing is to be avoided. A simulation model is developed using PSIM software to reproduce the results obtained during wire-burn test conducted up to 15kV. The same is also used for predicting the results of the test at 27 kV, as required for the next stage amplifier. The results would be useful for optimization of the component values without conducting actual wire-burn test.

NF71

Development and performance testing of resistances for 2-turns correction coil operation during helicity experiment in ADITYA tokamak discharges

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Abstract

Aditya, a medium size tokamak with R0 ~ 75 cm and a ~ 25 cm. A series of experiments were carried out in Aditya tokamak in four direction combinations of toroidal magnetic field (Bφ) and plasma current (Ip). The normal mode of

operation of Aditya is Bφ (CCW) and Ip (CW) with single turn correction coil is in series with OT coils for error field correction. To carry out experiment in other three possible combinations viz., left handed helicity (positive IP and negative BT) and right-handed helicity (negative IP and positive BT),
the discharge consistency was not observed with signal turn correction coil. Therefore, we have used two-turns correction coil in series with optimum parallel resistance to produce reliable discharges. Different values of parallel resistances made up of SS strip are varied from 1 mΩ to 9.0 mΩ. The performance of various resistances was tested with actual plasma discharge operation. We have reached a optimum resistance value of 1.2 mΩ suitable for reliable 2-turn correction coil operation. This paper mainly describes the manufacturing and accurate resistance measurement technique during the experiment.

NF72

Conceptual Design of ITER-India Gyrotron Test facility (IIGTF)

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Abstract

Indian domestic agency (IN-DA) has the responsibility to supplying 2 high power gyrotron sources for EC heating & current drive (EC H&CD) system on ITER. To establish gyrotron system integration, integrated system performance and

any routine testing/conditioning of other gyrotron require a dedicated gyrotron test facility. Hence the ITER-India Gyrotron Test Facility (IIGTF) is in development stage at IPR campus. IIGTF shall have test gyrotron, transmission line, dummy load, high voltage power supplies, Auxiliary power supplies, Local control unit, water cooling connections, gyrotron diagnostics and crowbar Protection systems to test the gyrotron.
The test facility shall comply with the ITER gyrotron specifications. Any other tube requirements that are of the interest from the domestic programs may also be considered within the cost and technical constraints. The test facility should have an independent lab space, sufficient enough to facilitate the envisioned functions. The test facility shall be well equipped with all the necessary tools and measurement instrumentation to fully support the trouble shooting and testing operations. The test facility should have an appropriate set of High Voltage Power supplies with sufficient ratings that could energies the tubes under test. Adequate protection measures shall be implemented to protect the tubes. This shall be given highest priority with redundancy measures if necessary. The testing and tube operation shall be full remote controlled with manual intervention as and when necessary.
Detail conceptual design of different sub systems of IIGTF will be discussed in this paper.

NF73

Implementation of Sequence Control System for ITER-India Gyrotron Test Facility (IIGTF)

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Abstract

Gyrotron is a high power high frequency microwave source used for auxiliary heating of the plasma. It was planned to test two high power Gyrotrons in IIGTF and finally supply to ITER. To test the Gyrotrons, various auxiliary systems like High Voltage Power Supplies (HVPS), auxiliary power supplies, cooling water system and a Local Control Unit (LCU) are required. LCU is required to facilitate remote, safe and reliable operation of the Gyrotron system. The LCU consists of the PLC based Sequence control system, PXIe based real time data acquisition and Interlock & protection system. The sequence control refers to application of different power supplies and auxiliary services to Gyrotron system in a predefined sequence, both during turn ON and turn OFF of Gyrotron system. This sequential application and removal of power supplies and services from Gyrotron system ensures safe and optimum use of Gyrotron source and related auxiliary systems & services. As a prototype, this application is implemented using an ABB Programmable Logic Controller (PLC AC500 system). It basically controls and monitors the sequence of various power supplies for Gyrotron operation in real time and modifies the execution of sequence in case of event of interlock.

This paper presents complete system requirements; concept, design and test results in detail.

NF74

Remote Frequency Measurement of 170GHz Gyrotron system for ITER-India Gyrotron Test Facility (IIGTF)

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Abstract

Millimeter wave source (Gyrotron) operates at a very high frequency (GHz) and power (MW). Output power measurement is generally done with a calorimeter integrated into the dummy load (water load). The output frequency of Gyrotron indicates the operating mode(s) and thermal loading of the cavity. Though the tube is designed to operate at an optimum mode (maximum efficiency) at the design frequency, simultaneous oscillation of competing resonator mode at different frequencies could also be excited depending up on the operating parameters and whose resonance frequency is close to that of the cyclotron frequency. Some time it is possible that the Gyrotron may get into a Spurious Mode Oscillation at adjacent frequency points which may result in excessive thermal deposition. So the output power and frequency are two key parameters that need to be measured. The frequency measurement of the gyrotron output beam forms one of the important Gyrotron diagnostics. There are various techniques that can be used to measure the output frequency of Gyrotron (viz. Frequency counter, Filter-bank technique, spectrum analyzer etc.).

For the ITER-India Gyrotron Test Facility (IIGTF) a Remote frequency measurement system is developed using Spectrum analyzer, External Harmonics mixers and LabView software. Spectrum analyzer with base frequency range upto 30GHz and External harmonic mixers with frequency range from 110-220GHz (D-band, G-band) allows the frequency measurements of various gyrotron source systems (110-220GHz). The application program developed in LabView software allows the remote control of spectrum analyzer parameters. This program acquires the measured frequency and power information and also store the time dependent frequency and power information at an interval of <100ms during the operation.

This paper presents complete system requirements, concept and test results in details.

NF75

Hardwired Interlock and Protection module for ITER-India Gyrotron Test Facility (IIGTF)

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Abstract

Electron Cyclotron (EC) system on ITER machine is intended to provide ≥20 MW of auxiliary power into the plasma for EC Heating and Current Drive (EC H&CD) at 170 GHz, CW. EC system mainly consists of Gyrotron sources, High Voltage Power Supplies (HVPS), Transmission Lines (TX line) and Launchers. The scope of ITER-India is to supply two

high power Gyrotron sources. It includes Gyrotron tube, auxiliary power supplies, cooling water connections and a Local Control Unit (LCU). Separate LCU units will be used for Gyrotron source, High Voltage Power Supplies (HVPS), Transmission Lines and Launchers. The main function of LCU is to operate the Gyrotron source safely and independently at their specified performance for testing purpose and provide operational compability for synchronized operation with CODAC. It consists of PLC system for Sequence control, PXIe system for Real time Data Acquisition & critical interlocks and a Signal Conditioning Unit (SCU) for interfacing field signals with control and acquisition system.

A Gyrotron Test Facility is planned at ITER-India to test two high power Gyrotrons which will facilitate integration and integrated system performance of the Gyrotron system. This test facility involves Gyrotron system with its auxiliary power supplies, services, high voltage power supplies and interlocks & protection system. Interlocks play a very crucial role in safely operating the Gyrotron system. While operating the Gyrotron System, different fault and un-acceptable condition may be encountered. These events could have varying degree of severity requiring mitigation through interlock actions of appropriate time scales. Failure of critical interlocks could be detrimental to the Gyrotron Tube. The interlock system should be highly reliable to protect the Gyrotron tube against any critical fault(s) within predefined time scale. For prototype, two types of approach are considered: Hardwired based and FPGA based interlock and protection system. Prototype hardwired interlock and protection module has been developed and tested in the Lab environment with dummy signals. The total delay between input signals to generated control/action signal is about 100ns.

This paper presents complete requirements, approach, detail design, features and test results.

NF76

Analog Fiber Optical Transmission Link based on Direct Intensity Modulation (DIM) Technique for ITER-India Gyrotron Test Facility (IIGTF)

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Abstract

ITER has Electron Cyclotron (EC) system to provide EC Heating and Current Drive (EC H&CD) at 170 GHz to the plasma. EC system consist Gyrotron sources, High Voltage Power Supplies (HVPS), Transmission Lines (TX line) and Launchers. The ITER Gyrotron sources have 26 high power Gyrotron of 1 MW each. In the scope of ITER-India is to supply a set of (2 units) high power Gyrotron. Each Gyrotron source includes Gyrotron tube, auxiliary power supplies, cooling water system and a Local Control Unit (LCU). The main objective of the LCU is to provide remote, safe and reliable operation of the Gyrotron source system. The LCU consists of PLC system for sequence control, PXIe system for real time data acquisition & critical interlocks and a Signal Conditioning Unit (SCU) for interfacing the field signals with control and acquisition system.

The SCU will provide interfacing between field signals and PLC/PXIe system. These interfacing signals from high voltage power supplies, auxiliary power supplies & services are transmitted through noisy and harsh EMI environment. These signals shall be isolated and transmitted without any EMC/EMI interference. Hence fiber optic transmission link is adopted for signal transmission.

Multi-functional signal conditioning unit is considered to reduce the complexity, interface, number of spares, easy maintenance and integration within the system. Analog and digital signal conditioning modules (SCM) are required. The current techniques available for analog fiber optic link are Direct Intensity Modulation (DIM), Voltage to Frequency Conversion (VFC) and ADC-DAC conversion. The DIM based prototype of Analog Signal Conditioning Module is

planned to develop indigenously at IIGTF using plastic and glass fiber optic transceiver. This DIM based SCM consist of transmitter section, receiver section and fiber optic cable.

This paper presents the complete system requirements/specifications, concept, design and test results in details.

NF77

Thermal Management of 3MW 12 Inch Radio Frequency Rigid Transmission Line

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Abstract

The Ion Cyclotron Heating and Current Drive (ICH & CD) system is to couple 20 MW Radio Frequency power to ITER plasma for heating and driving plasma current, in the frequency range of 35-65 MHz. There will be 8 RF sources to generate total 20 MW of RF power. Each RF source consists of two multistage amplifier chains (pre-driver, driver & final stage amplifiers), a wide band combiner, DC & AC power supplies and RF monitoring-control system along with measuring devices.

A 12 inch rigid transmission line is designed as per ITER specification for transmission of 3MW power. The thermal management includes thermal analysis of inner conductor, outer conductor, support disk and inner conductor joint of 12 inch Tx-line components using CFX, thermal and structural module of Ansys. Design of cooling arrangement for 12"Tx-line and optimization of cooling parameter is carried out.

This paper describes thermal analysis along with fatigue and creep damage at high temperature on 12" Tx-line components. The effect of electric arc on support disc will also be discussed.

NF78

Status of ITER Ion Cyclotron Heating and Current Drive Source Package

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Abstract

ITER Ion Cyclotron Heating and Current Drive (IC H&CD) system is designed to deliver 20MW to a broad range of plasma scenarios, during very long pulses (~500s in inductive, up to an hour in non-inductive plasma scenarios). It consists of two broadband equatorial port plug antennas, their pre-matching and matching systems, transmission lines,

Radio Frequency (RF) sources and their associated High Voltage Power Supplies (HVPS). Each subsystem includes a local controller, and a Plant System Controller (PSC) manages the overall operation, safety and protection.

ITER-India is responsible for delivering RF Source package to ITER, which includes one Prototype RF Source followed by 8 bulk production units. An R&D phase has been initiated for establishing the technology related to this package. In recent time ITER-India has signed two contracts, one with Continental Electronics Corporation (US) and another one with Thales Electron Devices (France) for establishing the technology in very high power RF amplifiers, using different type of vacuum tubes (Tetrode & Diacrode). To support the test activity at very high power, infrastructure is being developed at ITER-India lab. Low power RF components/sub-systems, Local Control Unit, Auxiliary power supplies, High power test bed etc. are being developed to support the R&D phase. The outcome of R&D unit will lead to establish the best technology for ITER RF source with required reliability.

This paper will describe the status of R&D program to identify & resolve major technological challenges involved.

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NF79

Design of High Power Co-axial Transmission Line for Ion Cyclotron System

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Abstract

An Ion Cyclotron Resonance Heating (ICRF) system for plasma heating and current drive (H&CD) experiments on ITER is planned in the frequency range of 35-65MHz. The RF sources are being developed at ITER-India, IPR under Indian responsibility. RF source system facilitated with highly reliable transmission line system is required to couple 20MW total RF power into the plasma effectively during different experimental scenarios on ITER. To achieve required RF power, there will be eight independent tunable RF Sources of 2.5MW capability. Since no high power tube exists as per ITER requirement, there will be two identical amplifier chains and one high power combiner to achieve the targeted power.

To transport such a high power from RF source to combiner a co-axial transmission line of 12" size is designed and simulated using high frequency simulation software Microwave Studio (MWS).

RF designing part and simulation results of the 12" coaxial transmission line will be discussed in this paper.

NF80

Traveling Wave Resonator For Ich&Cd Component Test

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Abstract

To test the passive components of ITER ICH&CD system at high power, a test bench based on traveling wave resonator is needed. Traveling Wave Resonator (TWR) is basically a Ring Resonator operated under certain conditions which leads to buildup of power within the ring to very high level at resonant frequency. In principal power is fed to the ring via a directional coupler continuously and circulating power build up in the ring.

This paper presents the design and simulation result of a ring resonator at frequency 50MHz. Different possible coupling schemes has been studied to excite the ring. The concept of resonate frequency splitting due to asymmetry in the ring is also observed and resolved successfully for smooth operation. This paper also includes some basic thermal analysis of the ring in high power condition.

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NF81

Anode Power Supply Design for Pre-Driver RF Amplifier

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Abstract

Anode power supply is required for biasing Pre-driver RF Amplifier (output power ~20 kW), which is basically a Tetrode based RF amplifier in the frequency range 35 MHz – 65 MHz. Considering appreciable margin, DC power supply having capability 10kV, 10A is being designed. It should be floating, having good dynamic response with minimum overshoot and undershoot, minimum ripple in the output voltage, good regulation, fast switch off capability (Minimum store energy) and precision voltage setting.

To choose the topology, different schemes are explored for finalizing the applicability with our system. A detailed survey has been conducted on the commercial availability of the suitable components and their application. Modular based chopper controlled power supply is chosen which consists of 10 modules each of 1kV rating. Multi secondary transformer with 12 pulse rectifier has been used.

This paper describes the detailed design of anode power supply for pre-driver amplifier

NF82

Development of Prototype Solid State Amplifier for ICH RF Power Source

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Abstract

The Ion Cyclotron Heating and Current Drive (ICH & CD) system is to couple 20 MW Radio Frequency power to ITER plasma for heating and driving plasma current, in the frequency range of 35-65 MHz. There will be 8 RF sources to generate total 20 MW of RF power. Each RF source consists of two multistage amplifier chains (pre-driver, driver & final stage amplifiers), a wide band combiner, DC & AC power supplies and RF monitoring-control system along with measuring devices.

A solid state amplifier is used to drive 15kW vacuum tube-based pre-driver amplifier. The required output power from solid state amplifier is from 300-1000W depending on mode of operation of pre-driver amplifier. To validate the design concept, a prototype solid state amplifier (~10W) is simulated, fabricated using lumped component & tested successfully. This paper describes design, simulation, test procedure and test result of 10 W Solid State amplifier.

NF83

Initial Integrated Test of Pre-Driver Amplifier for ITER Ion Cyclotron System

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Abstract

An Ion Cyclotron (IC) system for ITER is planned in the frequency range of 35-65 MHz for plasma heating and current drive (H&CD) experiments. The complete IC system consist radio frequency (RF) sources, transmission line, matching networks and two antenna port plugs. The RF sources are being developed at ITER-India, IPR under Indian responsibility. A highly reliable and stable RF source system of such power level is desirable to couple 20MW total RF power into the plasma effectively during different experimental scenarios on ITER.

To achieve 20MW required RF power, there will be eight independent tunable RF Sources of 2.5MW and to get 2.5MW power two identical amplifiers chains of 1.5MW capability will be combined using a high power combiner. A single chain of 1.5MW amplifiers consists of cascaded low power RF components, low power amplifier and three stages of tube based high power tuned amplifiers.

The developmental activity for pre-driver amplifier (HPA-1) of 15kW capability is in progress. It will feed the drive power to the next driver stage (HPA-2) of the amplifier during initial phase of R&D program. Passive and active test is initiated after the completion of mechanical assembly and integration of required power supplies to the amplifier.
Initial test results of the pre-driver will be discussed in this paper.

EP01

Salient features of dust grains in a rotating plasma sheath

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Abstract

A theoretical study of the salient features of the negatively charged dust grains under the effect of slow rotation in a plasma sheath analogous to those observed in moons, asteroids and other atmospheres in planetary systems has been carried out. The Sagdeev potential equation has been derived to enumerate the sheath characteristics in rotating plasma. Due to the ubiquitous presence of dust in every plasma environment, the motivation is to investigate the interaction of charged dust grains levitated into the rotating plasma sheath. The size of the dust grains, the generation of surface potential and the net forces acting on it inside the sheath has been calculated for some chosen laboratory plasma parameters. The overall merit of the investigation lies in the observation of the forces on different dust sizes which provides an insight about the formation of the dust atmosphere.

EP02

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EP03

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EP04

Analysis of Electron Energy Distribution Function in Magnetically Filtered Complex Plasma

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Abstract

The electron energy distribution function (EEDF) is analyzed for a magnetically filtered plasma using double plasma

device [1] where the electron temperature (T_e) can be varied from 0.15 eV to 2.6 eV and plasma density from 10^6 to 10^9 cm^{-3}. It is observed that a typical Druyvesteyn type EEDF in pristine plasma may behave like Maxwellian type in presence of sufficient amount of dust grains. This experimental observation confirms the theoretical predictions of Denysenko *et al* [2] although the dust density in their report is in a higher side compared to us. All the experimental observations are done for the above said range of plasma temperature and plasma density for a wide range of dust density ranging from 0.16×10^4 to 4×10^4 cm^{-3}. Also it was observed that dust grains are unable to affect the characteristics of EEDF in low temperature (0.15 eV) and low density (10^6 cm^{-3}) plasma. We have also demonstrated the crucial role of T_e on dust charging by measuring dust charge for a wide range of T_e (0.15 to 2.6 eV) at different plasma density. The results show that rate of increase of plasma density also has effect on dust charging. However compared to plasma density rate of increase of dust charge is found to be higher with the rate of increase of plasma temperature. The imperative role of electron temperature on dust charge is thus well demonstrated with detail experimental results. Observed results are found to be in good agreement with existing theories.

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EP05

Low Frequency Dust Acoustic Solitary Waves in Pair-ions Superthermal Plasma

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Abstract

Pair Plasmas are characterized by the coexistence of two charged particle species which have equal masses and opposite charges of same values. In the number of laboratory experiments, Pair-ion plasmas have been reported. Superthermal particles are present in the most of space and astrophysical environments (e.g.in the solar wind, corona etc). The superthermal particles are modelled more effectively using non-Maxwellian (Kappa type) distribution. In the present problem, we consider plasma comprising of Pair-ions, superthermal electrons and charged dust grains. We have studied the properties of propagation of Dust Acoustic Solitary Waves (DASWs) of arbitrary amplitude. We have analyzed the effects of superthermality of electrons, concentration of ions and dust grains on the DASWs. It is observed that solitary structures are significantly modified by varying the various plasmas parameters.

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EP06

Electrostatic Solitary Structures in A Dusty Plasma With Nonextensive Electrons

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Abstract

The presence of dust in usual plasma generates new types of modes (e.g. dust-acoustic (DA), dust-ion acoustic (DIA) etc.). Over the last few years a large number of investigations have been reported to study the solitary structures with Maxwellian distribution and non-Maxwellian distribution. The q-nonextensive distribution have been used to study the properties of solitary waves in space and astrophysical plasmas. We have investigated the characteristics of propagation of electrostatic solitary waves in a plasma consisting of fluid ions, nonextensive electrons and charged dust grains. From the solutions of nonlinear equation, we study the electrostatic solitary structures of dust ion acoustic waves. The combined effects of dust concentration and nonextensitivity, have been studied numerically to trace their influence on the characteristics of solitary structures. It is observed that both type of solitary structures are formed for various values of the plasma parameters. Amplitude and width of the solitary structures increase/decrease with the variation of dust concentration as well as nonextensitivity of electrons. Whenever $q \to 1$ in non-Maxwellian case, it approaches to Maxwellian limit. The findings in this investigation may be important for understanding the nonlinear solitary structures in astrophysical and space environments.

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EP07

Experimental Observation of Growth of Graphite Dusts in Presence of Acetylene using Bipolar Pulsed Power Supply

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Abstract

Study of growth of graphite dust particles in a cylindrical chamber of SS-304 of diameter 400 mm & length 500 mm has been done using bipolar pulsed power supply. Erosion of dust particles levitated between two parallel electrodes of dimension 40mm X 30mm with different gaps between them. It is observed with the help of He-Ne laser scattering that the scattering intensity increases due to the addition of acetylene gas in Argon plasma. We will present the temporal

growth of graphite dusts with the discharge parameters, like discharge voltage and mass flow rate of gas mixture. We will also characterize the graphite dusts collected from the lower electrode with the help of SEM.

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EP08

Velocity Shear Driven Low Frequency Instability in A Strongly Coupled Inhomogeneous Media

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Abstract

The effect of velocity shear on low frequency shear mode in a strongly coupled fluid/dusty plasma is investigated using Generalized Hydrodynamical (GH) model. For inhomogeneous plasma density it is shown that velocity shear coupled the longitudinal dust acoustic mode with the shear mode. These combined elasto-acoustic mode may be driven unstable for finite velocity shear parameter. We have used the GH model to write a nonlocal equation for small velocity shear to demonstrate these modes and their corresponding instabilities. In the weak viscoelastic limit we recover hydrodynamic results as expected whereas in the strong viscoelastic regime additional convective term gives rise to velocity shear driven instability and elasto-acoustic mode coupling. In the homogeneous density limit, in absence of equilibrium velocity shear `shear mode' is recovered. Next, we have shown that for nonzero equilibrium velocity shear parameter `shear mode' is unstable and the corresponding growth rates are estimated. The physical consequence of such solutions is also discussed.

EP09

Shear Flow Instability in A Strongly Coupled Dusty Plasma

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Abstract

Linear stability analysis of strongly coupled incompressible dusty plasma in presence of shear flow has been carried out using the generalized hydrodynamical (GH) model. With the proper Galilean invariant GH model, a nonlocal eigenvalue analysis has been done using different velocity profiles. It is shown that the effect of elasticity enhances the growth rate of shear flow driven Kelvin- Helmholtz (KH) instability. The interplay between viscosity and elasticity not only enhances the growth rate but the spatial domain of the instability is also widened. The growth rate in various parameter space and the corresponding eigenfunctions will be shown.

EP10

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EP11

Bhupen Borah

New Nonlinear Eigen modes of Self-Gravitating Spherical Charged Dust Molecular Cloud

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Abstract

We present a nonlinear stability analysis for an idealistic field-free hydrodynamic model of self-gravitating massive charged dust molecular cloud in presence of dust grain velocity convection. The identical spherical dust grains are equally charged, but the cloud as a whole is electrically neutral on the Jeans scale. Application of a multiscale analytical method shows that the self-gravitational potential fluctuation dynamics is governed by a new type of modified Korteweg-de Vries-Burger (mKdV-B) equation that has a self-consistent linear driving derivative source arising due to the dust flow convection. A detailed numerical analysis of the eigenmode structures in the steady state is carried out. It is found that the self-gravitational potential fluctuations contribute in the form of new oscillatory shock-like structures because of gravito-electrostatic coupling. The distinctive features of the eigenmode profiles are discussed in detail. In addition, main conclusions relevant to astrophysical context are briefly presented

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EP12

Solitary Waves In A Self-Gravitating Dusty Plasma Near Critical Density Of Two-Temperature Electrons

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Abstract

Ion-acoustic waves in a self-gravitating dusty plasma consisting of warm positive ions, isothermal two-temperature electrons and negatively charged dust particles having charge fluctuations has been studied using the reductive

perturbation method. It has been shown that the nonlinear propagation of ion-acoustic waves in such a plasma can be described by an uncoupled third order partial differential equation which is a modified form of Korteweg-deVries (KdV) equation [1]. The solitary waves exist in this quantum plasma when the density of two-temperature electrons has some critical values. A modified K-dV (MK-dV) equation has derived near the critical density of the two-temperature electrons. The quasi-soliton solution of the ion-acoustic wave has been obtained from the MK-dV equation The effects of attachment c-efficient for dust charge fluctuations, gravity and two-temperature electrons on the ion-acoustic solitary waves are discussed with applications.

EP13

Effect of Thermal Inertia on Pulsational Mode Stability

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Abstract

The lowest order inertial correction of plasma thermal electrons plays a considerable function to reduce the threshold value of the ion Mach number at near the sheath-edge boundary [1]. This is, therefore, very likely to modify and destabilize plasma sheath induced collective dynamics in an idealistic two component plasma in hydrodynamic configuration. The nonlinear saturation of the lowest order inertia-triggered destabilization may thereby result in the form of various nonlinear eigenmodes like soliton, shock, etc. depending on the various plasma model conditions.

We propose an idealistic multi-fluid quasi-neutral plasma model in which the solid phase of the self-gravitationally interacting dust grain matter is embedded in the gaseous phase of the background plasma in the present contribution. In order to avoid mathematical complications; we ignore the effects of external field, collision, rotation, etc. The various plasma species are assumed to pre-have their respective global uniform flows. The heavier dust grains are partially charged (due to electronic thermal loss) in the plasma background. Such models indeed exist in astrophysical reality and exhibit the pulsational mode of self-gravitational collapse playing a responsible role in the star formation mechanism [2 & References therein]. The basic set of the governing equations of the present concern are developed in the normalized (by standard astrophysical scales [2]) form. Now, for our stability investigation on the dust-acoustic time scale, both the parent plasma electrons and ions are considered to behave like thermal species (lighter) as compared with the inertial dust grains (heavier). We, therefore, coin the terminology “thermal inertia” to mean the ‘lowest order inertial correction of both the parent plasma electrons and ions, simultaneously’ to be introduced from their respective inertia-corrected population density distributions [1]. We apply a standard nonlinear perturbative analysis [3] over the coupled set of the normalized dynamical equations against the well-defined gravito-electrostatic equilibrium. A non linear dynamical evolution equation (KdV-B type) is obtained to study the inertia-modified gravito-electrostatic mode structures (normally, of pulsational type) and dynamics in the presence of the plasma thermal inertial corrections. The main outcome and applicability of astrophysical interest, following the analytical and computational investigations over this equation, will summarily be presented in concise.

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EP14

Dust Cluster in Presence of Magnetic Field

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Abstract

The formation of dust cluster under screened Coulomb potential is studied in presence of an external magnetic field. A molecular dynamics code is developed to produce stable dust cluster. A modified form of interaction potential is taken to include the effect of magnetic field on plasma particles that take part in the screening process. It is quite interesting to see the dynamics of dust cluster in presence of magnetic field. This investigation will give an idea about dust-dust interaction in presence of magnetic field.

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EP15

Dust Charge Measurement and Wave Excitation in a DC Glow Discharge Dusty Plasma

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Abstract

Low pressure plasmas are useful to study spatial and temporal evolution of dusty plasma. The main objective is to study of excitation and propagation characteristics of nonlinear solitary/shock waves in a dusty plasma. In this presentation, we will highlight the development of the vacuum system and other experimental accessories, and plan of the experiments that will be performed in future. The vacuum system comprises of a SS-304 cylindrical chamber with diameter of 260 mm and length 800 mm. Chamber contains ten side ports of inner diameter 50 mm alongwith two end flanges. Base pressure is obtained as 1 X 10^{-5}mbar and operating pressure ranging from 2 X 10^{-2} mbar to 5 X 10^{-1} mbar. The axial and radial floating potential profile have been measured by using an Langmuir probe in a solid constricted anodic glow discharge plasma in order to determine the charge of dust particles levitating in the plasma sheath region. The dust charge is calculated from the force balance equation between the gravitational and the sheath electrostatic force at the levitation height for different Ar gas pressure and compared with the values obtained from OML theory. The average dust charge is

found to be of the order of 10^4e. Shock/solitary wave propagating in a 3D dusty plasma have also been excited.

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EP16

Ion Beam Driven Lower Hybrid Waves In a Magnetized Dusty Plasma Cylinder

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Abstract

An ion beam propagating through a magnetized dusty plasma cylinder drives lower hybrid waves to instability via cyclotron interaction. Numerical calculations and growth rate of the unstable mode has been carried out for the typical parameters of dusty plasma experiments. It was found that as the density ratio of negatively dust grains to electrons increases, the unstable mode frequency and the growth rate of the instability of the lower hybrid waves increases. Moreover, the growth rate of the instability scales as the one-third power of the beam current.

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EP17

Studies on IAW Propagation In Low-Pressure Hydrogen Plasma In Presence Of Dust

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Abstract

Steady state direct current hydrogen plasma is generated in a dusty plasma device using hot cathode filament discharge technique. The effects on plasma parameters as well as on ion acoustic wave propagation (IAW) are studied at different working pressure and at different discharge current. IAW have been launched using the SS mesh of diameter ~ 6.0 cm with a combination of function generator and a power amplifier [1-3]. Micron size dust particles are injected into the plasma volume with help of an electrically controlled dust dropper. Plasma parameters namely plasma density and

temperature are measured using a cylindrical Langmuir probe. A planner Langmuir probe (diameter of the plate 4.5 m.m.) is used to study the effect on IAW propagation in presence of dust at different conditions. The probe position can be changed axially. By moving the probe away from the exciter, both the phase delay and the wave attenuation are measured. The current carried by dust grains in plasma background is measured using a combination of Faraday cup and a sensitive electrometer [4-6]. The phase velocities of the IAW are measured using time of flight method and its effect due to the presence of dust in plasma background is examined.

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LP01

Design of twin core nonlinear photonic crystal fiber for the all optical coupling and switching applications

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Abstract

We investigate the all optical coupling and switching dynamics through the twin core nonlinear photonic crystal fiber by modeling suitable photonic crystal fiber (PCF) geometry. The twin core fiber achieved from the PCF exhibits the very high dispersion and nonlinearity compared to that of convention optical fiber, which are the key properties governing the optical switching between the cores [1,2]. From the proposed design the necessary optical parameters namely the dispersion, nonlinear index, coupling length and extinction coefficient are calculated using the finite element method. The coupler system modeled is studied by a set of coupled nonlinear Schrödinger equations (CNLSE) [3] with incorporating the optical parameters calculated using the FEM. The dynamical and switching properties of the proposed system are explored using the split step Fourier method (SSFM). A transmission curve is also made to study the switching efficiency of the system is made and compared with that of the convention fiber.

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LP02

Vikram Sagar

LP03

The effect of plasma channel on the self-distortion of laser pulse propagating through the collisional plasma channel

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Abstract

In the present paper, laser pulse distortion / beam breakup and the effect of the plasma channel on the laser propagation through the plasma has been studied by using the moment theory approach. It has been observed that, when the laser

beam propagates through the homogenous plasma, the low intensity front and rear part of the laser pulse gets defocused/diffracted. This is due to the fact that, the refractive index profile modified by the low intensity front and rear part of the pulse is insufficient to cause focusing of these parts of the pulse. The high intensity central/main portion of the pulse gets self guided due to the effective focusing of this portion of the pulse.

As a result of the focusing and defocusing of the different portions of the pulse, the laser pulse gets distorted. This distortion of the laser pulse has not been observed when the laser beam is propagated through the plasma channel having density minimum at the axis and maximum at the edges, the laser pulse is guided as a whole, even the low intensity front and rear parts of the laser pulse are also guided. Therefore, the plasma channel is useful to prevent the distortion / beam breakup of the pulse. Such guided propagation of the laser beam up to several Rayleigh lengths through the plasma region without beam breakup is useful for the physics of laser induced fusion, electron acceleration and other heating experiments.

LP04

LP05

Sonu Sen

LP06

Effect of Laser Intensity on the Spatial Coherence of High Order Harmonic Radiation Generated from Plasma Plume

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Abstract

High order harmonic generation (HHG) from plasma plume is now a well-established technique for generation of coherent extreme ultraviolet (XUV) radiation. Here, the high order harmonics are generated by the interaction of ultrashort intense laser pulses with plasma plumes [1] instead of a gas jet. The measurement and optimization of spatial coherence of this radiation is highly desirable for application in fields such as XUV interferometry of dense plasma [2], coherent diffractive imaging [3], interference lithography [4], etc. The optimization provides a tool to control the spatial coherence of source for specific application. As the intensity of generated harmonic radiation depends on the laser intensity, it is important to optimize the spatial coherence of HHG with laser intensity. We have studied the dependence of spatial coherence of HHG from plasma plume on the intensity of laser.

The plasma plume was generated by focusing a low intensity (10^9-10^{10} W/cm^2) uncompressed (200 ps) laser pulse (referred to as "pre-pulse") on a solid target placed in a vacuum chamber evacuated to 10^{-5} mbar. After delay of ~50 ns, the femtosecond pulse (~45 fs) was focused in the plasma plume at intensity ~10^{15} W/cm^2 and generated harmonic radiation was analyzed using an in-house developed XUV spectrograph. The spatial coherence was studied using Young's double slit interferometry. Double slits of slit width 30μm and slit separation 100 μm were used in the study and was inserted before XUV spectrograph. The laser intensity was varied by moving the focusing lens position to shift the laser focus relative to plasma plume. By doing so, the focal spot size at the entrance of plume changes and thereby the

intensity of driver laser pulse changes.

It is observed that, initially with increase in laser intensity, the fringe visibility increases, reaches a maximum at laser intensity ~$3x10^{15}$ W/cm^2, and decreases thereafter. We have also studied the dependence spatial coherence on the laser pulse producing the plume. The fringe visibility reduces to zero when this pulse is focused right on the target surface. On moving laser focus away from target surface, the fringe visibility increase but remains constant up-to an intensity of 10^{12} W/cm^2.

The details of the experiment and results will be presented, and our present understanding of the physics aspects related to the results will be discussed.

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LP07

Measurement of the Coherence of a Soft X-ray Laser by Interferometry

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Abstract

Development of x-ray lasers has been a major technological advancement in the scientific arena. Due to their extraordinary properties like short wavelength (few tens of nanometers to few nm), high monochromaticity (bandwidth ~ 10^{-4}), low divergence (~ few mrad), and good temporal and spatial coherence (> 100 μm), these lasers have applications in wide areas of science and technology [1, 2]. X-ray lasing has been successfully realized for the first time in India at RRCAT, Indore, at 46.9 nm, in argon plasma, using the Capillary Discharge System [3]. This has been achieved by passing very high and fast current (~ 40 kA, with rise time of 50-60 ns) through an argon filled capillary. This current pulse is generated by charging a waterline capacitor upto 325 kV using a Marx bank, and discharging it rapidly through the argon gas through a self-triggered spark gap acting as a fast switch. A small pre-pulse (~20A, few μs before the main current) applied across the gas converts it into a plasma of few eV temperature. This formation of cold plasma ensures uniform magnetic compression during the passage of main current, leading to formation of a hot, dense plasma column which acts as the gain medium for x-ray lasing. Under optimized conditions of various parameters like main discharge current, pre-discharge current, their time delay, gas pressure in capillary etc., x-ray laser pulses of ~ 1ns (FWHM) duration, with beam divergence ~3.5 mrad, have been obtained. The spectroscopic measurements using a transmission grating spectrometer (TGS) confirmed the wavelength to be 46.9 nm.

In order to measure the degree of spatial coherence of this laser beam, Young's double slit experiment was performed using the laser beam. A double slit having 30 μm slit width and 120 μm slit separation was placed at a distance of 88 cm from the capillary end. It is essential that the incoming laser beam maintains spatial coherence for a width exceeding the slit separation. A quadrant vacuum diode was used to locate the centre of the laser beam and to place the double slit precisely in its path. As the laser beam passes through these double slits, secondary wavefronts are generated due to diffraction, which are made to interfere in space forming fringes. This fringe pattern was recorded using a micro channel plate detector. The detector was placed at large distance (1.7 m) from the double slit in order to resolve

the fringes properly. The interference fringe pattern was successfully recorded. The fringe separation was measured to be ~ 682 micron, which was in good agreement with the laser wavelength of 46.9 nm. The fringe visibility was found to be > 90% which indicates good coherence property of this x-ray laser beam. Further experiments to quantify the coherence of this x-ray laser beam are presently underway using multiple sets of slits.

Details of the experiment will be presented and the results will be discussed.

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LP08

Excitation of Electron Plasma Wave by Cross Focusing of Two Intense Laser Beams in Nonparaxial Region: Relativistic Ponderomotive Regime

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Abstract

The combined effect of relativistic and ponderomotive nonlinearties on the cross focusing of two intense laser beams in homogeneous plasma (laser intensity: 10^{20} W/cm^2) and the excitation of electron plasma wave at difference frequency ($\Delta\omega \approx \omega_1-\omega_2 \approx \omega_p$) has been studied in the nonparaxial region. These nonlinearties depend not only the intensity of one laser but also in the second laser. Cross focusing of laser beams in plasma takes place when the dynamics of one laser beam is affected by the second laser. Modified coupled equations for the beam width of laser beams, power of the electron plasma wave and energy gain at difference frequency has been obtained, when relativistic and ponderomotive nonlinearties are operative. These coupled equations are solved analytically and numerically to study the laser intensity in

the plasma, variation of the amplitude of the electron plasma wave and energy gain. By expanding the eikonal and other relevant quantities up to the fourth power of *r* (radial distance) and combined effect of both nonlinearties, it is observed that the focusing of laser beams becomes fast in the nonparaxial region. The difference in focusing/defocusing of the axial and off-axial rays leads the formation of the splitted profile of laser beams in the plasma. It has also been observed that there is a remarkable change in the amplitude of the excitation of electron plasma wave and particle acceleration in the nonparaxial region in comparison to the paraxial region, when both nonlinearties are taken in to account.

LP09

Studies of Light Absorption, Energy Transfer and Plasma Dynamics Processes in Laser Irradiated Low Density Foams and Comparison with Solid Target

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The studies of laser light absorption and scattering, plasma production and homogenization, energy transfer, and x-ray conversion in low-density volume-structured media irradiated by powerful laser beams [1-3] have opened up new opportunities for resolving a number of scientific and technical problems, in the fields of Inertial Confinement Fusion, development of powerful coherent and incoherent X-ray sources, Equation-of-State investigations in conditions of extreme energy density, etc. For instance, foam layers could be used for the improvement of the spherical symmetry of direct-drive inertial fusion [4].

In this paper, the interaction of high power laser with low density polymer foam with density as low as 2 mg/cc, 4 mg/cc, 20 mg/cc 30 mg/cc and 50 mg/cc targets are investigated and compared with solid polymer targets. Low-density triacetate cellulose (TAC) targets with various densities have been irradiated with intense Nd:Glass laser. The absorption is volumetric with a high lateral thermal transport. As the density of the targets increases, the laser absorption mechanisms are similar to that in a solid target. It is observed that the laser absorption in a target with density close to critical density is about 80%. This has also been demonstrated by measuring x-ray flux. At a constant laser flux the soft and hard x-ray fluxes are decreases with increase of target density. The soft x-ray yield in the spectral range (0.7 – 1.56 keV and >0.8 keV) from the subcritical foam targets (2mg/cc) is 2 times higher than the supercritical targets (50 mg/cc). The hard x-ray yield from 2 mg/cc foam target is 2 times higher than from 50 mg/cc and 14 times higher than solid polymer target with density 1.26 g/cc. The foil velocity in the laser direction and lateral heat transport decreases with the increase in the foam density. The velocity of the accelerated foil of 2 mg/cc measured was1.5 x 10^7 cm/s and reduced to 3.8 x 10^6 cm/s for solid polymer target of density 1.26 g/cc.

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LP10

Propagation of Intense Laser Beam through Density Profiles Plasma for Inertial Confinement Fusion

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Abstract

In this work propagation of laser beam through different density profiles plasma is analyzed. Employing the expression for the dielectric function of different density profile plasma, a differential equation for beamwidth parameter is derived under WKB and paraxial approximation. The laser induces modifications of the dielectric function through nonlinearities. It is found that density profiles plays vital role in laser-plasma interaction studies. The spot size of the laser beam decreases as the beam penetrates into the plasma and significantly adds self-focusing in plasma. This causes the laser beam to become more focused by reduction of diffraction effect, which is an important phenomenon in Inertial Confinement Fusion. Numerical computations are presented and discussed in the form of graphs for typical parameters of laser plasma interaction.

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LP11

Keshav Walia

LP12

Keshav Walia

LP13

Keshav Walia

LP14

Optical Guiding of Circularly Polarized Laser Beam through Axially Inhomogeneous Magnetized Plasma

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Abstract

In the present work optical guiding of circularly polarized intense laser beam through axially inhomogeneous magnetized plasma is investigated. The laser beam propagating along the static magnetic field, parallel to oscillating magnetic field in

plasma at relativistic intensities. The laser induces a large oscillatory velocity on electrons, raising their mass and lowering the plasma frequency, further, rising due to cyclotron resonance effect. Based on WKB and paraxial ray theory, an appropriate expression for a dielectric tensor has been evaluated in the presence of an externally applied magnetic field. The nature of propagation is characterized through the critical-divider curves in the normalized beamwidth with power plane. The propagation equation relating the variation of beamwidth parameter with distance of propagation, self-trapping conditions for optical guiding through axially inhomogeneous magnetized plasma are evaluated. For given values of normalized density (ω_p / ω) and magnetic field (ω_c / ω) the regions are namely steady divergence, oscillatory divergence and self-focusing. The results suggest strengthening of outside magnetic field enhances the relevant effect of self-focusing. The computational results are presented in the form of graphs and discussed.

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LP15

Self Focusing of Intense Short Pulse Laser in Air: Effect of Saturating Nonlinearity

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Abstract

A model of relaxing nonlinearity is developed to study the self focusing of an intense short pulse laser in air in the paraxial ray approximation [1]. This nonlinearity arises due to Kerr effect and we have retained terms upto the square of laser intensity in the dielectric susceptibility. The saturating nonlinearity has the decisive role in deciding the pulse duration suitable for long range propagation through atmosphere. For typical nonlinearity saturation time of ~20 ps, it is found that shorter duration pulses(~10 ps) will be suitable as they undergo periodic self-focusing without producing plasma channel [2] which in term tends to defocus the beam.

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LP16

Relativistic Ponderomotive Cross-Focusing of Two Electromagnetic Beams in an Inhomogeneous Plasmas

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Abstract

This paper presents an analysis of relativistic cross focusing of two electromagnetic beams in an inhomogeneous plasma. The non-linearity in the dielectric constant arises an account of the relativistic ponderomotive force. The non-linearity depends not only on the intensity of one beam but also on the second beam. The fact that the ponderomotive force is dependent on the intensities of both the beams, leads to cross focusing. Dynamics of one beam affects the dynamics of the second beam. When both the beams are strong the non-linearities introduced by the relativistic effect are additive in nature, such that one beam can undergo oscillatory self-focusing and other simultaneously defocusing and vice versa. It is found that, when the power of the strong beam equals the critical power, the medium provides an oscillatory wave-guide for the weak beam. Relativistic cross focusing has relevance in plasma beat wave excitation and laser particle accelerators.

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LP17

Stimulated Brillouin Scattering of Gaussian Laser Beam in Collisionless Magnetoplasma

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Abstract

In the present work, self-focusing of Gaussian laser beam in collisionless magnetoplasma and its effect on Stimulated Brillouin Scattering process is investigated. When the incident beam is propagating along the direction of externally applied static magnetic field, then there are two modes of propagation, viz., extraordinary and ordinary mode. Consequently, the redistribution of carriers is affected by the change in strength of static magnetic field. On account of Gaussian intensity distribution of laser beam, the time independent component of the ponderomotive force along a direction perpendicular to the beam propagation becomes finite, which modifies the background plasma density profile in a direction transverse to pump beam axis. This modification in density affects the incident laser beam, ion-acoustic wave and back-scattered beam. Nonlinear differential equations for the beam width parameters of the main beam, ion-acoustic wave, back-scattered wave and SBS-reflectivity have been set up and are solved numerically. Effect of focusing/defocusing of waves involved in the process on SBS back-reflectivity is investigated. It is observed from the analysis that focusing of waves greatly enhances the SBS reflectivity.

LP19

Effect of Impactor Material and Thickness on Impact Driven Shock in Al foil

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Abstract

Laser-driven acceleration of matter to velocities of several hundred or thousand kilometers per second enables laboratory experiments with high-temperature impact-driven plasma as well as investigations into the physics of impact fusion and also for the development of this approach for fast ignition ICF concept [1]. The impact by laser-accelerated projectile [2] is an effective method to ignite the preliminarily compressed ICF-target, along with the action of fast electron or ion beams. Such an approach known as the "impact fast ignition" concept [3] is being actively studied now. Another application of laser driven impactor experiment is in isentropic compression. Traditionally high pressure multi-Mbar states have been accessed by launching a near instantaneous compressive shock into the material. But, shock waves are associated with large jumps in temperature which greatly increases the thermal contribution to the pressure and can cause melting of the material under study. A recently developed technique which shocklessly (quasi isentropic) compress materials into the multi-Mbar pressure regime over tens of nanoseconds timescales prevents excessive heating of the targets. In this technique, an ablatively driven shock in a primary target (impactor or reservoir) is transformed into a ramp compression wave in a secondary target via unloading followed by stagnation across an intermediate vacuum gap [4, 5].

In this paper, we present the characterization of thickness and material of the impactor on shock generation in targets. A 5J, 1.060µm, 980ps, Nd: Glass laser system with a focusable intensity of ~6.5×10^{13}W/cm^2 was used in the experiment. The impactors used in the experiment were 2µm Aluminum, 5µm Aluminum and 6µm Polycarbonate foils

while the target used was 5µm Aluminum. The movement of the impactor and target foils was measured using multi frame optical shadowgraphy technique. It was observed that the 2µm Al impactor was more efficient in accelerating and compressing the target than the other impactor foils. The free surface velocities of the 2µm Al impactor and 5µm Al target were measured as 3.8×10^6cm/s and 1.4×10^6cm/s respectively. The shock velocity and shock pressure thus generated in 5µm Al target by 2µm Al impactor were estimated to be 1.5×10^6cm/s and 2.9Mbar respectively

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LP20

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LP21

THz Radiation Generation via Laser-Magnetized Plasma Interaction

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Abstract

Terahertz radiation generation due to propagation of a mildly relativistic laser pulse in homogeneous plasma embedded in a uniform magnetic field, has been analytically studied. This method involves perturbative expansion of the laser strength parameter $a_o (= eE_0 / mc\omega_0$, where E_0 and ω_0 are respectively, the electric field amplitude and frequency of the laser pulse) [1] and weak applied magnetic field (ω_c / ω_p <1,where ω_c and ω_p are respectively, the cyclotron frequency and plasma frequency), to obtain the electric & magnetic wakefields and hence terahertz radiation, generated in the wake of the laser pulse. The uniform magnetic field is applied along a direction perpendicular to the direction of propagation as well as the direction of polarization of the linearly polarized laser pulse.

The generated wakefields due to sinusoidal laser pulse tend to maximize when $L \sim \lambda_p$ [2]. It is observed in the broad beam limit $(r_0 >> L)$ that the mutually perpendicular transverse electric and magnetic wakefields have the same amplitude and oscillate with the plasma frequency, thus generating Terahertz radiation. This electromagnetic radiation field is generated due to the coupling of the second-order slow plasma electron velocities with the externally applied transverse magnetic field.

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LP22

Relativistic Interaction of Laser Beam in Magnetized Plasmas

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Abstract

This paper presents effect of self-focusing on circularly polarized beam propagating along the static magnetic field when the extraordinary and ordinary modes are present simultaneously for relativistic intensities. The nonlinearity in the dielectric function arises on account of the relativistic variation of mass, which leads to mutual coupling of the two modes that support the self-focusing of each other. Propagation and focusing one mode affects the propagation and focusing of the second mode. The fact that the two modes are laser intensity dependent leads to cross focusing. Dynamics of one laser beam affects the dynamics of the second laser beam. When both the beams or modes are strong the nonlinearities introduced by the relativistic effect in presence of magnetic field are additive in nature, such that one beam

can undergo oscillatory self focusing and other simultaneously defocusing and vice-versa .The dynamical equation governing the cross focusing has been setup and a numerical solution has been presented for typical relativistic laser – plasma parameters.

LP23

Transverse Emittance Measurement Studies of a Deuteron Ion Source Beam

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Abstract

A 400 keV, 1 mA deuteron radio frequency quadrupole (RFQ) based neutron generator is being developed at BARC [1]. A radio frequency (R F) plasma ion source (Alphatross, NEC) is used for deuteron generation. A low energy beam transport (LEBT) consisting of two solenoid magnets matches the 50 keV deuteron beam from the accelerating column to the RFQ [2]. A slit - wire scanner based emittance measurement setup is used for the transverse emittance measurements of D^+ beam in the LEBT. The details of the emittance measurement setup and experimental results will be presented.

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LP24

Stimulated Raman Scattering of a Circularly Polarized Laser Beam in Magnetized Plasma

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Abstract

Stimulated Raman scattering of a laser beam is studied in the presence of a static magnetic field. The laser beam propagates along the applied magnetic field as a right/left hand circularly polarized wave. Growth rate is calculated for both backward and forward (three wave as well as four wave) Raman processes. It has been demonstrated that the growth rate of right/left hand circularly polarized wave is increasing in backward Raman process as well as forward three wave Raman process while drastically decreasing in forward four wave Raman process with increasing the magnetic field value.

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LP25

Measurement of the Coherence of a Soft X-ray Laser by Interferometry

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Abstract

Development of x-ray lasers has been a major technological advancement in the scientific arena. Due to their extraordinary properties like short wavelength (few tens of nanometers to few nm), high monochromaticity (bandwidth ~ 10^{-4}), low divergence (~ few mrad), and good temporal and spatial coherence (> 100 μm), these lasers have applications in wide areas of science and technology [1, 2]. X-ray lasing has been successfully realized for the first time in India at RRCAT, Indore, at 46.9 nm, in argon plasma, using the Capillary Discharge System [3]. This has been achieved by passing very high and fast current (~ 40 kA, with rise time of 50-60 ns) through an argon filled capillary. This current pulse is generated by charging a waterline capacitor upto 325 kV using a Marx bank, and discharging it rapidly through the argon gas through a self-triggered spark gap acting as a fast switch. A small pre-pulse (~20A, few μs before the main current) applied across the gas converts it into a plasma of few eV temperature. This formation of cold plasma ensures uniform magnetic compression during the passage of main current, leading to formation of a hot, dense plasma column which acts as the gain medium for x-ray lasing. Under optimized conditions of various parameters like main discharge current, pre-discharge current, their time delay, gas pressure in capillary etc., x-ray laser pulses of ~ 1ns (FWHM) duration, with beam divergence ~3.5 mrad, have been obtained. The spectroscopic measurements using a transmission grating spectrometer (TGS) confirmed the wavelength to be 46.9 nm.

In order to measure the degree of spatial coherence of this laser beam, Young's double slit experiment was performed using the laser beam. A double slit having 30 μm slit width and 120 μm slit separation was placed at a distance of 88 cm from the capillary end. It is essential that the incoming laser beam maintains spatial coherence for a width exceeding the slit separation. A quadrant vacuum diode was used to locate the centre of the laser beam and to place the double slit precisely in its path. As the laser beam passes through these double slits, secondary wavefronts are generated due to diffraction, which are made to interfere in space forming fringes. This fringe pattern was recorded using a micro channel plate detector. The detector was placed at large distance (1.7 m) from the double slit in order to resolve the fringes properly. The interference fringe pattern was successfully recorded. The fringe separation was measured to be ~ 682 micron, which was in good agreement with the laser wavelength of 46.9 nm. The fringe visibility was found to be > 90% which indicates good coherence property of this x-ray laser beam. Further experiments to quantify the coherence of this x-ray laser beam are presently underway using multiple sets of slits.

Details of the experiment will be presented and the results will be discussed.

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LP26

Laser Wake-field Acceleration in Laser Produced Plasma Plume Target

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Abstract

The process of laser wake-field acceleration of electrons has attracted considerable attention, particularly during the last few years, due to the possibility of making compact size electron accelerator [1]. Theoretical and experimental studies gave rise to a new acceleration regime called "bubble regime", which could produce well-collimated mono-energetic electron bunches. Some experiments have observed mono-energetic electron bunches even in strongly self-modulated laser wake-field regime [2]. The effect of various laser parameters on the electron acceleration mechanism has been studied and it was found that a controlled amount of pre-pulse pedestal ahead of the femto-second laser pulse can enhance the laser guiding leading to higher electron energy [3]. In search of stable and high-quality electron beam generation, a variety of targets *viz.* gas jets, preformed plasma channels, steady state gas flow etc. have been investigated. Plasma plume is one candidates (not been studied much) which has additional benefit of being easy to produce and has potential for high-rep rate operation.

In this work, we experimentally demonstrate generation of quasi-mono-energetic electron beam in plasma plume, by self-guided laser-driven electron acceleration. The experiment was carried out using plasma plumes produced from the ablation of nylon ($C_{12}H_{22}O_2N_2$) target by focusing the second harmonic of Nd:YAG laser (derived from the pump of the Ti:sapphire laser final amplifier) with 40 mJ energy, 12 ns duration, to a peak intensity of 10^{10} Wcm^{-2}. A 45 fs laser pulse from Ti:sapphire laser system with 4 TW peak power in the focal spot of ~6 μm and peak intensity ~ 6×10^{18} Wcm^{-2} interacted with the plasma plume, parallel to the target surface, at a variable distance and a fixed delay of 90 ns w.r.t. the plasma forming laser pulse. The plasma density was varied *in situ* by changing the distance between the fs laser beam axis and the target surface. At the optimum interaction conditions, a high quality electron beam, with divergence ~10 mrad and energy around 10 MeV, with quasi-mono-energetic feature, was produced. The electron beam had about 1 nC charge and showed good reproducibility and pointing stability. The laser produced plasma plume enables fast time scale of hydrodynamic expansion to form appropriate plasma density profile and significantly reduces the amount of material released into vacuum chamber. It was observed that the plasma plume production at repetition rate of 10 Hz did not affect the vacuum conditions much. These results are encouraging for a number of applications which require high quality electron beam at comparatively high repetition rate from a compact and low cost set-up.

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LP27

Effect of Laser Intensity on the Spatial Coherence of High Order Harmonic Radiation Generated from Plasma Plume

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Abstract

High order harmonic generation (HHG) from plasma plume is now a well-established technique for generation of coherent extreme ultraviolet (XUV) radiation. Here, the high order harmonics are generated by the interaction of ultrashort intense laser pulses with plasma plumes [1] instead of a gas jet. The measurement and optimization of spatial coherence of this radiation is highly desirable for application in fields such as XUV interferometry of dense plasma [2], coherent diffractive imaging [3], interference lithography [4], etc. The optimization provides a tool to control the spatial coherence of source for specific application. As the intensity of generated harmonic radiation depends on the laser intensity, it is important to optimize the spatial coherence of HHG with laser intensity. We have studied the dependence of spatial coherence of HHG from plasma plume on the intensity of laser.

The plasma plume was generated by focusing a low intensity (10^9-10^{10} W/cm^2) uncompressed (200 ps) laser pulse (referred to as "pre-pulse") on a solid target placed in a vacuum chamber evacuated to 10^{-5} mbar. After delay of ~50 ns, the femtosecond pulse (~45 fs) was focused in the plasma plume at intensity ~10^{15} W/cm^2 and generated harmonic radiation was analyzed using an in-house developed XUV spectrograph. The spatial coherence was studied using Young's double slit interferometry. Double slits of slit width 30μm and slit separation 100 μm were used in the study and was inserted before XUV spectrograph. The laser intensity was varied by moving the focusing lens position to shift the laser focus relative to plasma plume. By doing so, the focal spot size at the entrance of plume changes and thereby the intensity of driver laser pulse changes.

It is observed that, initially with increase in laser intensity, the fringe visibility increases, reaches a maximum at laser intensity ~3x10^{15} W/cm^2, and decreases thereafter. We have also studied the dependence spatial coherence on the laser pulse producing the plume. The fringe visibility reduces to zero when this pulse is focused right on the target surface. On moving laser focus away from target surface, the fringe visibility increase but remains constant up-to an intensity of 10^{12} W/cm^2.

The details of the experiment and results will be presented, and our present understanding of the physics aspects related to the results will be discussed.

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LP28

Study of Gold Plasma Using Laser Induced Breakdown Spectroscopy

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Abstract

Our work presents results from spectroscopic investigations of gold samples by the Laser Induced Breakdown Spectroscopy(LIBS). Qualitative and quantitative studies using LIBS was done to evaluate the presence of radioactive

elements such as Iridium and Ruthenium. The traces of Ruthenium were found in one of the sample. Traces of copper, silver, titanium, iron, molybdenum, zirconium, rhodium were also observed. Comparative analysis with X-ray Photoelectron spectroscopy (XPS) and Energy Dispersive Spectroscopy(EDS) techniques is also reported. LIBS technique is found to be more efficient, simple and cost effective method than other techniques.

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IP01

Doped Cerium Oxide Nanostructures as Thin Film Electrolyte For ITSOFC

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Abstract

Energy demand of the world increases day by day due to rapid industrialization and population growth. But due to faster depletion of the fossil fuels, it is essential to venture alternative and renewable clean energy systems. Solid oxide fuel cell (SOFC) is one of the most efficient clean energy solutions with an additional advantage of fuel flexibility. But SOFC suffers from high operating temperatures, which limits the application due to material degradation. Reduction of operating temperature of the SOFC to intermediate temperature (300-700ºC, ITSOFC) minimizes the material degradation. Among the various components of SOFC, electrolyte plays a vital role in determining the efficiency of SOFC. The challenge is to design electrolyte material with minimum ionic conductivity of $0.1 Scm^{-1}$. Present work focuses on the synthesis of cerium oxide and 20mol% of samarium doped cerium oxide nanoparticles (SDC) electrolytes through co-precipitation technique and thin film deposition of these powders as precursor material using e-beam evaporation. . XRD, SEM, XRF, optical absorption studies and impedance spectroscopic analysis were used to analyze both synthesized powder and thin film. XRD results indicated the presence of cubic fluorite structure for both ceria and SDC without any phase separation and a shift in the peak position towards lower angle was observed for SDC due to lattice expansion while XRF results confirmed the presence of the stoichiometric amount of samarium (20mol%) for SDC. XRD and XRF results indicated the complete doping of samarium in the host lattice of cerium oxide. Optical absorption spectra exhibited a slight shift in band gap energy for SDC (2.80 eV) compare to that of pure cerium oxide (2.88 eV). Study of surface morphology of thin film with respect to the annealing temperature carried out through the SEM. The film thickness and porosity changes were estimated by using reflectance spectra of the deposited film. CeO_2 and $Ce_{0.9}Sm_{0.2}O_{2-\delta}$ precursor nano powders were annealed at different temperatures to investigate the influence of grain size and surface morphology of the deposited thin film.

IP02

Phase Transition Dynamics in Ceria-Zirconia Nano Composites

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Abstract

Cerium oxide (CeO_2) and Zirconium oxide (ZrO_2) have potential applications in various fields of engineering including

that of energy. Doped ZrO_2 and CeO_2 are used as electrolyte materials for high and intermediate temperature solid oxide fuel cells (SOFC), respectively. The performance of the electrolyte which determines the efficiency of SOFC system depends on the phase property of the material. In the present work, we report the effect of phase transition in ZrO_2 upon the addition of CeO_2 nanomaterials and analyzed the properties through X-ray diffraction (XRD), X-ray fluorescence spectroscopy (XRF), optical absorption spectra, scanning electron microscopy and TG-DTA / DSC. Various compositions of $CeO_2 - ZrO_2$ mixed oxides ($Ce_xZr_{1-x}O_2$, where x= 0 to 1) were synthesized by co-precipitation method under basic conditions. XRD analysis shows the formation of amorphous ZrO_2 and crystalline ceria and ceria-zirconia nano composite in the as prepared conditions at room temperature. For various compositions, on increasing the annealing temperature of $CexZr_{1-x}O_2$, the crystallinity of ZrO_2 gets modified. TG-DTA/DSC analysis of pure ZrO_2 shows a sharp change in phase transformation at various temperatures, while that of $Ce_xZr1_{-x}O_2$ has a broad peak. Stoichiometry of the composite was confirmed through XRF studies. Optical absorption spectrum shows a slight shift in band gap with change in composition. Surface morphology and quantitative analysis of the samples were studied using SEM. The effect of annealing on structural, optical and phase transition behavior and electrolyte properties of nano composites will be presented.

IP03

Kinetics in N_2 - H_2 Non-Equilibrium Plasma Sheath of a Negatively Biased Substrate

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Abstract

Ion sheath develops over a negatively biased substrate immersed in plasma and shields the effect of the external bias. The positively charged species accelerated due to the sheath potential impinge on the biased surface. This process is utilized for modification of the surface characteristics of the substrate. Plasma surface interaction in nitrogen rich plasma is utilized for case hardening of the negatively biased surfaces. Plasma assisted nitriding is a well developed technique for increasing the surface hardness. The process is energy efficient, environment friendly and versatile to treat samples of various shapes and sizes. In this industrially established process research emphasis is on the basic understanding of the migration of ions, electrons and radicals towards the surface. Particle kinetics plays important role in the plasma surface interaction. At low working pressures, the plasma electrons attain temperatures higher than that of the ions and neutrals. The kinetics of the multi-species plasma used in the nitriding process is rather complex because of the presence of neutral molecular species, radicals, ions and electrons. We have investigated the kinetics in $N_2 - H_2$ non-equilibrium, weakly ionized, hot cathode arc discharge plasma which is used for the surface nitriding. The hot cathode arc discharge plasma source is monitored independently to optimise the plasma and the work piece parameters.

IP04

Abhishek Sharma

IP05

Low Pressure RF Discharge Plasma for Cleaning of Carbon Contamination on Optics

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Abstract

The deposition of carbon layer on optics due to prolonged use in extreme ultraviolet (XUV) / soft x-ray region is a serious issue that reduces the efficiency of grazing incidence optics drastically. This may result in the reduction of reflectivity of mirrors or reduction of diffraction efficiency of gratings. The deposition of carbon layer on the optics surface leads to a low electron density layer that lowers the critical angle and thereby raises the lower wavelength reflectivity cutoff of the grazing incidence optics. Low pressure RF discharge is a technique frequently used for recovery of carbon contaminated optics, both online [1] and off-line [2]. This technique has been used for cleaning of different optical components like multilayer mirrors [3,4], gratings [4] etc.

At RRCAT, we have installed an RF plasma cleaning setup for cleaning of carbon contamination of optics. RF plasma is generated by a commercial 13.56 MHz source that can deliver a maximum average power of 300 W. This RF power is fed to a parallel plate electrode (200 mm x150 mm) through a vacuum feed through, and argon gas is used as the medium for plasma generation. Before starting the cleaning of optics, the plasma chamber is evacuated to 10^{-5} mbar. The pumping speed is then controlled by using a small diameter right angle valve attached to the chamber. In the experiment, we have used low RF power (10 W-20 W) fed to the electrodes for optics cleaning. The argon gas pressure is manually controlled by a needle valve to set pressure inside the plasma chamber, and gas pressure is monitored using a pirani gauge installed in the system.

The factors that are critical for cleaning of contaminated optics are: a) the RF power and b) the gas pressure used for plasma creation. The optimization of these two parameters is important to restore the reflectivity of optics. In the initial experiments, cleaning of a grating was performed using argon gas pressure of 0.08 mbar (the optimum pressure reported by other groups in similar experiments [1]). The RF power used in this cleaning was ~ 20 W and the sample was cleaned for ~1 hour. For comparison, half part of the sample was covered with a Teflon tape and other half was left uncovered. After the cleaning process, the contrast between the cleaned and un-cleaned surface was clearly observed without affecting the gold coating inside.

For quantitative estimation, a 150 nm thick carbon layer was deposited over a 450 nm thick molybdenum (Mo) layer on a glass slide. The sample was cleaned at a power of 20 W and Ar pressure of ~0.08 mbar. The reflectivity measurement of the cleaned sample was carried out using a hard x-ray (~ 8 keV) Coolidge tube. In the measurement, it was found that the carbon layer was completely removed. To estimate the cleaning rate, the RF power was lowered to 10 W at argon pressure of 0.04 mbar and sample was cleaned for 30 minutes. The reflectivity was measured again. The reflectivity measurement showed that the 100 nm carbon layer was removed. This gives an estimate of the carbon removal rate to be ~3.5 nm/minute for 10 W RF power and at Ar pressure of 0.04 mbar. The surface quality of the sample after cleaning was similar to that before cleaning. However, in this cleaning process, it was found that the removed carbon was deposited on the electrode itself and affects the next sample placed for cleaning. This problem was overcome by mixing oxygen with the Ar gas. Oxygen removes the carbon by converting it to carbon dioxide. We have mixed ~50% argon and ~50% oxygen in the cleaning. The cleaning rate was observed to be same. However, in this study, the RF power density used was very low (~$5x10^{-4}$ W/cm^2) compared to that performed by other groups [1-4]. This study has shown that the low RF power and low gas pressure is useful for optics cleaning without affecting the surface quality of the substrate.

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IP06

Discharge phenomena associated in wire explosion during the production of copper nanoparticles

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Abstract

In the past few years, the synthesis of copper nanoparticles has attracted much attention because of it's huge potential for replacing expensive nano silver inks utilized in conductive printing. A major problem in utilizing these copper nanoparticles is their tendency to oxidize in ambient conditions. So intermediate stages involved in the production of nanoparticles plays important role. This paper presents the experimental results of electrical explosion of preheated copper wire. The wire structure was characterized by the amount of deposited energy. During the pre pulse, the current flowing in each wire was 10-20 A/ns. Due to discharge of current wire core undergoes through the multiple phases. The wire explosion results in the formation of high density core and low density plasma corona. The core has a foam like structure, and it's size is typically several tens of micrometer.

IP07

Development of VUV/UV Excimer Source For Water Borne Germicidal Application

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Abstract

Water is the basic need for all the living creatures specially for drinking purpose. Generally, the water that is available for drinking is impure and polluted by bacteria, viruses and various organic compounds [1]. This impure and polluted water produce many waterborne diseases, which kill around half million people worldwide per year and seriously sicken hundreds of millions. Existing technologies for water purification include mechanical filtration, reverse osmosis (RO), distillation, Ultraviolet (UV) disinfections, chlorination, and Ozonation [2]. Each of these technologies suffers from various limitations. Out of the existing water purifying technologies, UV disinfection was found the most effective method for bacteria removal [3]. It does not provide any side effects on health and also any chemical byproducts. Low-pressure mercury vapor lamps are commonly used for water purification at the industrial level, which peak at present at 254 nm wavelength. Nevertheless, the mercury lamps sometime lead to catastrophic explosion and the toxic mercury mixing with the water can cause serious health problems. The major limitations of these techniques are performing fast process, portability, lightweight, energy efficiency, high water flow rate and low cost, etc. Hence development of small size water purification system to meet these critical requirements is a challenge which would be attractive for both military and commercial sectors.

In this work an effort has been made to develop a dielectric barrier discharge (DBD) based VUV/UV excimer source that would eventually be used for water disinfection. The dielectric barrier discharge is based on capacitive discharge and driven by high voltage pulse power [4]. A single barrier cylindrical DBD with helical tungsten electrode having high voltage and a number of striped grounded electrodes (Cusil alloy) has been used to develop VUV/UV light source. The source has been directly inserted inside the water and has been operated at different operating pressures in the presence of air. The study and analysis of DBD driven excilamps for water borne E-coli bacteria have been carried out. The preliminary results show around 23% bacterial reduction in 3 minutes of VUV/UV treatment from this source. The results of these efforts will be presented.

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IP08

Seri Sai Geetha

IP09

DIELECTRIC BARRIER DISCHARGE BASED VUV/UV EXCIMER PLASMA SOURCES FOR SOCIETAL AND INDUSTRIAL APPLICATIONS

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Abstract

To render unwanted or harmful microorganisms incapable of reproducing, the ultraviolet (UV) light is very useful in our daily life. The UV-light is divided into four distinct spectral areas and they are Vacuum Ultraviolet (VUV) (100–200 nm), UV-C (200–280 nm), UV-B (280–315 nm) and UV-A (315–400 nm). These spectral areas are very specific. A polymer surface can be smoothed by VUV radiations. Exposure to UV-B light, in particular, the 310 nm narrowband UV-B range, is an effective long-term treatment for many ill skin conditions. Certain fungal growths under the toenail can be treated using a specific wavelength of UV delivered and can be safer than traditional systemic drugs. The broad spectral dose of UV-A is quite useful in printing technologies like UV inkjet applications, UV auto printing, etc. The UV-C (200–280 nm) is the most lethal range as a germicidal disinfectant that is capable of altering a living microorganism's, DNA, keeping it from reproducing. The UV-C is highly useful for water purification. At present low-pressure mercury vapor lamps are commonly used for water purification at the industrial level, which peaks at 254 nm wavelength. The mercury lamps sometime lead to catastrophic explosion and the toxic mercury mixing with the water can cause serious health problems. Mercury is a highly toxic material. Mercury must be prohibited as a light dosant material on environmental grounds. Hence the development of new generations of mercury free disinfection and sterilization light sources for water purification, medical applications, industrial applications and surface treatment, etc. are of concern.

The dielectric barrier discharge (DBD) based electrical gas discharge plasmas are most effective alternatives for

VUV/UV sources [1]. These discharges are rich sources of VUV/UV radiations of various wavelengths depending on the type of gas used, gas pressures, discharge geometries, etc. In certain specific types of gases the emission of VUV/UV radiations is due to spontaneous radiation that employ non-equilibrium radiation of excimer and exciplex molecules [2]. The light emitting devices made by excimer and exciplex molecules are known as excilamps [3]. One of the simplest way to excite these molecules is with a glow discharge. However, the main disadvantage of glow-discharge excilamps is the life time. Today excilamps are most often excited by a DBD that was first reported for this application by Tanaka [4]. Later different designs for DBD excilamps have been proposed by several workers. Researchers have also measured radiation spectra in pure inert gases and their mixture with halogens and certain wavelengths peaking at 172 nm, 222 nm, 282 nm and 308 nm have been reported, which require in-depth research and development work to optimize the sources for higher efficiency at these wavelengths and also to identify the other useful wavelengths from full UV range (100-400 nm) for societal and industrial applications. We have made certain efforts in this direction and a few DBD based excilamps with different geometries have been developed for different societal and industrial applications. These devices have also been characterized electrically as well as spectroscopically. The results of these efforts will be presented.

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IP10

Fabrication of Conjugated Polymer: Inorganic Oxide Based Nanocomposite Films by Plasma Process

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Abstract

Organic-Inorganic hybrid materials based on Polyaniline: Titanium dioxide nanocomposite has gained immense importance owing to their interesting physical properties and many potential applications in diverse areas [1, 2]. Plasma polymerized aniline (PPani): Titanium dioxide (TiO_2) nanocomposite films were fabricated using a pulsed dc reactive magnetron sputtering technique combine with rf plasma polymerization. The plasma species were studied using Optical Emission Spectroscopy (OES). The synthesized nanocomposite films were characterized by Fourier Transform Infra-Red (FTIR) spectroscopy showing the incorporation of PPani with TiO_2 [3]. Ultraviolet-Visible (UV-Vis) studies of PPani: TiO_2 films supported the interaction of PPani with TiO_2 and the optical band gap falls in the semiconducting region [4]. X-Ray Diffraction (XRD) shows amorphous nature for PPani: TiO_2 films. Surface morphology of the films was studied using Scanning Electron Microscope (SEM). The results were compared with the films prepared using dc magnetron sputtering and rf plasma polymerization. Plasma technique being a single step and clean process can be considered as a potential alternative for preparing PPani: TiO_2 nanocomposite films suitable for photovoltaic applications.

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IP11

Surface Modification of Textile using Atmospheric Pressure Cold Plasma

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Abstract

Chemical processing of textile is important because it imparts highest value to the textile. It is known that during the wet chemical processing of textile, industries cause significant water pollution. Approximately, 100 litres of water is used to process 1 Kg textile, which is finally discharged as an effluent. Recently, due to the more environmental awareness, textile industries are now slowly moving towards the implementation of water-less or low water based processing technologies such as digital printing, spray & foam finishing, and plasma. Plasma processing of textile is an emerging area, which can be used for surface modification of textile at dry state to develop various valued added textile products. Low pressure plasma technology has been extensively studied for such purpose. However, the process technology has not been commercialized due its limitation of batch process carried out under vacuum, sample size, and longer treatment time. Atmospheric pressure plasma can overcome these limitations and expected to be commercialized in textile if stable glow plasma could be developed over a large surface area.

A prototype atmospheric pressure cold plasma reactor was indigenously developed for surface modification of various textile substrates. Stable glow plasma was generated in the presence of helium (He) and He/air gases at a discharge voltage of 5 kV and frequency of 18-23 kHz between the two aluminium rectangular electrodes. Glow plasma was characterized by analyzing the current-voltage waveform using oscilloscope. Optical emission spectrum (OES) showed the ionization of He and the presence of strong atomic lines at 705 nm & 655 nm and followed by at 587 nm, 666 nm & 725 nm. Similarly, in He/air plasma the atomic line of oxygen at 776 nm was observed. The He and He/air plasma was used to impart hydrophilic functionality in the various natural and synthetic textiles. It was observed that after the plasma treatment the samples turned into highly hydrophilic. As a result of this, a water droplet of 37 µl took only 5 s in the 120 s plasma treated polyester sample, whereas it was 320 s in the untreated sample. Similar in wool, the water absorbency time reduced to 2 s from the value of >3600 s in the untreated sample. In the 60 s plasma treated nylon sample, the water absorbency time reduced from >3600 s in the untreated sample to 4.9 s in He plasma treated sample. Similar to water absorbency time, water contact angle decreased from 100-130° in all the untreated samples to ~ 0° in the plasma treated samples. XPS analysis showed that plasma treated samples were hydrophilic due to the formation of more oxygen containing hydrophilic −C−O and HO−C=O groups. SEM micrographs do not show any significant change between the untreated and plasma treated samples. Plasma processing textile is carried out at dry state hence adoption of such technology would help to reduce the consumption of water in textile industry. Therefore, it can be said that atmospheric pressure plasma can be used to impart hydrophilic functionality in the various textile substrates.

Key words: Plasma, Textile, Hydrophilic, and Water conservation

IP12

Effects of Atmospheric Pressure Plasma Treatment and UV- Treatment on the Wettability Polycarbonate

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Abstract

In the work reported in this paper, the effects of atmospheric pressure plasma treatment (APPT) and ultra-violet treatment (UVT) on the wettability of polycarbonate surface had been investigated. In the case of plasma treatment, a high voltage (0-20 kV) power supply operating at 27 kHz was used to power a dielectric barrier discharge consisting of two parallel electrodes with a discharge gap spacing of 2 mm and with a dielectric of 2 mm thickness. Argon gas was fed at a controlled flow rate of 1 litre per min into the discharge gap. In the case of UV treatment, UV radiations with wavelengths of 254 nm and 365 nm were used. The effect of treatment time on the wettability of the sample was investigated by measuring the contact angle with water and glycerol. The contact angle values were further used to determine the surface free energy of the sample. The results indicated that in APPT, 5 to10 seconds of exposure time was sufficient to make significant improvement in the hydrophilicity of the sample. The total surface free energy of the sample calculated from two liquid model showed an increase from 21 mJ/m^2 to 75 mJ/m^2 after 90 s. In the UVT, shorter wavelength resulted in a higher wettability compared to the treatment at longer wavelength. The total surface free energy increased from 24 mJ/m^2 to 37 mJ/m^2 after 25 minutes of treatment in the UV radiation of 254 nm.

Key words : APPT, UVT, polycarbonate, wettability, contact angle, surface free energy

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IP13

Niraj Kumar

IP14

Sputter Deposition Of Platinum Nanoparticles Onto Porous Carbon Paper For Application As Electrodes In Fuel Cells

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Abstract

The membrane electrode assembly (MEA) is the main component of a proton exchange membrane fuel cell (PEMFC). MEA consists of two electrodes separated by a proton exchange membrane. The electrodes are prepared by depositing catalytic agents on conducting carbon material, preferably porous for the diffusion of gases. The efficiency of a fuel cell is highly dependent on the preparation of the electrodes. To increase the efficiency of the electrodes, platinum is used as the catalyst due its high catalytic properties. To prepare an effective electrode, platinum is deposited on the electrodes by plasma sputtering so that uniform platinum nano-clusters can be obtained on the electrodes. DC magnetron sputtering is a

very efficient method for minimum loading of Platinum nanoparticles with high catalytic behavior. By using DC applied voltage of 450V for different deposition times of 10s – 40s, platinum loading of 0.02 – 0.05 mgcm^{-2} is obtained. The presence of platinum was revealed by XRD analysis. SEM characterization shows that the platinum deposition is uniform with platinum cluster size of around 80 – 100 nm.

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IP15

Study And Characterisation Of Polypropylene And Polyethylene Films Deposited By RF Plasma

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Abstract

Propylene and ethylene are the important and lightest industrial hydrocarbon. Radiofrequency (13.56 MHz) plasma is used to polymerize and deposit the thin films of polypropylene and polyethylene at various RF power (20-80 W) and with different working pressure and compare with chemically obtained sane films. The film thickness is dependent on deposition time, pressure as well as applied power. Generated plasma characteristics are made with the help of self compensated emissive probe and optical emission spectroscopy (OES). The characterization of the films is carried out with the help of scanning electron microscopy (SEM), fourier-transform infra red (FTIR) and UV-visible analyses. The energy acquired by the ions toward the substrate play an important role for film stability. Owens-Wendt-Rabel and Kaelble) WORK method is used to calculate the surface free energy (SE) of all deposited films as well as roughness hysteresis loop. The film obtained for optimized condition is found to be of high performance as compared to conventional one.

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IP16

Dolly Gogoi

IP17

Size Engineering Of Nickel Nanoparticles As a Catalyst For Carbon Nanotube Growth

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Abstract

To synthesize carbon nanotubes (CNTs) by chemical vapour deposition (CVD), transition metal as a catalyst is required. Catalyst particle size is a crucial factor for CNT growth because it is related to tube diameter [1]. Morphology and characteristics of the nickel nanoparticles for the catalytic growth of carbon nanotube (CNT) is studied. Nickel films having different thicknesses are deposited by magnetron sputtering on Si(100) substrate with or without silicon dioxide as barrier layer. Nickel films are then heated in vacuum to 560^0 C in order to coagulate the film into nano sized particles. Also, particles are H_2 plasma treated to remove the residing oxide layer [2]. X-Ray diffraction pattern gives the phase change from amorphous to crystalline under heat treatment. SEM characterization shows the uniformly dispersed catalyst particles having size within the range of 30- 90 nm, which is also confirmed from XRD analysis.

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IP18

Characterization of Plasma Treated ZnO Nano Composites Polymer Membranes

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Abstract

Systematic study was carried out to characterize the effects of Nitrogen ion plasma on nano composite polymer membrane. Nano particles of ZnOaresynthesized by chemical root. Using solution casting and spin coating method, nano composite polymeric membranes in the range of 20–40 micron were prepared. Nitrogen ion plasma treatment was done for these membranes. Variable treatment time were used to modify the membrane surface and its characteristics. These membranes were characterized before plasma treatment and after plasma to make comparative study by different technique such as optical microscopy, SEM- Scanning electron microscope, UV-Vis Spectrometry, Fourier transform infrared spectroscopy, I-V measurement. Results of gas permeation shows improvement in porosity N_2 plasma treated Membrane. The permeability of these membranes also depends upon thickness, ion energy and etching time. So the Plasma treatment is a quite effective tool for improving the properties of composite membranes with unique

characteristics. These results are discussed in this paper.

IP19

Hot And Dense Plasma Used For Synthesis Of Zirconium Oxide Nanostructures

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Abstract

Zirconium oxide (ZrO_2) has drawn great attention due to its applications in wide range of technologies [1]. ZrO_2 is a suitable candidate for several industrial applications including field of optics, electronics and optoelectronics due to its outstanding electrical and mechanical properties. ZrO_2 can be act as a replacement to the conventional silicon dioxide dielectric due to its high-permittivity (κ). In this work, the synthesis of ZrO_2 nanostructures on silicon substrate using the ions produced from ZrO_2 target (99.99% pure) by means of hot and dense argon plasma is reported. The ZrO_2 target is fitted on top of modified anode of dense plasma focus (DPF) device. Substrates placed on substrate holder are inserted from outside the plasma chamber with the help of vertically moveable brass rod. The distance between top of anode and substrates is taken as 5.0 cm. The ions generated from ZrO_2 target (due to focused plasma) along with argon ions move vertically upward in a fountain like structure in post focus phase of plasma dynamics and material ions get deposited on silicon substrates. This process of production of material ions from ZrO_2 target leads to nucleation and nanostructures formation with single focused DPF plasma shots. X-ray diffraction (XRD) spectra of deposited material will be analyzed to study the structural properties. The surface morphology will be studied using scanning electron microscope (SEM). Photoluminescence (PL) spectra will also be studied for the application of deposited material in optoelectronic devices.

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IP20

Synthesis of Silver Nanodots using Hot, Dense and Extremely Non-Equilibrium Plasma Generated in 3.3KJ Dense Plasma Focus Device

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Abstract

Silver nanodots are synthesized on glass substrates using silver ions generated by hot, dense and strongly non-equilibrium argon plasma. The hot and dense argon plasma formed during the focus phase ionizes the silver disc placed above the top of the anode. Silver ions along with argon ions move vertically upward in a fountain like structure during post focus phase, hit the substrates placed above the anode. These energetic ions can interact with the substrate in two ways: firstly the flux of energetic ion impinging on the substrate that can change the physical properties of outer layer of substrate by ablating substrate surface ions. Secondly, it increases the surface temperature abruptly due to which the argon ions can penetrate to a depth of the surface layer. Due to this high temperature no external heating is required in the device. Moreover, argon being inert gas, argon ions doesn't combine with substrate whereas when silver ions hit the substrate they either combine with substrate ions or enter into interstice or substitute as silver atoms created by gas ions

in the form of nanodots. The high temperature of substrate surface may help in adhesion of nanodots to the substrate surface. Glass substrates are placed at an axial distance of 4.0 cm from the top of anode and are exposed to one, two and three focus shots. The X-ray diffraction shows the (111), (200) and (220) reflections of silver nanodots deposited on glass substrates. Atomic Force Microscopy shows near spherical particles like nanostructures. The surface plasmon resonance peak is observed in the absorption spectra for silver nanodots on glass substrates.

IP21

Influence of Annealing Temperature on the RF/DC Co-sputtered $Ti_XAl_{1-X}N$ Thin Films.

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Abstract

Ti and Al targets attached to DC and RF power supply is used to deposit $Ti_XAl_{1-X}N$ coatings by reactive RF / DC magnetron co-sputtering. MKS type mass flow controller is used for nitrogen and argon gases purging into the chamber with fixed ratio. Working pressure was kept constant throughout the experiment. Ceramic beads are used as substrates for the coating. The phase structure, microstructure, surface roughness and electrical resistivity were investigated. The roughness of the coatings decreases with increasing annealing temperature. Electrical resistivity study is carried out to confirm whether $Ti_XAl_{1-X}N$ coating can be used in carbon resistor as heat insulator for high temperature applications. The thickness of the coatings were found to be in the range 350 ~ 750nm.

TiAlN coatings have been attracting more and more attentions since last decade due to their excellent thermal resistance (800− 900 °C), hardness (30-35GPa) and high corrosion resistance. TiAlN coatings are used for cutting tools in dry and high speed machining. TiAlN films significantly increase the tool life in comparison of TiN films and hence the downtime of the instrument. TiAlN coatings can be used as high-density complementary metal-oxide-semiconductor (CMOS) memory devices, temperature controller for the satellites in the form of heat shield and selective coatings for solar collectors. TiAlN films proposed as bio-implants by several authors**.** Al content and the phase structure of the TiAlN coatings are responsible for the different properties of the films. In industries TiAlN coatings is used in the field of high temperature cutting operations with minimum use of lubricant. TiAlN coatings are also used for machining titanium, aluminum, nickel alloys, stainless steels, alloy steels, Co-Cr-Mo and cast irons.

Key words: Co-sputtering, $Ti_XAl_{1-X}N$ film, Annealing, Resistivity

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IP22

Influence Of DC Power On The Properties Of AlN Thin Films

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Abstract

High electrical resistivity (~10^{14} Ωcm) and highly transparent AlN films were deposited at room temperature by DC magnetron sputtering of Al target in pure argon and nitrogen atmosphere. Thin films were deposited on Si and glass substrate without any intentional heating at various DC powers ranging from 50W to 200W and the influence of DC power on the structural, electrical and optical properties of the films were investigated. Enhancement of crystallinity and conductivity was observed with increase in DC power. Film deposited on Si substrates at an DC power of 50W was oriented in the (200) direction and it showed a high resistivity of 2.07 x10^{13} Ωcm. It has been observed that the film properties are greatly influenced by the plasma conditions during sputtering. DC plasma during sputtering was analyzed using Langmuir Probe and Optical Emission Spectroscopy (OES). The plasma parameters such as ion density and electron temperature were determined and their dependence on properties of thin film deposited under similar plasma conditions were studied. Plasma parameters were determined for different DC powers keeping the distance from the target a constant.

Keywords:- AlN thin film , DC power, electrical resistivity, Langmuir probe

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IP23

Gold-Silver Bimetallic Nanostructures By Hot Plasma And Their Characterization

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Abstract

Nanostructures of noble metal such as gold, silver and copper are of great research interest for their unique optical

properties due to surface plasmon resonance in visible range. The plasmonic properties of these nanostructures have been exploited in bio-sensing [1], bio-imaging [2] and enhancing absorption in photovoltaic cells [3]. We present fabrication of bimetallic nanostructures of gold and silver using ions produced from their bulk by hot, dense and extremely non-equilibrium argon plasma such as found in dense plasma focus device. Firstly, gold disc of 99.99% purity is inserted inside the top of detachable anode. Gold ions are generated using shot of focused plasma. These energetic ions along with argon ions move vertically upwards in a fountain like structure, hit glass substrate placed at a suitable distance from anode top and lose their energies through electronic and nuclear processes to subsequently form gold nanostructures on glass substrate. The anode fitted with gold disc is replaced by anode fitted with silver disc of high purity. The hot and dense plasma is then used to generate silver ions which accelerate upwards in the post focus phase and hit the as grown

gold nanostructures on glass substrate placed at the same distance from anode top. These energetic silver ions lose their energies through electronic and nuclear processes which cause in thermal spikes locally to melt and resolidify the as grown material resulting in bimetallic nanostructures of gold and silver. The bimetallic nanostructures are characterized for their structural properties using X-ray diffractometer. The plasmonic properties of these bimetallic nanostructures are obtained using UV- visible spectrophotometer.

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IP24

Optical Absorption Study of GaAs Nanostructures Synthesized Using Hot And Dense Plasma

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Abstract

Gallium arsenide (GaAs) is a compound semiconductor of III-V class having band gap ~ 1.425 eV. In the recent decades, optical properties of GaAs have been extensively studied for applications in optoelectronic devices [1]. In the present study, the synthesis of GaAs nanostructures on glass substrate using the ions produced from GaAs target (99.99% pure) by means of hot and dense argon plasma in a modified dense plasma focus (DPF) device is reported. The substrates are placed at optimum distances to deposit GaAs nanostructures. The nanostructures so obtained are thermally annealed (rapid) at elevated temperatures. The optical properties of as-grown and annealed nanostructures are studied using optical absorption spectra. A comparative study of as-grown and annealed GaAs is done and results are reported.

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IP25

Performance Evaluation of Gas Tunnel Type Plasma Sprayed Graded YSZ-$La_2Zr_2O_7$ Composite Coatings in Molten Salt Environment

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Abstract

In this study, functionally graded four layer YSZ/$La_2Zr_2O_7$ composite coatings with CoNiCrAlY bond coat were prepared by using gas tunnel type plasma spraying torch at selective operating conditions. Hot corrosion resistance performance of the graded composite coatings was evaluated against 60 wt.% Na_2SO_4 + 40 wt.% V_2O_5 molten salt environment at 1000°C and compared with single layer YSZ and $La_2Zr_2O_7$ coatings. X-ray diffraction, scanning electron microscopy and energy dispersive spectroscopy techniques were used to determine the nature of phases formed and to carry out microanalysis of the hot corroded coatings respectively. Results indicated that $LaVO_4$ and YVO_4 are the main corrosive products along with the ZrO_2 phase transformation from tetragonal to monoclinic phases in the $La_2Zr_2O_7$ and YSZ coating layers respectively due to the formation of $NaVO_3$. Similarly, penetration of molten $NaVO_3$ across the graded coating microstructure produced different kinds of corrosive products in different microstructures with respect to the presence of La_2O_3 and Y_2O_3 content. It was observed that the durability of the graded coatings was relatively better than the single layer coatings in the present hot corrosion environment. The overall observation illustrated that the hot corrosion resistance of the coating was largely influenced by the performance of the corrosion resistant bond coat, which provided protection against the corrosive components penetrating through the ceramic topcoat.

IP26

S. Yugeswaran

IP27

Microwave Plasma Enhanced Chemical Vapor Deposition of Carbon Nanotubes on Metallic Substrates

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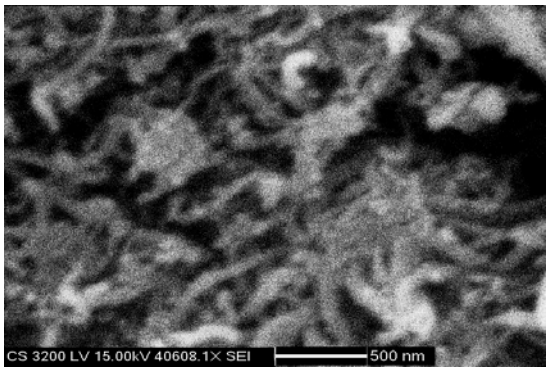
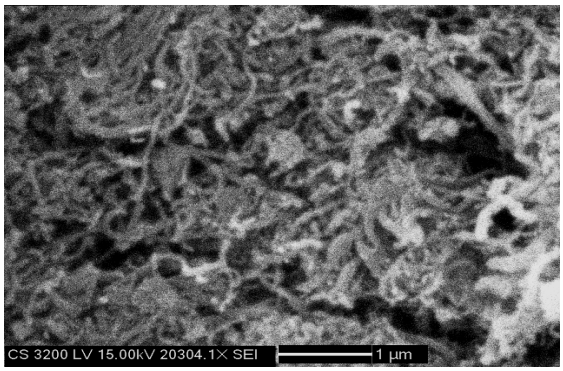
Abstract

Direct growth of carbon nanotubes (CNTs) on metallic substrates is desired for many practical applications of CNTs like electron field-emitters in electron gun devices, scanning probe tip etc. But experimentally it is very difficult to grow CNTs directly on the metal surfaces. The main challenges remain in issue of nano sized catalyst formation required for growth.

In the present work successful deposition of CNTs was done on metallic substrates using microwave plasma enhanced chemical vapor deposition (MPECVD). Inconel 600 was chosen as the metallic substrate for the deposition of CNTs. Experiments was performed with both oxidized and unoxidized substrates to see the differences in growth. CH_4 and H_2 were used as precursor gases for the deposition of CNTs. Substrate temperature of around 500^0C was required for the growth. The deposited CNTs were characterized by scanning electron microscopy (SEM) and Raman spectroscopy. Typical SEM image of CNTs deposited on Inconel by MPECVD is shown in the figure below. Both characterizations confirm the formation of CNTs on the metallic substrates.





This paper will describe our experimental findings and will highlight the key issues like catalyst formation on the metal during growth at different plasma conditions and what are the practical challenges lies ahead in the road to mass production.

IP28

Formation and Sliding Wear Behaviour of Plasma Sprayed Ti_3Al Intermetallic Compound

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Abstract

Inter-metallic compounds such as Ti_3Al and TiAl are of great interest as high-temperature structural materials because of their specific strength and oxidation resistance. Hence in this study, an attempt was made to produce Ti_3Al inter-metallic coatings through unique gas tunnel type plasma spraying torch in a single step process at selective operating conditions. The formation, microstructure and sliding wear behavior of the coatings were analyzed by XRD, SEM, and BOD tribometer, respectively. It can be seen that the coating thickness has increased with increasing plasma current. The results showed that the formation of coatings and sliding wear rate increases when increasing the spraying distance and applied loads, respectively. At all the loading conditions, the major presence of Ti_3Al phase provides remarkable wear resistance.

IP29

Preparation And Characterization Of Proton Conducting Sulfonated Polystyrene Membrane For Fuel Cell By Plasma Process.

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Abstract

Fuel cells are the new promising technology of power generation which is preferred as clean energy source for portable power applications. The proton exchange membrane fuel cell consists of two electrodes separated by a polymer membrane which exchange the protons formed at the anode side to the cathode side. The required physical properties of the polymer electrolytic membrane include good functional properties like proton conductivity, water transport property, high gas barrier properties, higher thermal and chemical stability and durability. Plasma polymerization technique is a one of the convenient polymerization process which is used to synthesize the proton exchange membrane of sulfonated polystyrene membrane by continuous RF glow discharge process. The mixture of Styrene (C_8H_8) and Trifluoromethane sulfonic acid (CF_3SO_3H) monomers is copolymerized by triggering glow discharge to prepare the membrane without using any carrier gas. The chemical composition and surface morphology of the developed membranes are investigated using FTIR spectroscopy and Scanning electron microscopy. The SEM micrographs of the membranes show uniform and pine hole free surfaces. The thermal behavior of the plasma polymerized membrane is studied by TGA analyses which show the thermal stability of the membrane up to 150 °C temperatures. The proton conductivity of the developed membrane achieved is comparable to the commercially available Nafion- 117 membrane.

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IP30

Bio-adoptabilityfor Ion-Plasma Treated Polymer Nano Composites Membrane

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Abstract

Nano particles of TiO_2 are synthesized by chemical root and were used as nano composites for polymer membranes. Using solution casting and spin coating method, nano composite polymeric membranes in the range of 20–40 micron were prepared andion plasma treatment was done. Variable treatment time was used to modify the membrane surface. These membranes were characterizedby different technique such as SEM- Scanning electron microscope, Fourier transform infrared spectroscopy. The selectivity of these membranes depends upon thickness, ion dose, etching time, and chemical nature.The plasma treatment modifies the bio-adoptability of membrane and creates active site to enhances the bacterial growth.

Keywords: Polymer Nano Composites, Synthetic Membrane, Plasma Treatment, Ion Energy, Plasma Etching Time.

IP31

Miniaturised plasma opening switch based axial VIRCATOR

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Abstract:

A generator based on Tesla transformer [1] for application in plasma opening switch (POS) has been developed. Overall dimension of this system is very small compared to other generator. This system is designed to operate with up to 250 kV on water pulsed forming line to generate 45 kA, 40 ns current pulse which further is compressed in time with the help of plasma opening switch [2]. Ultimately this system is producing voltage in excess of 500 kV and current rise time of around 15 ns.
An axial VIRCATOR system connected to this generator is producing microwave for the plasma – microwave interaction experiment. This VIRCATOR system is producing microwave in the range of 8 GHz to 16 GHz. Attempts are being to enhance the microwave power output form this generator.
This paper will present different aspects of this compact generator and its experimental results.

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IP32

Surface Morphology and Barrier Properties of Plasma Processed Biodegradable Polymer (CSPCL) Films

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Abstract

Biodegradable polymers may play important role to control the environmental hazards created by synthetic polymers. Number of biodegradable polymers are being synthesized and studied extensively to reduce the environmental problems associated. Of them, starch-based biodegradable polymers are of greater interest due to total biodegradability, low cost, easy availability of starch. The poly(ε-caprolactone) is one of the synthetic polymers having good tensile properties and comparatively good biodegradability than other synthetic polymers. The blending of starch and poly(ε-caprolactone) results in cost effective and improved strength biodegradable polymer. However, for its application as packaging, it is necessary to improve its barrier properties.

In the present investigation plasma polymerization of Tetraethylorthosilicate (PPTEOS) was carried out on corn starch/poly(ε-caprolactone) (CSPCL) film substrates in view of offering shelf life and improvement of barrier properties, important for packaging material. Tetraethylorthosilicate (TEOS) plasma deposition was carried out for different time period and its effect on CSPCL films was studied. The % weight change and thickness measurement evaluates the successful deposition of PPTEOS onto the substrate film. PPTEOS deposition results in hydrophobic surface, which was

concluded, from surface energy. The surface morphology of these plasma-processed samples was studied using AFM. Decrease in peel strength of PPTEOS samples agrees well SE and AFM data. Oxygen Transmission Rate (OTR) study showed the effect of PPTEOS deposition on barrier properties, which reveals the highly crosslinked, conformal and pinhole free nature of SiOx layer. Thus, such modified films can find applications in packaging.

Key words: Corn Starch/Poly(ε-caprolactone) (CSPCL); Tetraethylorthosilicate (TEOS); AFM; Peel Strength; Oxygen Transmission Rate (OTR).

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IP33

PIC Simulation of Pseudospark Hollow Cathode Plasma Electron Gun

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Abstract

The pseudospark (PS) discharge has been shown to be a promising source of high brightness, high intensity electron beam pulses. In recent years pseudospark discharges attracted significant attention from diverse fields such as pulsed-power switching, electron and ion beam generation, free electron masers, EUV radiation sources, and micro thrusters due to their unusual and interesting discharge properties [1- 4]. In the present work an effort has been made to understand the pseudospark discharge using PIC plasma simulation code "VORPAL" [5]. The plasma generation process by self discharge mechanism is examined. Investigations are made to analyze the effect of different applied conditions on the discharge parameters. We have also developed single gap PCE gun [4].For all the simulation and the experimental analysis argon gas has been used. The simulated and the experimental results are compared and found to be in good agreement with the experimental results.

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IP34

Unbalanced Magnetron Sputtered SnO_2 and SnO_2-CuO Thin Films for Trace-level level H_2S Gas Sensing

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Abstract

Thin film deposition technique of magnetron sputtering is a widely preferred method of realizing engineered coatings because of the associated characteristics of high deposition rate, ease of scaling, and quality of the deposited films [1 Jayaraj].

In the present work trace-level (20 ppm) H_2S gas sensing characteristics of polycrystalline SnO_2 thin films prepared by unbalanced magnetron sputtering technique have been analyzed. H_2S gas interaction mechanisms of sputtered SnO_2 and CuO - SnO_2 sensors with a varying distribution of Cu catalyst on SnO_2 are investigated. Changes in the microstructure of the films due to in-situ bombardment effects during film growth and variations in H_2S gas sensing characteristics are correlated with the observed difference in gas sensing characteristics. Changes induced on the sensor surface, the CuO - SnO_2 interface, and the internal bulk region of the sensing SnO_2 film upon exposure to H_2S have been analyzed to explain the observed enhancement of sensitivity. SnO_2 film covered with 0.6 mm diameter ultrathin (~ 10 nm) CuO clusters is found to exhibit a high sensitivity of 7.33×10^3 at a low operating temperature of 150 °C. A response speed of 14 seconds for 20 ppm of H_2S, and a fast recovery time of 118 seconds in flowing air have been measured. The presence of ultrathin CuO dotted clusters allow effective removal of adsorbed oxygen from the uncovered SnO_2 surface due to spillover of hydrogen dissociated from the H_2S – CuO interaction, and the spillover mechanism is sensed through the observed fast response characteristics. Finally, an rf compensated tungsten Langmuir probe is utilized for plasma diagnostics to acquire information about fundamental plasma parameters, including electron temperature, electron density and the same are related to the observed H_2S gas sensing response of the thin film sensors.

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IP35

A Simple Crowbar Switch For Pulsed Power Applications

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Abstract

Effective crowbar circuit is desired in many capacitor based pulsed power systems to avoid the feeding of negative voltage cycles to the load and to enhance the operating life of capacitors. The most common scheme is to use fast recovery high voltage, high current diodes in series with crowbar resistors [1] across the capacitor bank, which is less complex but sometimes difficult to implement due to its high cost. The other scheme is to sense the voltage across the capacitor bank and to trigger a spark gap connected to crowbar resistors at the start of negative cycle of voltage [2,3]. This scheme is quite effective but requires fast circuits to trigger the spark gap just at the start of the negative cycle. In present work the above scheme is simplified by closing the sparkgap, by the discharge plasma generated and electromagnetically accelerated in a modified main rail gap switch. The geometry of rail gap switch is modified by replacing its knife edge trigger electrode by a point electrode placed at one end of the rails and by placing another electrode connected to crowbar resistor near the high voltage electrode at the other end of the rails. The concept of main spark gap design is based on ref-4 to achieve less electrode erosion, especially for high coulomb charge transfer applications. The mechanism of this scheme is as follows: first the trigger electrode initiates the breakdown at one end of the rails; Lorentz force (**J** X **B**) accelerates this discharge channel along the rails; when this discharge reaches at the other end of the rails it closes the gap between HV electrode and crowbar electrode and diverts the current from load to crowbar resistors. The impedance of crowbar resistors is kept smaller than the main load.

The experimental implementation of this scheme has been carried out on a 10 μF single capacitor charged to

voltages up to 10 kV and connected to a 1.6 μH inductive load through the modified rail gap switch operated in air at atmospheric pressure. The total length of the rail electrodes was 50 mm, but the effective usable length of these electrodes has been varied from 3-25 mm by changing the position of trigger electrode and placing an insulator sheet between unused portions. The crowbar electrode is placed near the HV electrode with a gap slightly higher than the main gap to avoid its early closing by self breakdown. The crowbar resistor is made from a thick aluminum strip (11 mΩ) and has been connected to the capacitor ground with a short length cable. To measure the rate of change of main current and crowbar current one pick up loop is placed in the main current path and other in the crowbar path. The time of crowbarring is detected by the time of current start in the crowbar resistor. The effective length of main electrodes has been varied to observe its effect on crowbarring time and it has been observed that crowbarring can be achieved at current peak, current zero cross-over point or at any desired point of current profile by carefully choosing the length of main electrodes. The main current after crowbarring has been found to be decaying exponentially with small oscillations. At present the electrode lengths and value of crowbar resistors are kept small to show the viability of the concept on a fast (low inductance) capacitor, but this scheme is more suitable for large current and relatively slow (rise time 100-500 μs) capacitor banks utilized for applications like rail gun, coil gun, magnetic flux compression generator etc. The work is in progress to experimentally measure and theoretically estimate the velocity of discharge channel for electrode length optimization.

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IP36

Deposition and Characterization of Yttrium Oxide thin films by RF Plasma Assisted MOCVD

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Abstract

In view of their potential applications, Yttrium oxide (Y_2O_3) based coatings have attracted a lot of attention. Due to their excellent properties like high permittivity, large band gap, high melting point etc. they play a very important role in electronic, optical and magnetic applications. Further because of their non wetting characteristics with the molten liquids at high temperature, they are very attractive as corrosion resistant barrier coatings on various containers that are used during processes like crystal growth etc. For these particular applications it is extremely important to deposit non porous coatings on various substrates (container materials). For these requirements plasma assisted metal organic chemical vapour deposition (MOCVD) is very promising technique as it can lead to deposition of non porous coatings because of the intrinsic process properties.

In view of these expanding applications we have deposited Y_2O_3 thin films on various substrates like s.s, silicon and tantalum by using radio frequency (RF) plasma assisted chemical vapour deposition process using a plasma of

argon, oxygen and $Y(thd)_3$ (Tris (2,2,6,6,-tetramethyl-3,5-heptanedionate) / $Y(tod)_3$: Yttrium 2,7,7-trimethyl-3,5-octanedionates (tod) precursor. The coatings were deposited under similar experimental conditions except the change in the yttrium containing precursor. The deposited coatings have been characterized by X-ray photoelectron spectroscopy (XPS), glancing angle x-ray diffraction (GIXRD) and IR spectroscopy.

Characterization results indicate that good quality single phase C-Y_2O_3 coatings can be deposited on the above mentioned substrates using $Y(thd)_3$ (Tris (2,2,6,6,-tetramethyl-3,5-heptanedionate)precursor under these experimental conditions. However, while using $Y(tod)_3$: Yttrium 2,7,7-trimethyl-3,5-octanedionates (tod) precursor a multiphase mixture is deposited on the substrates. This is due to the difference in the nature of the evaporation characteristics of the precursors (i.e their vapour pressures). $Y(tod)_3$ precursor being more volatile, single phase deposition by this precursor would require more oxygen as compared to deposition using $Y(thd)_3$ precursor.

This paper will discuss the experimental details and characterization results.

IP37

TiN-WS_2 Coating: Optimization of Deposition Conditions in Nanocomposite Coating Deposition System

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Abstract

Metal dichalcogenides such as MoS_2 and WS_2 compounds with layered nanostructures are not stable in planar form because of the weak covalent bonding and they simultaneously fold into fullerene like structures or nanotubes which are analogous to carbon fullerenes or nanotubes. It is very well known that these materials are widely applied as solid lubricants, spherical topology of which could idealy suit for tribological applications. When these fullerenes are embedded inside hard coating matrix like TiN, it provides an independent control of tribological properties usually known as antagonists (holding high load bearing capacity and low friction coefficient when sliding in dry conditions). In this work, TiN-(IF-WS_2) nanocomposite coating was produced by Nanocomposite Coating Deposition System (NCDS). NCDS was developed by combining nanocluster gun with dc-magnetron sputtering. IFLNs was injected by using nanocluster gun whereas TiN matrix was deposited by DC magnetron sputtering - a simultaneous process. This paper is focused on, (1) experimental methods of NCDS involving dc magnetron sputtering and nanocluster gun, (2) optimization of deposition conditions and (3) studies of crystal structure, chemical structure, surface morphology and elemental composition of TiN-WS_2 coating.

IP38

Inductively Coupled Plasma For Generating High Intensity Proton Beam

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Abstract

Proton beams have demands from various fields like neutron generators, neutral beam injectors, accelerators etc and generally ECR ion source or Duoplasmatron source is used for generating high current proton beam. RF inductively coupled plasmas are comparatively less complex and cheaper compared to ECR sources and unlike Duoplasmatron, ICP has no electrodes exposed to plasma which makes them possess longer life time. Considering the many benefits of ICP including the scalability and high plasma density, it can be a good choice for proton beam generation. An inductively coupled plasma ion source operating at 13.56 MHZ with external antenna for producing gaseous beam is developed and the capability of the source for producing high current proton beam is being assessed. With parallel plate single aperture extraction system proton current of 2.5mA at 3keV extraction voltage at a low RF power of 300 W is achieved. Plasma density of the source is measured to be $>1x10^{18}/cm^3$. The high plasma density of ICP suggests that extracted current can increase to higher level and calculation says it will be nearly ~10 mA. The present limitation on the current comes from the extraction geometry. For improving the ion extraction, a high perveance extraction system is designed. A Wien filter type mass spectrometer is developed and being tested to find out the proton fraction.

IP39

Activities on plasma based micromachining system at VECC

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Abstract

Plasma based focused ion beam systems are gaining importance. A focused ion beam system based on inductively coupled plasma ion source is being developed. A new type of inductively coupled ion source is developed and optimized to produce various gaseous ion beams with very high brightness and low energy spread. This ion source is characterized by measuring the beam emittance, brightness, ion energy spread etc. and found that the source is capable of producing high current density micron and submicron ion beams. The system comprises of two electrode extraction system and a focusing column consisting of two Einzel lens. The minimum beam spot size obtained on focal plane is 2.0 micron for 6 KeV argon ion beam. Beam size is measured using knife edge scanning method. Since the current density at this plane is over 500 mA/cm^2, the system is an appropriate one for high rate micromachining. Micro-patterning capabilities of the system are demonstrated by creating different kinds of patterns on silicon wafer, micro-drilling in metal foils etc. Measurements show that the currents in the range of 500 nA to 1 microA can be focused to spots having diameters in the range of 8–10 micro meter resulting in a current density of 450 mA/cm^2 at the focused spot. In order to evaluate the milling rate of steel, experiments were carried out using 7 keV, 800 nA of argon ion beam. Preliminary results indicate that the milling rate of steel is >100 $microm^3/s$.

IP40

Investigation of Strain in Ti Film Grown on Patterned Substrate

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Abstract

Titanium compounds plays a key role in our day-to-day life starting from the manufacture of toothpaste, false teeth and wedding rings to the development of artificial hip-joints and deep-diving submarine. To make a film that is long lasting mechanical properties of the films are very crucial, like strain development in the film can peel off the layer. Therefore in this work study of the variation in Ti film strain was conducted at various process parameters. Not only the temperature and biasing voltage was varied but also surface roughness was varied using a patterned substrate. Magnetron sputtered Ti thin films deposited on Si (Ptype-100) substrates under various deposition parameters were characterized by X-ray diffraction (XRD) and Scanning Electron Microscope (SEM). Strain development in Ti film for both normal and pattern substrate was calculated using Williamson's Hall technique. The Ti films deposited on Si substrate (Normal and patterned substrate), characterized by XRD (SEIFRT, 3000 PTS) with CuKα analysis reveals that the grain size and strain varies substantially with biasing voltage, and substrate temperature. The thickness of the Ti films was measured by taking cross-sectional view of Ti films using SEM (Model -LEOS-440i). The deposited Ti film shows similar morphology with decreasing thickness, when grown on heated substrate. Film grown on patterned substrate, shows entirely different columnar structure in the cross-section view.

Keywords: Magnetron sputtering, Titanium, XRD.

IP41

High Speed Voltage Ramp And Data Acquisition Circuits For Langmuir Probe Measurements In Radio Frequency Plasma

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Abstract

A voltage ramp generator with output voltage swing capability of - 40 V to + 40 V is constructed for biasing a RF (radio frequency) compensated Langmuir probe used for characterizing plasma produced by RF magnetron sputtering. The circuit is interfaced with a computer which controls the entire measurement process and data acquisition. The probe is capable of measuring plasma electron current up to 100 mA using a circuit which is devoid of expensive isolation amplifiers. The program to control the ramp generation and measurement is written in Visual Basic. The time taken for a single sweep without averaging is 20 ms which is essentially the analog to digital conversion time for 400 data points included in one sweep. The circuit was used to map the plasma properties of RF sputtered zinc oxide plasma.
Key words: Langmuir probe, Voltage ramp, RF magnetron sputtering

IP42

Thermally Assisted Etching Of ZnSe With ECR Plasma Under CCl_2F_2/Ar Discharge

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Abstract

A low damage dry etch process for nanometer etching of ZnSe has been reported. II-VI compounds have attracted increasing attention, primarily because of the large range of energy band gaps available. Electron Cyclotron Resonance plasma was excited at Pressure range between 0.015 to 0.020 mbar. Thermally assisted ECR etching using gas mixtures of CCl_2F_2 and Ar is done at a process temperature between 60 – 150^0C. ECR plasma etching of ZnSe in a CCl_2F_2/Ar discharge with rf biasing are investigated at different temperature and different flow rate ratio. The etch rates are found to be increasing with the increase in flow rate of reactive gas and process temperature. The use of ECR conditions with additional rf biasing provides the good etching of the surface and fast etch rates. The surface morphology are taken with Scanning Electron Microscopy and the etch depths are measured by Dektek Profilometry.

Keywords: ECR Plasma; ZnSe; Microwave; Etch rate

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IP43

Production of Hydrogen from Hydrogen Sulfide in a Catalytic Non-thermal Plasma DBD Reactor

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Abstract

Hydrogen is considered to be a clean fuel and has high energy density compared to all other energy sources. Especially, fuel cells utilize hydrogen to produce electricity without emitting any environmental pollutants. In the present investigation the decomposition of hydrogen sulfide (H_2S) to hydrogen and sulfur was carried out in a non-thermal plasma reactor with inner sintered metal fibre electrode modified with a variety of metal oxide catalysts such as MoO_x/ SMF, CoO_x/ SMF and NiO/ SMF and characterized by various physic-chemical techniques (Fig.1). In order to understand the influence of catalyst on H_2S conversion, the reaction was carried out with 3.5 mm discharge gap, 5 vol. % H_2S and 50 ml/min (STP) flow rate. Typical results (Fig. 2) indicated the conversion of ~55 % at a specific input energy of ~ 1 kJ/L H_2S. Among the different catalysts, MoO_x/ SMF and CoO_x/ SMF showed best performance, which may be assigned due to synergy between plasma excitation of the carrier gas molecules and catalytic behaviour of MoO_x/ SMF and CoO_x/ SMF catalyst.

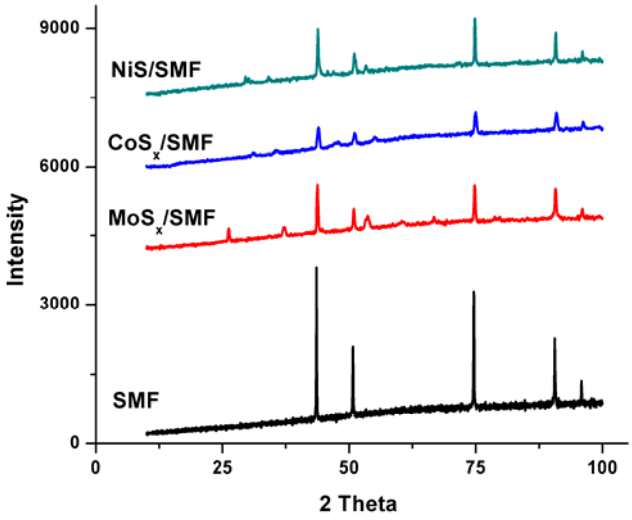

Fig. 1. XRD patterns of SMF and different metal oxides (Mo, Co and Ni) supported on SMF

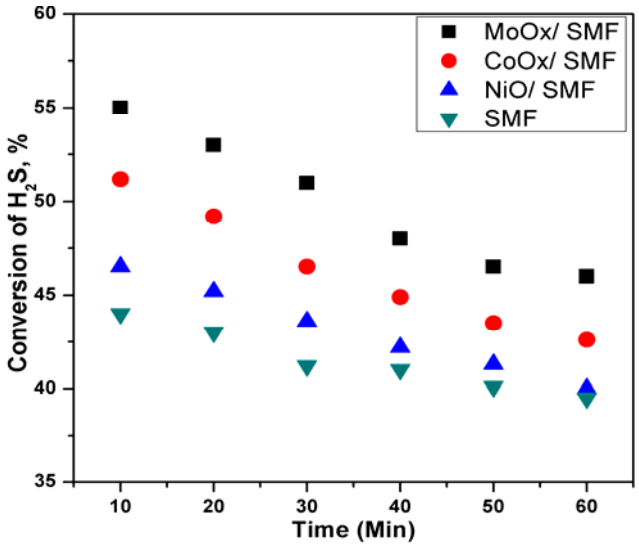

Fig. 2. Conversion of H_2S with respect to time (min) over SMF, MoO_x/SMF, CoO_x/SMF and NiO/SMF catalyst modified DBD reactor at 20 kV applied voltage, 50 Hz frequency, 150 ml/min flow rate and 5 vol.% initial concentration.

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IP44

Green and Eco-Friendly Approach to Wastewater Treatment

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Abstract

Water pollution by dyes discharged from textile industries is a major concern. Discharge of wastewater into water bodies causes pollution and affects water quality in many ways. A variety of physical, chemical and biological methods are presently available for the treatment of waste water. However, these methods are not completely destructive and may transfer the contamination from one phase to another [1]. It is significant and necessary to study the degradation and mineralization of textile wastewater. In this context, Nonthermal plasma (NTP) chemistry has made significant role over the past two decades, as it presents a good promise [2, 3]. Metal oxide catalyst combined with NTP was shown to be a promising technology for environmental applications particularly due to the synergy on combination with catalysts [4].

The present work was focused on the degradation and mineralization of dyes present in water with and without catalyst. For this purpose, various parameters like applied voltage, initial dye concentration, effect of pH, addition of H_2O_2 and addition of metal oxide catalyst on was studied. The decrease in concentration was determined by spectrophotometer, whereas, mineralization was confirmed by CO_x analyzer and quantified by TOC analyzer. COD was measured by the titration method. The catalyst characterization was done by XRD, BET, Raman, ICP-OES, elemental analyzer and UV-Visible spectrometer. Electrical characterization of plasma was done by using digital oscilloscope. The

chemical oxygen demand and total organic carbon levels were monitored continuously and the kinetics of dye degradation were determined. A plausible mechanism has been proposed for the NTP degradation of dyes in wastewater.

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IP45

Response Of Tungsten Material To Fusion Grade Plasma

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Abstract

Tungsten material is projected as one of the major components of fusion plasma reactor. Plasma focus (PF) device is a compact laboratory fusion device. It is an efficient source of ions, electrons, X-rays and neutrons. A PF device operated at 11.5kJ (40µF, 24kV) of bank energy with deuterium gas at 6mb of pressure has been developed here. The tungsten sample was irradiated with deuterons and neutrons at 6cm from tip of the anode. The ion flux and neutron flux in a single PF discharge at this position were 4.3x 10^{17} ions/m^2 and 2.2x10^{10} neutrons/m^2 respectively. The pre and post irradiated tungsten samples are analyzed using X-ray diffraction (XRD), energy dispersive X-ray fluorescence (EDXRF) and optical microscope. Though no new phase was observed but micro cracks were noticed due to ion irradiation. The micrograph of unexposed and irradiated sample are shown in Figure 1 and Figure 2 respectively. The details of the result of our preliminary study will be reported reported.

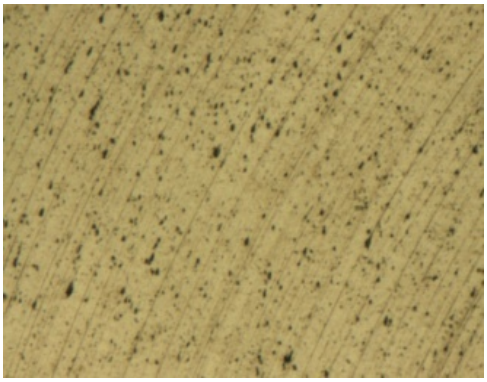
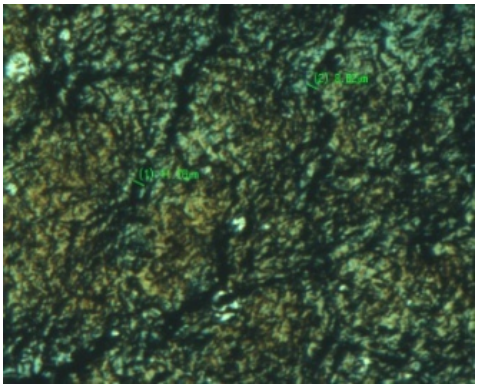


Figure 1. Optical micrograph of unexposed tungsten



igure 2. Optical micrograph of irradiated tungsten

IP46

A facile unconventional method for Water gas shift reaction

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Abstract

The need for developing highly efficient, cleaner and environmentally friendly energy devices drives the sustainable development[1]. Fuel cells are promising candidates as energy-efficient conversion devices. Hydrogen, used as fuel in electrochemical cells has the potential to meet the global energy needs in a clean and sustainable way. Currently, the water-gas shift (WGS) reaction is attracting renewed interest because of its importance in hydrogen production. The WGS can be used as an initial stage for hydrogen generation and for reduction of the CO level in the reformed fuel and automobile exhaust gas.Many authors have studied different noble metal supported catalysts in this reaction [2-4]. But this method has some limitations such as design of active catalyst, use of noble metals, thermal stability of the catalyst, deactivation of the catalyst at higher temperatures etc, Hence, there is an immediate need to develop alternate technologies for to overcome these limitations.

In this study Nonthermal plasma (NTP) assisted WGS reaction for H_2 production will be presented, NTP generated under ambient conditions [5] seems to be the best choice, where CO can act as a reductant and water act as an oxidant. The experimental set up consists of in a quartz tube of length 30 cm and diameter was 21 mm and effective discharge area was 15 cmfor plasma generation. Stainless steel rod was used as an inner electrode and the outer electrode was Cu wire wound around the quartz tube. The discharge gap was 3.5 mm. The AC voltage is fixed at 12-20 kV at 50Hz was applied. The discharge power (W) of the DBD reactor was calculated by V-Q Lissajous method [6]. Products were identified by using an online GC-2014 and confirmed with a GC-MS. The influence of various parameters like input power, total feed flow rate, dilution and catalyst on the conversion and product selectivity were studied. Typical results with NTP combined with NiO/Al2O3 indicated the better performance of over NPT alone for hydrogen production.

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IP47

Calcium Modified Li_2Ti0_3 for breeder blanket reactor

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Abstract

Calcium modified Lithium Titanate Pebbles were fabricated by sol.gel technique of chemical

method. Calcium Acetate(E-Merk) , Lithium nitrate (E-Merk) and titanium butonoid (E-Merk) were taken as basic solution. Ethylene Glycol and Citric acid were taken as chelating agents. Solutions were heated with continuous stirring at 80^0C for 120 h with Ph value of 9. Modified Lithium titanate pebbles were fabricated by using acetone as spherodizer. Pebbles of diameter around 5 mm were fabricated. Thermal characterization of green gel was done by help of DTA/TG. Ceramics were calcined at 600^0 C for 1 hour. For optimum value of density, samples were sintered at varying temperature. Moderate increase in thermal conductivity and crush strength is observed due to calcium doping.

IP48

Sputter pressure influenced structural, morphological and optical properties of magnetron sputtered MoO_3 films

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Abstract

Thin films of MoO_3 were formed on glass substrate at room temperature by sputtering of molybdenum target in an oxygen partial pressure of about $4x10^{-2}$ Pa, sputtering power of 150 W and at various sputter pressures in the range 2 – 6 Pa. The effect of sputter pressure on the structure, morphology and optical properties of MoO_3 films have been investigated by employing the characterization techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM) and VU-Vis-NIR spectroscopy respectively. XRD analysis of the thin films exhibit polycrystalline nature with (020) orientation corresponds to the orthorhombic MoO_3 phase. The intensity of (020) peak increased with increase of sputter pressure. The crystallite size increased from 16 to 25 nm with increase of sputter pressure from 2 Pa to 6 Pa respectively. Microstructural analysis of the films reveals that the dense grains observed at low sputter pressure of 2 Pa. Nano flower like structure can be observed at sputtering pressure of 4 Pa. The microstructure of the films transform into needle like structure when deposited at higher sputter pressure of 6 Pa. The optical transmittance of the deposited films was about 85 % at low sputter pressure and it decreased with the increase of sputter pressure. The optical band gap increase from 2.86 to 3.12 eV and the refractive index of the films increased from 2.02 to 2.12 with increase of sputter pressure from 2 Pa to 6 Pa respectively.

IP49

Nonthermal plasma for energy and environmental applications

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Abstract

Oxidation of pollutants present in air and aqueous media presents is very much in demand due to adverse effect of pollutants on environment. Removal of these pollutants based on the combination of electrical discharges and catalytic degradation is receiving attention over the years, mainly due to the availability of potential oxidants and possibility of up gradation. Dielectric barrier discharges (DBD) present a specific advantage over other techniques like ease of operation,

durability, etc. DBD in air and at the water-gas interface have been used for degradation of various organic pollutants.

Electrical discharges generated in water induce different physical and chemical effects like high electric fields, UV radiation, overpressure shock waves, and the formation of chemically active species. The interaction of the high energy electrons created by the discharge with the water molecules produces highly oxidative species like hydroxyl radicals (OH), ozone radical ions (O_3^-), ozone (O_3), atomic oxygen (O), hydrogen peroxide (H_2O_2) and hydroperoxyl radicals (HO_2). This presentation will be focus on

- Design of plasma reactors
- Understanding the nature of electrical discharges in air/water
- Results on degradation of selected organic pollutants in air/water
- The role of oxidising species and catalyst
- NTP for hydrogen production

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IP50

Phase Structure And Particle Size Of Nano-Crystalline Titanium Dioxide Powder Synthesized By Reactive Plasma Processing

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Abstract

Nanocrystalline titanium dioxide powders synthesized by reactive plasma processing often yields a mixture of the stable phase and meta-stable phase. A novel method involving 'in-flight' oxidation of TiH_2 was processed in thermal plasma jet. The powder collected from various regions of the plasma reactor was analyzed for particle size, surface area and phase composition. Particle size and surface area are vital factors that decide the phase structure of the oxides synthesized by plasma route. The relative amounts of anatase to rutile fractions varied with respect to zone from which the powder was collected. It was also observed that the relative amount of anatase with respect to rutile was closely related to the particle size. Details are presented in this paper.

IP51

Study Of Space Charge Transition During Titanium Nitride Thin Film Deposition By Magnetron Sputtering

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Abstract

This work focuses on the study of space charge transition in the plasma sheath and pre-sheath regions and its effect during the plasma deposition process of titanium nitride thin film by magnetron sputtering using Emissive probe diagnostic. Non-intrusive optical emission spectroscopic technique study shows that the emission intensities of the different species comprising the reactive discharge in the plasma process undergoes fluctuations. Proper adjustment of the gas partial pressures is very essential to overcome the instability. The optimization of the plasma parameters required indepth study for proper deposition of the coating.

IP52

Surface effects by glow discharge plasma on surface properties of polyvinyl alcohol film

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Abstract

The Poly (vinyl alcohol) films have been exposed to glow discharge air plasma to improve their surface properties for technical applications. Surface energy values have been estimated using contact angle value for different exposure times for water is a test liquid. Surface composition of the films was analyzed by FTIR. From the FTIR analysis, polar groups are increasing on the polymer surfaces to be highly hydrophilic, which mainly depend on the increase in oxygen-containing groups.

Keywords: Glow discharge, PVA, Surface treatment, Surface energy, Wettability

IP53

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Abstract

A dc potential was applied between the two electrodes and adjusted till stable glow discharge plasma is generated. The PVA film was inserted with its surface perpendicular to the discharge axis between the electrodes. The exposure time of the sample was varied from 1 to 15 min. The discharge potential and base pressure were kept constant

at 350 V and 0.3 mbar. After the plasma treatment, the samples were immediately weighed to estimate etching effects on the surface layers of PVA films [1-2]. The plasma etching effect described by weight loss ratio was calculated as following expression

$$\text{Weight loss } \% = (W_{ut} - W_{pt}/ W_{ut}) \times 100$$

Where W_{ut} and W_{pt} are the weight of untreated and plasma treated samples respectively.

The etching process is predominant on the amorphous regions of the surface than on the crystalline regions. Therefore it is possible that the initial rates of etching are more rapid. Once all the etchable amorphous materials on the surface have been removed, the remaining crystalline and tightly bound amorphous material cannot be removed easily, causing decline in the etching rates. The second reason for the decline in the etching rate could be the re-deposition of sputtered fragments. Sputtered polymer fragments are reactivated in plasma and re-deposition takes place.

A small drop of distilled water was placed on the polymeric surface with a microsyringe and observed through a microscope. The height (h) and radius (r) of the spherical segment were measured, and the contact angle was calculated by the following equation

$$\text{Contact angle } (\theta) = \tan^{-1} \{x/y\} \text{ ---------- (1)}$$

The contact angle values are considerably reduced after the plasma treatment even for short exposure time (5 min) shifting them to lower values (36.4° for water).

From the FTIR results, most pronounced changes between the untreated and treated PVA samples after air plasma treatment are in the range 3000-3500 cm^{-1} and 1000=1700 cm^{-1}. The peaks attributes to OH and NH vibrations, aliphatic CH groups and metal carbonyl groups. Around 830 cm^{-1} CCl groups and 940 cm^{-1} corresponds to Olefinic CH wag. The region of 1000-1300 cm^{-1} corresponds to C-O bonds.

The presence of these polar groups strongly contributes to increase the hydrophilic nature of the fabric surface.

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IP54

Surface Modification of Toughened Polymeric Hydrogels for Biomedical Applications

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Abstract

Plasma treatment of polymeric materials has emerged as a promising research field for speedy commercialization of biomedical implants, as it is a safe and non-toxic process and can provide suitable surface modification for improving biocompatibility and cell growth within human body.
In the present work a few polymeric hydrogel substrates are being treated in plasmagen gas with a suitably modified magnetron sputtering device to study the effects of surface treatment. An increase in hydrophilicity and surface roughness are expected from the plasma treatment which will be studied by scanning electron microscopy and contact angle measurements. The polymeric hydrogels used by us were previously toughened by a novel sol-gel crosslinking process to increase their toughness and resilience. Surface treatment by plasma will be an effective tool for achieving enhanced surface properties for use as biomedical implants while retaining the desirable mechanical properties such as toughness and resilience.

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IP55

The Effect of Nitrogen (N_2) Partial Pressure And Substrate Biasing On The Growth Of TiN Thin Film On Pre Nitrided AISI M2 High Speed Steel.

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Abstract

The present study examines the mechanical and structural properties of titanium nitride coating deposited onto plasma nitrided AISI M2 high speed steel substrates. The plasma nitriding process [1-2] was carried out at a temperature of 500 ^oC for time duration of 24hrs with a gas mixture of 80% N_2 - 20% H_2 at 5 mbar pressure. The titanium nitride (TiN) coatings were deposited using a planar magnetron sputtering system[3-4] at different substrate biasing voltages(5-100V) and N_2 partial pressure($4.0X10^{-2}$ Pa-$6.0X10^{-2}$ Pa).This range of partial pressure was obtained by using N_2 flow rate from 1 to 5 ml/mint. The highest surface hardness of 845 HV0.1 was obtained on plasma nitrided substrates. The surface properties of the coated substrates were characterized using surface roughness tester, Vickers microhardness tester, X-ray diffraction (XRD), and Scanning Electron Microscopy (SEM).The growth of TiN coating on plasma nitrided AISI M2 steel samples at different substrate biasing voltages and N_2 partial pressure is investigated in the present work.

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IP56

Surface Modification Of Toughened Polymeric Hydrogels For Biomedical Applications

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Abstract

Plasma treatment of polymeric materials has emerged as a promising research field for speedy commercialization of biomedical implants, as it is a safe and non-toxic process and can provide suitable surface modification for improving biocompatibility and cell growth within human body. In the present work a few polymeric hydrogel substrates are being treated in plasmagen gas with a suitably modified magnetron sputtering device to study the effects of surface treatment.

An increase in hydrophilicity and surface roughness are expected from the plasma treatment which will be studied by scanning electron microscopy and contact angle measurements. The polymeric hydrogels used by us were previously toughened by a novel sol-gel crosslinking process to increase their toughness and resilience. Surface treatment by plasma will be an effective tool for achieving enhanced surface properties for use as biomedical implants while retaining the

desirable mechanical properties such as toughness and resilience.

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IP57

Studies on Synthesis of Carbon Encapsulated Iron Nanoparticles by Supersonic Thermal Plasma Expansion Technique

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Abstract

Metallic nanoparticles are attracting a lot of interest because of their enhanced properties. They have diverse prospective applications [1]. But bare metallic nanoparticles are easily oxidized which reduces their magnetic performance. To prevent oxidation, encapsulation of magnetic nanoparticles is necessary and carbon is found to be an ideal material for encapsulating magnetic nanoparticles. In this paper, we present results on the synthesis of carbon encapsulated iron nanoparticles by a supersonic thermal plasma assisted technique. The synthesized particles are characterized by XRD, TEM and Raman. The magnetic properties of the samples are also studied. The effect of variation of different experimental parameters on the properties of the synthesized materials is studied. Core iron nanoparticles showed a very impressive size distribution with an average size less than 6 nanometers, one of the best by a plasma assisted method. The pressure in the sample collection chamber had a profound effect on the properties of the synthesized particles.

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IP58

Improvement of surface and antibacterial properties of PET/TiO_2 films using low pressure RF glow discharge oxygen plasma

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Abstract

In this paper, the thin transparent titania (TiO_2) film were coated one the surface of poly(ethylene terephthalate) (PET) films surfaces using simple sol gel techniques. The surface properties of obtained PET/TiO_2 thin film surfaces were further improved by RF glow discharge oxygen plasma as a function of exposure time at the discharge power of 30W. The change in hydrophilicity of the PET/TiO_2 films were analyzed by contact angle and surface energy analysis. The structure and chemical state of the plasma treated samples were analyzed by X-ray diffraction pattern (XRD) and X-ray photo electron spectroscopy (XPS) analysis. The change in surface topography of the PET/TiO_2 films were investigated by atomic force microscopy (AFM). The antibacterial activities of the PET/TiO_2 films were evaluated by bacterial eradication tests with *Escherichia coli* at incubation time of one day. The results show that surface hydrophilicity has been improved due to increasing the roughness and the introduction of oxygen containing polar groups. The XPS results showed an increase of Ti^{3+} state and oxygen containing polar groups due to oxygen plasma treatment. The AFM observation on PET/TiO_2 film shows that the roughness of the surface increased due to oxygen plasma treatment. The bacterial test results showed the reduction of adhesion of e-coli bacteria on the surface of the PE/TiO_2 films compared with untreated film surface.

IP59

Biocompatibility of metal (silver and titanium) containing diamond like carbon (DLC) on flexible PET film surface by hybrid reactive sputtering technique

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Abstract

Diamond like carbon is one of the superior materials which have been widely used for many industrial applications due to its superior tribological, mechanical and biological properties. The properties of the DLC films is further significantly increased by the incorporation of other foreign metal element such as Cu, Ti, Ag, W and Pt. Such type of metal containing DLC films can be effectively coated on flexible polymer surfaces can facilitate to modify polymers for highly functionalized materials. This functionalized DLC-polymer composite materials can create soft, flexible, highly functionalized and cost effective biomedical blood contacting devices such as artificial heart valves, rotary pumps etc. In this paper, silver (Ag) and titanium (Ti) containing DLC films were coated on the surface of flexible polyethylene terephthalate (PET) film surface by novel hybrid reactive sputtering technique. The metal containing DLC films were prepared as a function of deposition power level. The surface morphology and chemical composition of the Ag and Ti- DLC were analysed by atomic force microscopy (AFM) and X-ray photo electron spectroscopy (XPS). The hydrophilicity of the film was measured by contact angle and surface energy analysis. Furthermore, the biocompatibility of the metal DLC's were analyzed *in vitro* testes such as thrombus formation, whole blood clotting time and protein absorption analysis.

IP60

IP61

Dual Frequency Discharges: A potential tool for Large Area Plasma Processing

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Abstract

The plasma processing is being extensively used in microelectronic industry for manufacturing various electronic devices. Presently, the semiconductor industry is looking forward to move for fabrication of electronic devices at a few tens of nano-meter level. However, the device fabrication cost increases as the size of electronic device reduces. Therefore, large area wafer size is necessary to be adopted in order to improve productivity and optimize the fabrication cost of such microelectronic devices. According to a technology trend forecast, the wafer size will be 450 mm in

diameter within a few years.

The most significant challenge for fabrication on a large area wafer size is to precisely control the distribution of plasma species over the substrate. Various ideas, such as segmented and gridded antennas, capacitively coupled plasmas (CCP) and very high frequency capacitively coupled plasmas (VHF-CCPs) have been proposed and implemented to achieve large area plasma sources with enhanced discharge uniformity over the substrate. Due to ability of being operated at low pressure, high plasma density,easier plasma uniformity control and the separationof discharge production and ion acceleration mechanism of the ICP sources turned the research direction towards developing and investigating the ICP sources for large area microelectronic device fabrication. However, scaling up conventional ICP sources pose some problems such as increased antenna impedance that, in turn, increase RF voltage drop across the antenna and therefore, decrease average power transfer efficiency to the discharge and produces azimuthal non-uniformity due to the standing wave effect. To overcome this issue, a novel approach of dual frequency dual antenna inductively coupled plasma (DFDA-ICP) source has been adopted. The experiments that demonstrate center to edge plasma density control, modulation of plasma parameters, electron energy distribution (EED) and Ion Energy distribution (IED) will be described in this presentation.

IP62

Temporal evolution of plasma potential in a 60 MHz / 2MHz pulsed dual frequency capacitively coupled discharge

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Abstract

Using an electron emitting probe, time-resolved plasma potential (V_p) measurements have been carried out in a pulsed dual frequency 60 MHz / 2 MHz capacitively coupled discharge. The discharge was produced using argon gas at two chosen pressures of 20 and 40 mTorr, a duty ratio of 50% and pulse powers ranging from 100 to 500 W. The pulsing frequency was set at 1 kHz. The plasma potential measurements have been performed at 10 mm above the center of substrate.

It has been observed that the V_p follows the source discharge pulse voltage and remains positive during the whole pulse cycle. Without substrate biasing, the prominent features observed in the V_p, at all the operating conditions, remains similar, however the magnitude of the V_p increases with the applied RF source power. To further analyze, three distinguished features in the $V_p$profile, a transient spike at the beginning of the discharge pulse, a stable 'on-phase' and a 'stable-off" phase, have been identified. For a typical operating condition (20 mTorr and 500 W), the transient spike in the V_p of ~30 V appears for 30 μs, then it attains a stable value of ~12 V during rest pulse on-period. The V_p decreases up-to ~3 V as the pulse is switched off.

It has also been observed in this study that a continuous wave (CW) RF biasing of the substrate significantly modulates plasma potential evolution, specifically when the pulse is switched off and the magnitude of modulation depends upon the substrate biasing power.

IP63

Discharge Current Noise Characteristics in Non-thermal Plasma Reformers of Hydrocarbons

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Abstract

A non-thermal plasma reformer of hydrocarbons (Plasmatron) has been designed and developed. Here plasma is used as catalysis of the hydrocarbons to separate out hydrogen from hydrocarbons in appropriate experimental conditions. Plasma is produced between typically design electrodes of different configurations. Stain less steel, Nickel and copper

are used as electrode materials for the whole experiments. A variable frequency AC power supply of peak to peak voltage 2 kV has been used for the discharge mechanism. Periodic fluctuations have been observed in the measured oscilloscope data of discharge current only for very short time scale. Fluctuation in the discharge current has been observed for very short time scale in the initial part of the applied voltage. In this study an attempt has been made to understand these fluctuations characteristics both analytically as well as numerically.
The advantage of this developed Non-thermal low current plasma is involved in the process to have less power consumption compared to the other plasma process like thermal plasma reformation. The reaction taking place in this case is partial oxidation, which is an exothermic process. So this leads to a reduction or elimination of metallic catalyst. This type of small scale hydrogen production has a potential use in internal combustion engines of vehicles besides other decentralized hydrogen production for industries and other areas like fuel cell technologies.

IP64

Phase depth distribution study of nitrided layer in the mirror polished plasma nitrided AISI304 stainless steel using XRD characterization

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Abstract

An experiment was carried out to study the phase depth distribution characteristics of plasma nitrided layer on AISI304 stainless steel (Ra=0.02 μm). Plasma nitriding was carried out using Pulsed DC discharge at 500 ^{0}C under 5mbar pressure for 24 hours in the presence of N_2-H_2 gas mixtures (80%N_2-20%H_2).Hardness of 1201Hv and case depth of 135μm were achieved after plasma nitriding. The phase depth distribution of nitrided case was studied using x-ray diffraction technique by removing the nitrided layer step by step using the standard polishing method. Hardness seems to increases with case depth in the beginning and then decreases .The XRD results confirms that the dominant iron nitride phases present in the surface of the plasma nitrided samples are γ' (Fe_4N) and ε ($Fe_{2-3}N$) along with the formation of CrN .Depth distribution study of the nitrided layer indicates the formation of FeN phases which replaces the γ' (Fe_4N) at 23μm and ε ($Fe_{2-3}N$) at 68μm along with the formation of α-Fe phase.

PD01

Radiation Power Loss Measurement in Tokamaks

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Abstract

A tokamak plasma emits electromagnetic radiation from low energies upto energy almost equal to the temperature of the plasma. This radiation loss fraction can vary from 0.1 to 1 depending on several factors like the operation regime, plasma parameters and its size. It is generally desirable to obtain plasmas that have less radiation power loss. But the same is not true for D-T plasmas like the one in ITER. There, a large fraction of the power from alpha particle heating must be radiated to limit the power falling on the divertor plates. So it is essential to estimate and control the power radiated from the plasma. In addition to this control, measurements of the radiated power are required for evaluation purpose; in particular, spatially resolved measurements are required in studies of power balance.

Bolometer diagnostic measures the radiation power loss and its spatial variation. Wide-angle-viewing single bolometers are used to estimate the total radiated power. The measurement from a single bolometer is only adequate to estimate the total radiated power when the radial and poloidal emissivity distributions are known reasonably well. However presence of high-Z impurities and certain instabilities could lead to localized peaks in the emission profiles, necessitating collimated bolometer measurements along several lines of sight. The collimated measurements are then inverted using tomography algorithms to obtain the radiation emission distribution in the plasma.

This talk will provide background on bolometry, discuss the bolometer detectors and techniques for tomographic inversion, summarize the important bolometric results from fusion devices including Aditya tokamak and project requirements for next generation devices.

PD02

Modified Atomic Spectral Lines Due to Opacity Useful For Branching Ratio Technique in Plasma Spectroscopy

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Abstract

Calibration of a Vacuum Ultra Violet (VUV) Spectrometer-detector system is essentially needed in order to use it in fusion plasma machines [1] and other laboratory applications. Recently, a simple and cost effective VUV calibration scheme is proposed [2], which requires more investigation to establish the same and to use it for VUV spectrometer applications. The other often used technique is branching ratio method [3-4]. The branching ratio method demands

plasma to be optically thin but this condition frequently differs and one need to include the effect of opacity to get the correct VUV calibration. In this work an effort has been made to identify the effect of opacity on atomic lines commonly used in branching ratio method. In order to include the opacity effect on the spectral lines, extensive analysis is carried out using Atomic data and Analysis Structure (ADAS) code [5], which provides new findings and will be presented.

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PD03

Magnetic Measurements in Tokamak SST-1

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Abstract

Magnetic measurements during the Engineering validation phase of SST-1 are presented in this paper. As the Ohmic coil system can be operated at the room temperature, it is energized first. Due to the toroidally continuous Vacuum vessel and Cryostat in Tokamak SST-1, it is very important to know the response of the central solenoid and other correction coils. The field attenuation and penetration delay caused due to the vessel and cryostat are measured using 11 one-turn flux loops are inside the vacuum vessel, 2 loops inside the cryostat and 10 loops outside the cryostat. In addition, 12 pairs of two-component magnetic probes are also installed inside the vacuum vessel. In addition, after cool-down phase, TF coils (and PF coils) are energized and their effects on various magnetic measurements (to see the effect of coils misalignment) are also measured. All these experimental results are also compared with the computed fields and these are used to calibrate various magnetic probes/coils in-situ.

PD04

Ultra high vacuum testing and the initial calibration results of Time of Flight Neutral Particle Energy Analyzer

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Abstract

Time of Flight Neutral Particle Energy Analyzer (TOF-NPEA) is designed and developed for the detection of the low energy (50eV – 1000eV) Charge Exchange Neutrals (CX-N) escaping from the magnetically confined Tokamak plasma and to estimate the Tokamak ion temperature. TOF-NPEA system consists of an ultra high vacuum compatible chamber for chopper & detector housing and a long flight tube [1]. The TOF-NPEA is specially designed by taking care of the limited flux, required energy resolution and Tokamak environment. For Low energy neutrals, the scattering with the background gases becomes significant hence it poses critical requirement for UHV in the TOF-NPEA vessel for detecting low energy neutrals.

CX-N flux is mechanically chopped into bunches using a chopper disk of 150mm diameter spinning at ~ 60,000 RPM. Vacuum grade slotless brushless DC motor with low outgassing material and ceramic hybrid ball bearings is specially chosen to ensure UHV compatibility of chopper's motor [2]. Separate Turbo Molecular Pumps having speed of 1500 l/sec and 900 l/sec (for H_2 gas) are employed for chopper chamber and detector chamber pumping respectively to maintain UHV conditions (<1.0x 10^{-7} Torr) throughout the TOF vessel.

Neutrals fall on a Cu-Be plate after travelling through the flight tube, the Cu-Be plate generates the secondary electrons (SEs) in response to the neutrals and these SEs are detected by channel electron multiplier (CEM). UHV environment is also required to ensure the improved collection efficiency of these SEs over CEM and their detection and to improve signal to noise ratio. This paper describes the TOF-NPEA system and reports the results of test experiments and initial calibration of the system.

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PD05

Measurement of Electron Temperature and Electron Density in an Atmospheric Pressure Dielectric Barrier Discharge

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Abstract

A homogeneous dielectric barrier discharge (DBD) in argon was produced by applying high voltage A.C. source of potential difference (0-20) kV operating at a frequency of 10-30 kHz across two parallel plate electrodes with glass as dielectric barrier. The discharge was characterized by optical emission spectroscopy and electrical measurement. Four

argon emission lines from the discharge were analyzed and the electron temperature was estimated by line intensity ratio method. The electron density in the discharge was estimated by power balance method. An investigation of the effect of inter-electrode distance on the electron density was made. The results showed that the electron temperature is less than 1 eV and the electron density is of the order of $10^{11}cm^{-3}$which varied with the distance with electrode.

PD06

Conceptual Design of Charge Exchange Recombination Spectroscopic Diagnostics On the SST-1 Tokamak

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Abstract

In high temperature plasma devices equipped with neutral beam injection, charge exchange spectroscopy is a key diagnostic which can provides spatially localized measurements of the ion temperature, toroidal and poloidal velocities of the ionic species present. The temperature and velocities are derived from the Doppler broadening and Doppler shift of spectral lines. In addition, density of the impurities species can be derived from the line intensity coupled with a neutral beam deposition calculation. Furthermore, the radial electric field can be derived from the radial force balance equation.

The measurements are spatial localized to the region where the spectroscopic view crosses the neutral beam.

In SST-1 tokamak, charge exchange spectroscopy diagnostic will utilize the hydrogen neutral beam for plasma heating. This 40 keV netural beam delivers 1.2 MW into the plasma. The spectroscopic measurement utilizes the n=8-7 transition in hydrogen–like carbon at 529.05 nm, which is produced by charge exchange between fully stripped carbon ion (C^{6+}) and energetic beam neutral. The optical system has been designed to allow study of H-mode physics, which requires measurements with fast temporal and high spatial resolution. For this purpose, a high throughput Czerny-Turner spectrometer (f/4.7) with 1800 grooves/mm holographic grating and sCMOS CCD camera is planned, which will achieve a time resolution of ≤ 5 ms. The SST1 plasma has a minor radius of 20 cm. The spectroscopic system uses 1 mm core diameter fiber to obtain 40 tangential views spaced 1 cm apart across the plasma midplane. The fibers view the plasma through a 50 mm diameter objective lens with 200 mm focal length. In this presentation, details on the conceptual design of the system will be discussed.

PD07

Alika Khare

PD08

Determination of Electron Density in Laser Induced Molybdenum Plasma

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Abstract

In this paper, the electron density of laser induced plasma of Mo at relatively low fluence of laser is reported as a function of background Helium gas pressure. The second harmonic of Q switched Nd: YAG laser (532 nm) was loosely focused on to the Mo target in Helium background. The laser fluence was maintained around ~ 2.4 J/cm^2. The emission from laser induced plasma was scanned with a monochromator. The recorded Mo spectrum at 0.5 mbar Helium ambient is shown in figure 1. Only Mo I lines has been marked in the spectrum. The electron density was estimated from the stark broadened line profile of Mo I. The dependence of electron density on the Helium gas pressure at such low laser fluence shall be presented during the conference.

PD09

Effect of 30 keV Deuterium Ion Beam onto Pulsed Laser Deposited Rh/W/Cu Multilayer

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Abstract

Thin films of heavy metals of Rh, W, Mo, Cu have been looked upon as a simple alternative for the first mirror (FM) application in the optical diagnostic of a fusion device. The durability of these thin film FM can be enhanced by depositing the the multilayer of these mirrors in proper sequence. In the present paper, the effect of 30keV deuterium ion beam on multilayer Rh/W/Cu mirror like thin film is reported. The multilayer thin film was fabricated on to a polished SS substrate via pulsed laser deposition technique. The UV-visible and FIR reflectivity was measured before and after irradiation of D ions. It was observed that rms surface roughness changed from 12 nm to 15 nm after irradiation. The post irradiation changes in the UV-visible and FIR reflectivities were 3% and 1% respectively. The FIR spectrum showed a broad peak at 15μm corresponding to the scissor vibration mode of D-D confirming the implantation of D ions into the film during irradiation of D ion beam. The details shall be discussed during the conference.

Acknowledgment:
This work is partially supported by BRFST, NFP (India), Project nos. NFP/DAIG/A10/01 and NFP/DAIG/01.

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PD10

Electron Impact Ionization for Heavy Element Impurities in Plasmas

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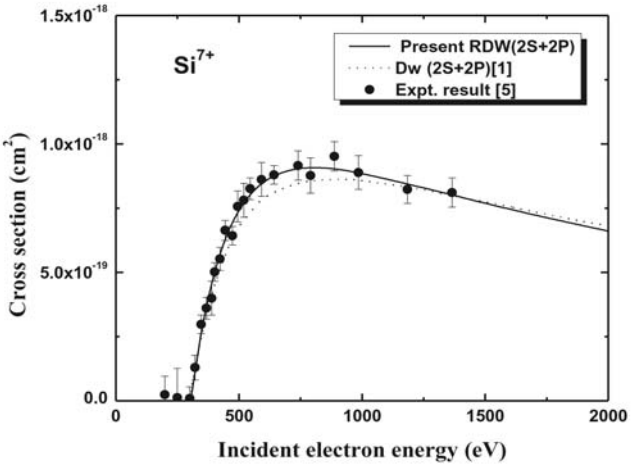
Abstract

The ongoing need for accurate atomic data has been motivated several groups to generate high-quality atomic collisional data for the systems of interest. Electron impact ionization (EII) is one of the important processes which plays a vital role in the laboratory and astrophysical plasma. The cross section data for the ionization process are required for plasma modeling and diagnostics purpose. A number of theoretical calculations and experimental measurements for electron impact ionization have been performed for different ionic stages of impurities *viz.* Si, Cl, Ar, W [1-3]. In the International Thermonuclear Experiment Reactor (ITER) tungsten is used as plasma facing components in its divertor region. There can be different ionic stages of tungsten present in divertor region due to electron impact ionization. Trzhaskovskaya *et al* in a recent paper [4] considered the photoionization process for heavy plasma impurities like Si, Cl, Ar, Ti, Cr, Kr and Xe. There has not been much attention paid for studying the electron impact ionization of such impurities.

In the present work, therefore we have considered electron impact ionization of the different ionic stages of Si, Cl, Ar, W and have calculated total cross sections for ionization using fully relativistic distorted wave theory (RDW). Our cross section results are compared with the available experimental and other theoretical results [1, 5-7]. As an elastration the following figure shows the comparison of our electron impact ionization cress section for silicon (Si^{+7}) ion with semi-relativistic DW calculation [1] as well as experimental result [5].The detailed calculated results of the ionization cross sections for other impurities considered in this paper will be presented in the conference.



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PD11

Determination of Electron Density in Laser Induced Molybdenum Plasma

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Abstract

In this paper, the electron density of laser induced plasma of Mo at relatively low fluence of laser is reported as a function of background He gas pressure. The second harmonic of Q switched Nd: YAG laser (532 nm) was loosely focused on to the Mo target in helium background. The laser fluence was maintained around ~ 2.4 J/cm^2. The emission from laser induced plasma was scanned with a monochromator . The recorded Mo spectrum at 0.5 mbar Helium ambient is shown in figure 1. Only Mo I lines has been marked in the spectrum. The electron density was estimated from the stark broadened line profile of Mo I. The dependence of electron density on the He gas pressure at such low laser fluence shall be presented during the conference.

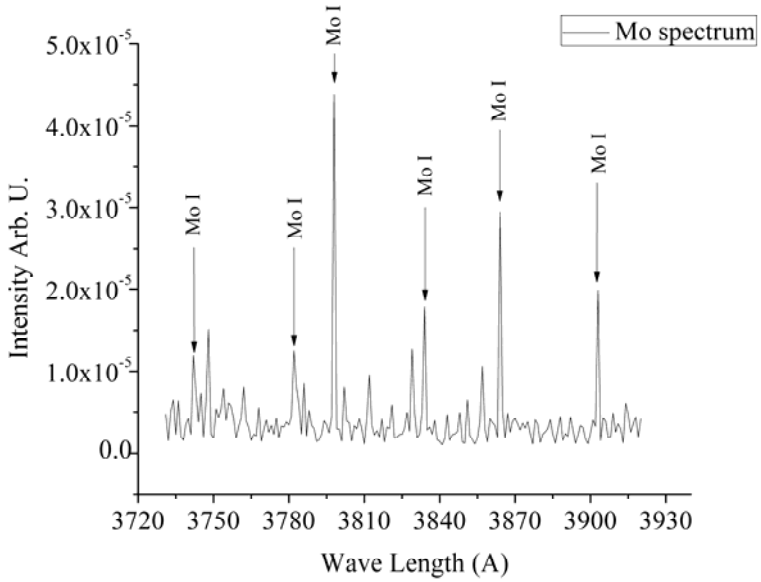

Figure 1. Laser induced Mo spectrum at 0.5 mbar of Helium ambient

Acknowledgment:
This work is partially supported by BRFST, NFP (India), Project nos. NFP/DAIG/A10/01 and NFP/DAIG/01.

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[3] J. Clementson et al, Can. J. Phys. 89 (2011) 571–580.

PD12

Effect of Laser Fluence on Plasma Parameters and its Implication on PLD Thin Films of Ruby (Al_2O_3: Cr^{3+})

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Abstract

The properties of Pulsed Laser deposited (PLD) thin films are governed by the dynamics of laser induced plasma (LIP). Hence the quality of these films shows strong dependence on the laser fluence, target substrate distance and the background gas and its pressure. All these experimental parameters govern the LIP dynamics. In the present paper laser induced plasma of the ruby (Al_2O_3:Cr^{3+}) is reported. To produce the ruby plasma, second harmonic of a high power Nd:YAG Quanta Ray (λ = 532 nm) laser was focused on to the ruby pellet using a Plano convex lens of focal length 35 cm, placed inside a vacuum chamber. The pressure inside the chamber was maintained at ~ 0.05 mbar of oxygen throughout the experiment. The ion density, electron density and electron temperature were measured as a function of laser fluence from I-V characteristics of langmuire probe. The probe was placed at distance of 4cm from the Ruby target, as this was observed to be the optimum distance for the deposition of good quality thin film of Ruby via pulsed laser deposition technique. The laser energy per pulse was varied from 20mj, to ~150 mj. To study the effect of plasma parameters on to the PLD thin films, quartz substrate was placed at a distance of 4 cm to deposit the ruby thin films at various laser energy. The PLD thin films of Ruby were analysed for surface morphology and crystal structure. The correlation between LIP parameters and the quality of the thin films shall be presented in the conference.

Acknowledgement:
This work is partially supported by Department of science and Technology (DST) India, Project No. SR/S2/HEP-19/2008

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PD13

A comparative study of spatial distribution of plasma parameters along and perpendicular to plasma flow direction via planar Langmuir probe

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Abstract

The laser induced plasma (LIP) is investigated using flat plate langmuir probe along as well as perpendicular to the plasma flow direction. LIP is created by focusing a second harmonic of a high power Q switched Nd:YAG laser on to the ruby pellet, using a Plano convex lens of focal length 35 cm, placed inside a vacuum chamber. The probe was placed

normal as well as along the direction of plasma plume expansion as shown in Fig 1 and was scanned along the respective directions. The electron temperature and density were measured from the I –V characteristics of Langmuir probe as a function of the distance from the target over a range of 10 mm to 80in both the directions. The detailed studies shall be presented in the conference.

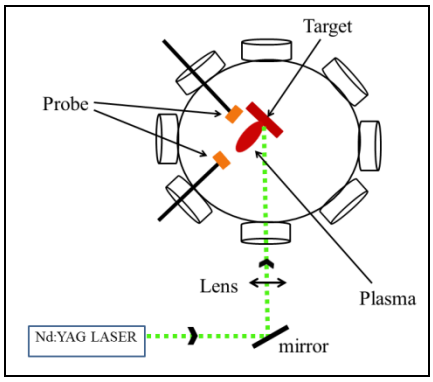

Fig 1: Schematics of Experimental set up

Acknowledgement:
This work is partially supported by Department of science and Technology (DST) India, Project No. SR/S2/HEP-19/2008

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PD14

Spatial evolution of Laser Induced Graphite Plasma by Langmuir Probe

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Abstract

A planar Langmuir probe was used to study the spatial evolution of laser produced graphite plasma in vacuum (~ 10^{-5} mbar) and oxygen ambient (0.1 mbar). The plasma was produced by focusing second harmonic of the nanosecond Nd:YAG laser beam on to the graphite target placed inside a vacuum chamber. The time of flight (TOF) signals from the probe were recorded by biasing the probe from ~66V t0 +66Vas a function of target distance in the range of 2 cm to 7 cm along the direction of plasma expansion, normal to the target. The multiple peaks on the TOF signal reveal the presence of different velocity components of electrons and ions in LIP. The ion saturation current, electron temperature

and electron density were calculated from current-voltage (I-V) characteristics of Langmuir probe as a function of distance from the target. The detailed information of the above work shall be presented during the conference.

Acknowledgement: This work is partially supported by Department of science and Technology (DST) India, Project No. SR/S2/HEP-19/2008

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PD17

Design of a Retractable Bolometer System for Divertor-Bolometry Application in SST-1 Tokamak

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Abstract

Primary motivation for divertor-bolometer diagnostics is to obtain better spatial and temporal resolution of the radiated power in divertor discharges. A fully automated retractable bolometer system has been designed for this purpose which shall penetrate the vacuum vessel from top module at an inclination of 6^0 and azimuth of 10^0. An opening in the baffle module permits visual access to SST-1 plasma. Combination of bellows and gate valve allows the retractable system to provide a vacuum discontinuity and hence removal or replacement of the detector array is made possible without affecting tokamak operation. Area of the divertor scanned by the detector array can be varied due to adjustable final vertical reach of detector head. Servo motors have been used to actuate the system and provide fine spatial increment of the order of 0.5 mm. The detector array is expected to scan 0.011 m^2 area of the inboard divertor and shall subtend a solid angle of 0.05375 Steradian. Movement of the retractable system is controlled remotely by means of a programmable logic control system with a resolution of better than 1 mm.

PD18

Prabhat Kumar Sharma

PD19

Indrajeet Kumar

PD20

Laser Induced Breakdown of Poly (methyl methacrylate) (PMMA) in Air

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Abstract

PMMA is an economical alternative to the polycarbonate (PC) which is a harmful plastic containing bisphenol-A. The interest of this work is to investigate PMMA using Laser induced Breakdown spectroscopy (LIBS). Laser induced PMMA plasma is produced by focusing 2nd harmonic of a high power Q-switched Nd: YAG laser onto the bulk PMMA in air. The LIB spectrum is recorded using a combination of monochromator (SPEX 750M) and PMT which shows well resolved CN violet bands at 388.4 nm. The decay behavior of the vibrational band of CN molecules in laser induced plasma of PMMA is also studied. Furthermore, to get compositional fingerprint of PMMA, the Raman spectrum is recorded before exposing laser onto it. The sharp Raman peaks are observed at 602, 814, 1460, 1725, 2183 and 2957 cm^{-1}. Out of the observed Raman bands, the peak at 2957 cm^{-1} is the most prominent which is due to the C–H stretching vibration.

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The financial support of Department of Science and Technology (DST), India is acknowledged (Ref. No. SR/WOS-A/PS-05/2009).

PD21

Development, calibration and performance testing of the Infrared Imaging Video Bolometer for the SST-1 Tokamak

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Abstract

Infrared Imaging Video Bolometer (IRVB) is a powerful diagnostic tool for the measurement of total radiation power loss from plasma devices and it can provide temporally resolved two-dimensional (2D) images of plasma radiation brightness [1-6]. Recently an IRVB system is designed, developed, calibrated, tested for its performance and installed on the ADITYA tokamak for initial study [7]. IRVB is being developed for the first phase of SST-1 tokamak and to be deployed at mid plane of radial port 2 [8]. The IRVB system developed for the SST-1 tokamak is utilizes a 9cm x 7cm size and 2.5 μm thick free standing Platinum foil as radiation absorber which provides broad radiation absorptions band 1 eV to 8.5 keV (SXR to IR). The foil is clamped on a metal frame having 9cm x7cm opening, experiments were performed to evaluate suitable foil frame material among S.S., aluminium and copper. A square aperture 0.7x0.7 cm2 of pinhole camera geometry provides 13x10 bolometer pixel arrays (130 channels) and ~5cm of spatial resolution at the plasma mid-plane with a 73°(H) x 63(V)° wide field of view (FOV). This wide FOV covers a tangential and a poloidal

cross-section view of SST-1 plasma. The FOV provides unique plasma viewing geometry which is confirmed by simulation results. A medium wave Infrared Camera having 320x240 focal plane arrays, 200Hz frame rate and temperature sensitivity ~0.02°C is used to record 2-D temperature distribution of the foil. Using 2-D heat diffusion analysis method total radiated power deposited on the foil can be obtained. Optimal time resolution of 10ms is achieved with Noise Equivalent Power Density (NEPD) ~200 mW/cm2. The Present paper discusses the development and calibration of the SST-1 IRVB system. Performance of the IRVB system for its time response & NEPD are experimentally investigated and has also been reported here.

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PD22

Parametric Study of Total Radiation Power Loss from the Aditya Toakamak using Infrared Imaging Video Bolometer

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Abstract

Infrared Imaging Video Bolometer (IRVB) is a new type of total radiation power loss measurement system and it provides time resolved two-dimensional images of line integrated plasma radiation with wide field of view [1-6]. An IRVB system is designed, developed, calibrated, tested for its performance and installed on the ADITYA tokamak [7]. The ADITYA IRVB has broad radiation absorptions band ~1 eV to 8.5 keV, wide Field of View 46°x46°, 9x9 bolometer pixel array (81 channels), data acquisition rate 166 Hz, spatial resolution at plasma mid plane is ~7 cm and the Noise Equivalent Power Density (NEPD) ~200 mW/cm^2. Using the IRVB, 2-D radiation brightness images were obtained and analyzed. The present paper describes IRVB data analysis scheme, estimation of total radiation power loss from the plasma. Parametric of variation of total radiated power loss obtained from analyzed IRVB images with density, temperature and plasma current have been reported here. It was found that during plasma current flat-top the total radiation power loss varies from 20% to 40% of the total input ohmic power for different plasma discharges. It was observed that radiated power fraction (P_{rad}/P_{in}) increases with increasing plasma density- The recent results also confirm previous measurements carried out on the ADITYA toakamak using AXUV Bolometer [8].

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PD23

Signal Conditioning System for Neutral Beam Power Profile Analysis of NBI (SST-1)

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Abstract

A positive ion neutral injector (PINI) capable in delivering 5MW (55kV, 90A) ion beam power is being operated for SST-1 neutral beam injection (NBI). SST-1 Neutral beam injection systems has various components on beam line like ion source, neutralizer, deflection magnet, ion dump, beam dump etc. A Thermocouples based diagnostics is being used for Power density distribution, Beam alignment and System protection.

Temperature of beam line components rises when beam passes through them. In order to measure the rise in temperature and estimating beam power profile, beam line components are instrumented with thermocouples (TCs). The thermocouples, which are all K (nickel-chromium/nickel-aluminum) type, have their hot junctions on ground so as to respond quickly to temperature changes. Here 'the ground' means beam line components, which in turn are connected to the single reference point of the electrical circuit. The beam itself is dumped on these parts so TCs are subject to severe voltage transients up to few hundred volts.

PD24

Comparison of Langmuir probe characteristic of argon and oxygen plasma in presence of external magnetic field

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Abstract

In the recent years electro-negative plasmas has drawn significant interest due to various applications arising from low temperature plasma processing of semiconductors, negative ion plasma thrusters and for neutral beam heating in fusion devices. The Langmuir probe is the most basic plasma diagnostic tool used for characterizing negative ion density. The information of negative ion density and electro-negativity can be obtained from electron saturation current of the Langmuir probe. However interpretation of plasma parameters in presence of negative ions can be highly complex in magnetized plasmas as the magnetic field attenuates plasma electrons from reaching the probes surface.

In this paper we present a comparative study of planar Langmuir probe characteristics in argon and in electronegative oxygen plasma. The plasma is produced using a cylindrical DC magnetron discharge operated in conjunction with a constricted anode. The plasma is characterized by an intense annulus glow adjacent to the cylindrical cathode. The

density is found to be dropping sharply towards the centre of the plasma column (figure-1) with application of magnetic field. The above feature is due to limitation in cross field diffusion of plasma electrons radially towards the centre of the plasma column. However the characteristic diffusion length for the negative oxygen ions is much greater than electrons. Comparison of probe characteristics for electro-positive argon discharge and electro-negative oxygen plasma shows that the Langmuir probe characteristic in oxygen tends to be symmetric around the floating potential as the magnetic field

was increased (figure-2). This preliminary result indicates that the central region is likely to be composed of mainly negative ion and positive ions species in a quasi-neutral equilibrium.

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PD25

Polycapillary Optics for X-ray Diffraction Studies with Laser Produced Plasma X-ray Source

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Abstract

Ultra-short laser pulse irradiation of a solid target creates a high temperature and high density plasma, which is a source of high peak brightness ultra-short duration characteristic (K-α) x-ray line radiation. This x-ray line radiation is most useful in time resolved x-ray diffraction (TXRD) experiments. A major drawback of this source is the fact that the radiation from the plasma is emitted into a large solid angle. Therefore, suitable x-ray optics elements are required for collection and focusing of these x-rays for the applications. Many x-ray focusing optics like curved crystal, multilayer mirrors, ellipsoidal capillary, polycapillary etc. are used in various studies. The choice of optics is decided by its ability to deliver the maximum photon flux on to the sample and minimum time smearing of the x-rays by the optics. A polycapillary provides high angular flux, ease of experiment, and pulse broadening of less than 1 ps. Its relatively low cost makes it an optimal choice for TXRD applications in Bragg configuration with crystalline solid samples. The use of polycapillary collimating optics makes it possible to record the diffraction in Debye–Scherrrer configuration, particularly suitable for powder sample.

Polycapillary x-ray optics consists of an array of a large number of small hollow tapered glass (fused silica) tubes (all oriented towards the focus), where focusing is achieved by multiple total external reflection of x-rays on the inside surface of each hollow glass tube, for the x-rays incident at an angle less than the critical angle. This features also makes the polycapillary optics a band pass filter. In order to use this polycapillary in TXRD with laser produced plasma x-ray source, it is necessary to characterize it with a high repetition rate source.

A filament tube x-ray source, having copper target, operating at 20 kV voltage and 10 mA current, emitting x-rays at 8.05 keV (Cu K-α), was used to characterize the polycapillary optics viz. a) focussing lens and b) beam collimator. The polycapillary focusing lens used in the present study was of length 98 mm, with input focal length 50 mm, output focal length 102 mm, and input aperture 4.5 mm. The beam collimator had length 58 mm, with input focal distance 50 mm, and input aperture of 5.3 mm. The focal spot diameter with the focusing polycapillary was measured to be 384 μm (FWHM), for the Cu K-α line. Similarly, the beam collimator was characterized using the same source. A collimated output beam with a divergence of ~ 1.3 mrad was observed.

For the application in TXRD studies, initially the polycapillary optics were tested for recording Debye-Scherrer pattern of standard powdered sample of Si and later by recording an unknown sample. The diffraction pattern recorded without capillary optics shows broad diffraction rings, whereas with the polycapillary collimator optics, sharp rings were

observed, showing an improvement in the resolution of the diffraction pattern.

Details of the present experiment for characterization of the polycapillary optics will be presented and the results will be discussed.

PD26

A Novel Technique to obtain Surface Plasma Electron Density and Temperature of Semiconductor Surfaces Excited by Ultra short Laser Pulses

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Abstract

Surface modification, nano-structuring, and nano-particle formation by ultra-short pulse with intensity in the range of 10^{11} W /cm^2 – 10^{13} W/cm^2 is a topic of current interest because of wide technological advancement in the quest for miniaturization of devices, and also from the point of view of basic sciences to understand the underlying physical processes. For such applications, and also for studies on laser damage and ablation threshold, it is important to know the laser generated electron density and temperature during the laser pulse. The final outcome of such studies critically depends on the initial conditions at the surface. A prior knowledge of n_e and T also helps in evaluating various transport properties like the thermal conductivity or resistivity, pertinent for comprehending the dynamics of laser matter interaction for more controlled growth of the structures. Moreover, experiments with intense ultra-short laser, the dynamics of the interaction is affected by the pre-pulse forming plasma prior to the arrival of main pulse. The knowledge of n_e and T is also helpful in studying the dynamics of laser shocked surfaces, which are studied by time resolved x-ray diffraction.

Here, we propose a new method to obtain the electron density and temperature of ultra-short laser excited semiconductor surface, based on our experiments on interaction of multiple ultra-short laser pulses with semiconductor materials, where nano-ripple formation is observed. The ripple period depended on the incident laser wavelength, angle of incidence, laser fluence, band gap, and the refractive index of the ambient medium. Few laser shots (5-50) from a 45 fs Ti-sapphire laser, were fired on the semiconductor wafers at an intensity in the range of ~10^{12}–10^{13} W/cm^2 , which is in the vicinity of ablation threshold. Ripples are formed when the wave vectors of the incident laser and the surface plasmon satisfy the relation $k_s = k_L + G$. Based on this, the instantaneous generated electron density can be calculated from the expression

$$n_e = n_c[(\mu^2+1)(\frac{\lambda_L}{d}+\sin\theta)-\mu^2]\div[(\frac{\lambda_L}{d}+\sin\theta)-\mu^2]$$

,

where d is the experimentally observed ripple period, λ_L is the laser wavelength, θ the incident angle, and μ is the refractive index of the ambient medium. The electron density of the photo-excited semiconductor surface has contribution from collisional absorption, excitation, linear single photon absorption, and nonlinear absorption process like multi-photon ionization at high intensity. All these absorption processes elevate the temperature of the surface making free electrons available in the conduction band. For a particular temperature, the number density of the conduction electrons can also be calculated by integrating product of density of conduction electron states with the Fermi function. This gives $n_e = 2^{5/2}h^{-3}(\pi mkT)^{3/2}e^{-E_g/2kT}$. One can get the instantaneous temperature information by obtaining a graphical solution of this equation, where one needs to put the already calculated n_e from the momentum matching condition *($k_s = k_L + G$).* In the above mentioned range of intensity of irradiation, the electron density of the surface plasma is always greater than $2n_c$. The wide ripples indicate that the electron density of the surface plasma is up to $10n_c$ whereas the narrow ripples are formed when density is slightly higher than $2n_c$. The estimated temperature of the

surface is of the order of ~1-2 eV. The electron density and the temperature obtained is in close agreement with those from analytical theory and simulations.

Our method has a definite advantage over other methods that here one does not have to speculate about various material constants and physical parameter values needed for predicting n_e and T at extreme conditions. Also, n_e and T can be found for any angle of incidence, ambient medium, laser wavelength, or band gap, whereas, the general analytical or simulation methods would require inclusion of such complexities. Finally, since the interference of the laser field and the field of surface plasmon occur only over the laser pulse duration, a snap-shot of the instantaneous density and temperature is obtained.

PD27

Spectroscopy Data Management System based on Linux Server

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Abstract

Efficient and lossless procedure of data storage, retrieval and its access is very much important for data analysis and processing in research and development field. In Aditya tokamak, spectroscopy data from different spectrometers coupled with CCD cameras are normally acquired and stored using its own data acquisition (DAQ) software installed in the individual DAQ PC during the plasma discharge experiment. Every spectrometer system does have also its calibration data, logbook file of an experiment. To retrieve access and transfer these data, storage media, windows file sharing, and or FTP are traditionally used. It consumes time and is having the probability of data loss. There are also concerns of the corruption of data affected by virus or bug considering that the DAQ PC runs on windows platform. To provide data access and retrieval to all users, there should be a centralized data storage system, i.e. Data Management Server System, which stores and saves the acquired data. We have chosen Linux Server, which stores and saves the data, acquired by windows based DAQ PC connected with spectrometer. It is an open source operating system. It provides data security. Each DAQ PC is assigned to specific directory in the server to store and save the acquired data during

Aditya plasma discharges. Linux server is connected to individual DAQ PC through the Institute's LAN network. Individual user can access the saved data using their respective password protected user account in the data server.

PD28

Spectroscopic Studies of Aditya Tokamak Discharges during Electrode Biasing Experiments

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Abstract

It has been observed in many tokamaks that inserting a biased electrode inside the tokamak plasma improves both the energy and particle confinement of tokamak plasma. The signatures of improved confinement due to biasing include reduction in recycling, rise in plasma density and temperature. On Aditya tokamak, Electrode biasing experiment has been carried out to understand the detailed physics of Low confinement to High confinement transition in tokamaks. Spectroscopic diagnostics remains one of the important diagnostic techniques in this experiment. Measurements in visible, UV and VUV ranges provided many useful information in this experiment about the processes occurring during the biasing time. Using Photomultiplier tube and optical filter combination H_α (Balmer alpha) signal has been monitored during electrode biasing experiment, which gave information about recycling. The temporal profiles of OVII signal and L_α (Lyman alpha) also have been recorded using Normal Incidence Monochromator during this experiment. Also we have acquired data in the VUV range with the help of VUV spectrometer mounted on Aditya tokamak. The analysis of all measurements highlighting the effect of biased electrode on Aditya plasma will be presented in this paper.

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PD29

A New Phenomenological Method for Obtaining Plasma Density Using Spectral Line-Ratio Technique

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Abstract

Electron temperature estimation using spectral line ratio method depends significantly on the choice of excitation/emission models such as LTE, Corona or Collisional-Radiative based on the electron density values. Electron temperature has been estimated using the H_α / H_β spectral line ratio from plasmas with different densities varying in the range of $10^9 - 10^{12} cm^{-3}$ including Tokamak plasma, RF Plasma , Gun plasma etc.. The temperature estimation has been carried out using both the LTE and Corona model. Interestingly, the results show that the temperature estimated using LTE and Corona models match quite well in the plasmas with low densities, however, the difference between the temperature values using both models increase for the higher densities. In this paper we will show that how this result can be used to predict electron densities in plasma by taking the difference between the estimated temperatures from H_α / H_β spectral line ratio using LTE and Corona models.

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PD30

Zero Bias Emission Current Characteristics of Graphite Material due to Laser Heating Used for Laser Heated Emissive Probe

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Abstract

Laser heated emissive probes are recently gaining popularity owing to the advantages of having a higher life time, uniform heating and no physical deformation of the probe in magnetic field compared to the wire emissive probe. Graphite material has been considered as probe material because of its higher absorption coefficient at CO_2 laser wavelength. It is observed that the quality of the graphite material used to play an important role in the emission current [1, 2] even at zero probe bias voltage. The possibilities of this current may be due to the ablation current, ionization due to E-field of the laser [3], multi photon ionization, which is discussed in this report. It is important to know the actual behavior of this current as it is contributing some change in the plasma *I-V* characteristics. In this paper an attempt has

been made to quantify the amount of the material ablated from the graphite surface of certain dimension at a particular laser power, both theoretically [4, 5] and experimentally. A simplified version of faraday cup has been used to check to characteristics of the ablated charged particle and then use some basic equation to quantify it. The motion of the ablated particles at a fixed laser power is viewed through a mega speed camera. Based on the experimental results, quantitative estimation has been made to know the ablated particle density as well as amount of charge carries by these particles.

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PD31

Plasma Diagnostics of Reverse Polarity Planar Magnetron

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Abstract

DC magnetron system is widely used in thin film deposition and other variety of coating applications. In this work possibility of using planar magnetron as an ion source is being investigated, the idea is to bias the DC magnetron in

reverse polarity so 'target' is biased positively with respect to surrounding shield. Magnetron plasma passes through various modes until it behave like and ion source. Magnetic field profile, operating pressure and applied potential plays a crucial role in the beam profile. Experiment was performed with varying pressure and discharge voltage in the range of 10^{-2} to 10^{-4} mbar of pressure and 150 to 800 volt dc voltage, respectively. It is found that current still increases according to I^n law as observed in normal magnetron mode. The plasma property of the source was measured with the help of cylindrical Langmuir probe. Floating potential profile has been studied and is found to have peak just below the centre of magnetron and then reduces on the both sides. Different target materials were examined to investigate the role of secondary electrons ejected from the target materials. Observed different modes seem to be appear due to different mean free path and gyro radius under various operating conditions. Experiments are in the way to characterize the beam profile using retarding potential analyzer.

PD32
Estimation of Aditya Soft X-ray Spectrum

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Abstract

An estimative study is made for the spectral distribution of the soft X-ray (10 eV to 20 keV) emission produced by the Aditya tokamak plasma, 500eV temperature and 2×10^{13} cm^{-3} density, hydrogen plasma. The main aim is to account the electron transition (free-free) induced bremsstruhlang X-ray and the possible characteristic X-ray line strengths for carbon and oxygen in accordance with the plasma temperature for Silicon Drift detector (SDD). The silicon drift detector (SDD) offers excellent energy resolution at extremely high count rate applications, 50Kcps. SDD exhibits lower capacitance than a conventional diode with same area, reducing electronic noise at short shaping times. This results in as an enhanced energy resolution for X-ray applications. The X-ray response from the Aditya plasma consists of bremsstruhlang X- ray and the characteristic X-ray lines are determined separately, later transformed in to an integrated X-ray spectrum. Fractional abundance and excitation rate coefficient were considered from NIFS data base for line strength. The X-ray response for the Aditya temperature and density along with detector consideration characteristic X-ray lines were be faintly visible but a prominent continuum is visible. Currently the SDD spectrometer system has been installed at Aditya for the X-ray observations.

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PD33
Study of Space Charge Transition During Titanium Nitride Thin Film Deposition By Magnetron Sputtering

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Abstract

This work focuses on the study of space charge transition in the plasma sheath and pre-sheath regions and its effect during the plasma deposition process of titanium nitride thin film by magnetron sputtering using Emissive probe diagnostic. Non-intrusive optical emission spectroscopic technique study shows that the emission intensities of the different species comprising the reactive discharge in the plasma process undergoes fluctuations. Proper adjustment of the gas partial pressures is very essential to overcome the instability. The optimization of the plasma parameters required indepth study for proper deposition of the coating.

SA01

Solitons In Warm Magnetoplasmas

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Abstract

In this work, the phenomenon of formation localised electrostatic waves (ESW) or soliton is considered in a warm magnetoplasma with the possibility of non-thermal electron distribution. The parameter regime considered here is relevant in case of magnetospheric plasmas. We show that deviation from a usual relaxed Maxwellian distribution of the electron population has a significant bearing in the allowed parameter regime, where these ESWs can be found. We further consider the presence of more than electron, which is inspired by recent space-based observation by the fleet of Cluster spacecrafts.

SA02

Plasma Waves in our Solar System

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Abstract

Plasma waves are observed in almost all our solar system objects such as planets [1] and their satellites, comets [2] and their vast tails. All the planetary bodies having an atmosphere necessarily have an ionosphere in which the plasma density can be in the range of $10^3 – 10^6$ cm^{-3} and plasma temperature about 0.1 eV. These plasma densities are capable of sustaining plasma waves. A number of natural plasma waves are detected in planets having an appreciable magnetosphere such as Mercury, Earth, Jupiter, Saturn, Neptune, Uranus and Neptune. In the case of planets deprived of a global magnetic field, the scientific scenario becomes more interesting as the solar wind penetrate more deep through the atmosphere of these planets such as on Venus [3].

Planetary plasma wave studies help us to understand the ionosphere or magnetosphere of any planet or satellite in a better way. Similarly, cometary plasma waves reveal the structural details of comets. Some of these waves play an important role in the dynamics of the ionosphere by controlling the scattering and loss of energetic charged particles. Also, plasma waves provide an important diagnostic tool by revealing various characteristic frequencies of the plasma, from which quantities such as the electron density can be computed. These studies also provides valuable information on important solar wind - planet interactions, the generation of planetary radio emissions from magnetospheres, the energy and particle transport processes, the energy distribution in plasma, etc.

In this presentation, all these issues shall be discussed with a special emphasis on plasma wave detection in Mars ionosphere.

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SA03

Spiky Solitary Waves in Electron-Ion-Positron Plasma

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Abstract

Ion-acoustic solitary waves have been theoretically studied in a noncollissional multicomponent plasma consisting of warm positive ions, positrons and nonisothermal electrons using pseudo-potential method. From the nonlinear equation derived from the Sagdeev potential, the solutions of the solitary waves up to third order nonlinear effect are obtained using tanh-method. The first- and second- order K-dV equation give usual solitary wave solution , but spiky solitary wave solution is obtained from the third order nonlinear equation. The profiles of Sagdeev potential and solitary waves are drawn taking different values of the positron density, positron temperature and nonisthermal parameter of the electrons . It is seen that both compressive and rarefactive solitary waves would be excited due to the presence of positrons and nonisothermal electrons in the plasma. The variation of amplitudes of the solitary waves are shown graphically for different values of plasma parameters.

SA04

On the Safety of Satellites From High Energy Particles In The Ionosphere

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Abstract

High energy electrons trapped in Van Allen radiation belts in space destroy the shield of not only low earth orbiting satellites but also geosynchronous, sunsynchronous and polar satellites. Wave particle interaction is studied between whistler mode waves in the ELF/VLF range and counter streaming high energy electrons beam. This phenomenon reduces the pitch angle of high energy electrons because of which electron dumps into the lower ionosphere and is unable to attack the shield of the satellite. Pitch angle diffusion coefficient increases with increase in L shell, as well as

interactive frequency. It is suggested that at high L shells/ high frequency whistler mode waves are very efficient to save a satellite from the high energy electrons. It is also shown that the life time of high energy electrons at low latitudes consisting of inner radiation belt (L=1.1-1.7) comes out to be between hours and days when we take interacting signal strength as 1pT²/Hz. The results are supported by various data observed aboard satellite such as CRRESS.

SA05

Jaya shrivastava

SA06

Ion-Acoustic Double- Layers In An Electron-Ion Positron Plasma With Nonthermal Electrons

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Abstract

The study on the Double Layers (DLs) has been a topic of great interest because it gives some fundamental ideas regarding various astrophysical phenomena such as acceleration of charged particles in the atmosphere of astrophysical objects. It is also important in understanding ion heating in linear turbulent- heating devices and confinement of plasma in tandem mirror devices. The presence of DLs in space has been confirmed by Viking satellite and S3-3 satellite observations. It is known that the positrons and nonthermal electrons exist in space plasma and many interesting characteristics of nonlinear propagation of waves are observed in such plasmas. In the present paper, the ion-acoustic DLs in a plasma consisting of warm positive ions, positrons and nonthermal electrons have been theoretically studied. Using the pseudo-potential technique, the Sagdeev potential of the ion-acoustic wave in electron-ion-positron (e-i-p) plasma has been derived and used to obtain the solution of ion-acoustic DLs in e-i-p plasma. Through numerical calculations the profiles of the DLs have been obtained for different values of positrons concentration and the nonthermal parameter of electrons in the plasma. It is shown that positrons and nonthermal electrons in the plasma have significant contribution to the excitation of compressive and rarefactive DLs in e-i-p plasma. The results obtained in the present study have been compared with that obtained by the previous authors. The analysis presented in the paper is expected to be useful in understanding the acceleration processes of charged particles in space plasma.

SA07

IMPROVED CCW PREDICTIONS DESCRIBING ISOTHERMAL MOTION OF HYDROMAGNETIC CYLINDRICAL SHOCK WAVES IN SELF GRAVITATING ROTATING GAS

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Abstract

CCW*** predictions (Free Propagation) have been arrived describing the isothermal propagation of hydromagnetic cylindrical shock waves in a self gravitating rotating gas in presence of constant axial magnetic field $H_Z = H_{Z0}$ (constant), for two conditions viz., i) when it is weak and ii) when it is strong. For density decreasing atmosphere described by $\rho_0 = \rho' r^{-w}$, where ρ' is the density at the axis of symmetry and w is a constant, the analytical expressions for flow variables have been derived simultaneously i) when the shock is weak and ii) when it is strong. Finally, the effects of overtaking disturbances behind the flow have been included and modified analytical expressions for flow variables have also been obtained.

Such studies are of importance for theories of sun spot, magnetic fields in heating of solar corona and in the stability of stellar atmospheres in magnetic fields.

SA08

Recent Advances In Plasmaspheric Wave Research

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Abstract

Plasma waves play a fundamental role in our geospace environment. In particular, they are key to understand the way mass and energy are transferred from the magnetotail to the plasmasphere, the ionosphere and finally the atmosphere. A key region where such waves are generated is the plasmasphere, either within it or in its near vicinity. Various waves are found in this region having frequencies from a few mHz to a few MHz. Plasmaspheric wave phenomena with plasmaspheric density structures derive electron density profiles and heavy particles content of the plasmasphere, better locate the source of waves and how they propagate. Recent observations from various instruments onboard IMAGE and CLUSTER spacecraft have made significant advances in our understanding of plasma density irregularities, plume formation, erosion and refilling, presence of thermal structures in the plasmasphere as well as the existence of radiation belts also. Recent advances on plasmaspheric wave phenomena in the medium frequency (MF) range (300 kHz–3MHz) down to the very low frequency (VLF) range (3–30 kHz), the ultra low frequency (ULF) range (300 Hz–3 kHz) and the extremely low frequency (ELF) range (3–30 Hz) will be presented in detail.

SA09

Magnetospheric Plasma Parameters Deduces from Analysis of Multiple-Whistlers Detected by Automatic Whistler Detector (AWD) at Low Latitude Varanasi.

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Abstract:

Whistlers are exotic electromagnetic phenomena produced by lightning discharges [1] and have been regarded as cheap and effective tool for the case studies of plasmasphare diagnostic since the early years of whistler research [2]. Recently, at Indian low latitude station Varanasi (geomag. lat. =14$_0$ 55/ N, long. = 153$_0$ 54/ E) an Automatic Whistler Detector (AWD) has been installed in Dec, 2010 for detection and analysis of whistlers. This instrument has two main propose (i) to automatically detect and collect statistical whistlers data for the investigation of whistlers generation and propagation and (ii) to provide plasmasphere electron densities extracted from whistlers [3].

In this paper, we have analyzed the large number of multiple whistlers detected during continuous recording at Varanasi and computed magnetosphreic plasma parameters such as Whistlers dispersion, L-value of propagation path of whistlers, nose frequency, plasmaspheric electron densities and convection electric field. The results are discussed in the light of reported features of whistlers and magnetospheric plasma parameters observed at other low latitude stations.

SA10

Characteristic of Ionospheric Plasma Bubbles using GPS based Measurements at Varanasi

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Abstract

Equatorial plasma bubbles (EPBs) are plasma density depletions and accompanying plumes of irregularities that give rise to severe radio signal disruptions. EPBs are most frequently observed in the pre-midnight sector, as shown by in-situ and ground based measurements, such as a range spread echo in ionogram, radio scintillation shown as rapid amplitude or phase fluctuations for the radio wave communication between space and ground, the pronounced density depletion in airglow, significant bite-outs in density from in-situ observations etc. The trajectory of a GPS satellite plays an important role in observing these bubble characteristics.

In the present work, we have considered the propagation of electromagnetic waves through the irregular ionosphere in the L-band frequency range using dual frequency (F1 = 1.5 GHz and F2 = 1.2 GHz) GPS receivers. The GPS scintillation observed at our low latitude station Varanasi have been analyzed during the year 2011. The various characteristic of EPBs observed over Varanasi have been studied. The structure and morphology of irregularities that are responsible for scintillations of radio waves have been studied at low latitude. The occurrence of EPBs is maximum in months of February-March and July-August predominant during Equinox months. The characteristic lengths of the plasma bubbles observed at Varanasi generally varies between 100 m to 1000 m which shows that the plasma bubbles observed at Varanasi are of intermediate scale sizes. The power spectrum analysis of the observed scintillation patches at Varanasi shows that the spectral index of the plasma bubbles varies between -2 to -8 with the mean value of -4. The observed characteristics of EPBs are discussed in light of the reported results at other low latitude stations.

SA11

P.K.Sharma

SA12

Quasi-periodic behavior of dust ion acoustic solitary waves in dense Fermi plasmas

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Abstract

The properties of dust ion acoustic solitary waves are investigated in an unmagnetized dense Fermi plasmas. The one dimensional quantum hydrodynamic model is used to study small arbitrary amplitude dust ion acoustic waves in dense Fermi plasmas. It is found that ion temperature plays a critical role in the dynamics of dense dusty plasmas. Also, it is seen that the dust density affects on the propagation nonlinear wave in such dense dusty plasmas. For arbitrary amplitude waves, in the fully nonlinear regime, the system exhibits possible existence of quasi-periodic.

SA13

Dispersion Characteristics of Kinetic Alfven Waves in a Multi ion Cometary Plasma.

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Abstract

Kinetic Alfven Waves (KAWs) are important in a number of astrophysical, space and laboratory contexts. The large magnetic shears observed around comets could be due to either quasi-stationary structures standing in the solar wind or steepened magnetosonic waves. Waves propagating initially parallel to the magnetic field in such sheared fields end up with the propagation vectors perpendicular to the magnetic field becoming significant: the result is a KAW. It is also well known that the plasma composition around comets consists of hydrogen and heavier ion components such as positively and negatively charged oxygen ions.

We therefore study the stability of KAWs in a plasma of the above composition by generalising the pioneering dispersion relation of Hasegawa. The distribution function used for all components consists of a drifting Maxwellian in the direction parallel to the magnetic field; in the perpendicular direction a loss cone distribution is simulated by subtracting two Maxwellians.

We find that while positively charged oxygen ions increase the growth rate of the wave, the negatively charged oxygen ions do the opposite. The growth rate also increases with increasing drift velocities and decreases with increasing propagation angles. The last result is being put forward as supportive of the mechanism proposed for the generation of

KAWs.

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SA14

Sham Singh

SA15

Initial Acceleration Of Fast Solar Wind Protons In The Lower Corona : Role Of Mode Conversions And Wave-Particle Interactions.

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Abstract

In the current scenario, solar wind acceleration and coronal heating are the most challenging problems in solar physics. The observational data reveals that there exists temperature anisotropy of protons ($T_{\perp}>T_{II}$) and we suggests that this is due to the electrostatic proton cyclotron resonance heating. In this paper we show that an initially obliquely propagating MHD wave in the lower corona($< 2\ R_s$) gets converted into electrostatic proton cyclotron waves. These high frequency waves transfer their energy preferably with protons since they are the dominant component of the solar wind plasma through wave-particle interactions. We further propose that when the protons are heated preferably in the perpendicular direction, magnetic mirror force comes into play and drives the solar wind radially outwards. Our analytical results prove that the initial fast solar wind acceleration is ultimately proton driven via electrostatic proton cyclotron resonance heating.

SA16

Linear Analysis of the Kelvin-Helmholtz Instability for Relativistic Anisotropic Magnetohydrodynamics

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Abstract

A linear analysis of the Kelvin Helmholtz instability (KHI) in relativistic anisotropic magneto-hydrodynamics (RAM) is considered. As appropriate for astrophysical systems, the effect of gravity, surface tension and viscosity are neglected. The relevant equations are given by equations governing the conservation of particle number and energy-momentum density of a relativistic perfect fluid in flat Minkowskian metric. These equations are supplemented by the induction equation and the double-polytropic equations of state defining the evolution of the pressures transverse and along the magnetic field. In a vortex sheet approximation an equation governing the dispersion relation is derived and numerically solved for parameters appropriate for astrophysical situations. Based on physical parameters, regimes of the KHI are

studied and corresponding ranges of parameters are analyzed.

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SA17

Dispersion Characteristics of Kinetic Alfven Waves in a Multi ion Cometary Plasma.

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Abstract

Kinetic Alfven Waves (KAWs) are important in a number of astrophysical, space and laboratory contexts. The large magnetic shears observed around comets could be due to either quasi-stationary structures standing in the solar wind or steepened magnetosonic waves. Waves propagating initially parallel to the magnetic field in such sheared fields end up with the propagation vectors perpendicular to the magnetic field becoming significant: the result is a KAW. It is also well known that the plasma composition around comets consists of hydrogen and heavier ion components such as positively and negatively charged oxygen ions.

We therefore study the stability of KAWs in a plasma of the above composition by generalising the pioneering dispersion relation of Hasegawa. The distribution function used for all components consists of a drifting Maxwellian in the direction parallel to the magnetic field; in the perpendicular direction a loss cone distribution is simulated by subtracting two Maxwellians.

We find that while positively charged oxygen ions increase the growth rate of the wave, the negatively charged oxygen ions do the opposite. The growth rate also increases with increasing drift velocities and decreases with increasing propagation angles. The last result is being put forward as supportive of the mechanism proposed for the generation of KAWs.

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SA18

Dust Ion-Acoustic Double Layers In A Non-Maxwellian Plasma

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Abstract

Dust being a common species in a wide range of space and astrophysical plasmas such as the cometary tails and comae, interstellar clouds, Earth's mesosphere and ionosphere, Saturn's rings, the gossamer ring of Jupiter, and in laboratory experiments, the study of dusty plasmas has been an important focus of much recent research. Theoretical and experimental studies have confirmed the presence of Dust-Ion acoustic (DIA), Double acoustic (DA) waves etc. In this investigation, we have focussed on the study of characteristics of DIA waves.We have considered a plasma which contains cold fluid ions, charged dust grains and kappa-distributed electrons. We have derived modified Korteweg deVries (mKdV) equation with finite amplitude using a reductive perturbation method. An investigation into small

amplitude DIA Double Layers (DLs) is discussed. Double layers act as the particle accelerators and dust grains may be trapped within a double layer potential structures. Double layers have direct relevance to cosmic plasma environment. It is instructive to study the possibility of formation of such double layers potential structures in dusty plasma. It is found that both compressive and rarefactive double layers exist. Further, the effects of κ-parameter (superthermality of electrons) and dust concentration have been observed on the characteristics of double layers.

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SA19

Electron Cyclotron Instabilities Driven By Ion Beams Perpendicular To The Magnetic Field

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Abstract

Plasma instabilities driven by cross field currents have been extensively studied for nearly three decades. The initial motivation that spurred research in this area were the experiments on magnetic compression heating and the investigations on collisionless shock waves. Some of the well known instabilities driven by cross field currents are the ion acoustic, electron cyclotron drift, ion-ion streaming, lower hybrid, modified two stream instability, etc.

Observations by the ISEE 1 and 2 spacecrafts have revealed the presence of accelerated beams of cold ions perpendicular to the reconnected field lines within the low latitude boundary layer. Hydrogen was normally the major constituent of these beams, though helium and oxygen ions were also occasionally detected (Gosling *et. al*., 1990)

We have studied the stability of the electron cyclotron waves in a three component plasma of electrons, hydrogen and

oxygen, with the ions drifting perpendicular to the magnetic field to agree with the satellite observations. We have analytically proved that the ion beams drifting perpendicular to the magnetic field can drive electron cyclotron harmonic waves unstable. Numerical studies for typical observed parameters show that the growth decreases with increasing harmonic numbers and drift velocities. The magnitude of the growth is seen to be lower and extending in normalized wavelength with an increase in hydrogen ion temperature. Growth is, however, insensitive to oxygen ion temperature. Our studies thus complement the simulation studies of Berchem *et. al.* (1991) who found that electron cyclotron harmonic waves to be driven unstable by field-aligned ion beams in the plasma sheet boundary layer.

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SA20

Stability of Electrostatic Ion Cyclotron Waves In A Multi-ion Plasma

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Abstract

We have studied the stability of the higher harmonics of the electrostatic ion cyclotron wave in a plasma consisting of isotropic hydrogen ions (H^+) and temperature-anisotropic positively (O^+) and negatively (O^-) charged oxygen ions, with the electrons drifting parallel to the magnetic field. Analytical expressions have been derived for the frequency and growth/damping rate of ion cyclotron waves around the higher harmonics of both hydrogen and oxygen ion gyro-frequencies. A detailed numerical study, for parameters relevant to comet Halley, reveal the following: the frequencies and growth/damping rates are dependent on the densities and temperatures of electrons and positive species of ions, and the electron drift velocities, it is dependent only on the density of negative ions and not its temperatures. It is noted that the magnitude of growth shifts towards longer wavenumbers for higher harmonics. Also while the critical electron drift velocity for driving the instability is dependent on densities of ion species, temperature of electrons and positive ion species, it is independent of the temperature of O^- ions.

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SA21

Small Amplitude Ion-Acoustic Solitons In A Plasma Containing Multi Temperatures Ions

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Abstract

Linear and nonlinear properties of solitary waves in different plasma situations has been an important area of research for the last many years. A large number of investigations have been reported for such kind of studies in different plasma systems with Maxwellian or non-Maxwellian distributions. Superthermal particles are believed to be present in astrophysical environments. A kappa type distribution function is most appropriate to model effectively the supertherma population of particles. It is interesting to study the role of superhermality of these particles for modifying the solitary structures in multicomponent plasmas. We have considered a plasma which contains superthermal electrons, and ions with two types of temperature. Reductive perturbation technique is used to derive the Korteweg-de Vries (KdV) equation. The nonlinear and dispersion coefficients of KdV equation are functions of superthermality parameter and temperatures of two ions. The effects of hot ion concentration and superthermality parameter is explained. It is

observed that hot ion concentration and superthermality of electrons play a significant role in the characteristics (amplitude, width) of solitary waves. The findings of present investigation may be useful in understanding the solitary wave structures observed in Earth's ionosphere.

SA22

Developing Low Conductivity Plasma Sprayed Thermal Barrier Coating Using Solid Glass Micro-Spheres

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Abstract

Thermal barrier systems have been the subject of vigorous research activities over the last decades and are widely used to insulate metallic components in gas-turbine engines from high temperatures. This work seeks to develop an innovative thermal barrier coating (TBC) that will exhibit low thermal conductivity and high durability compared with that of current TBCs. As for the coating materials, it is well understood that for a number of unique application, spherical particles are preferred over irregular ones due to low surface area to volume ratio, high density, free flowing ability and close sizing etc. In view of this, the present paper reports on the preparation of glass microspheres coatings on Al substrate using plasma spray technology. An 80 kW atmospheric plasma spray set up is used for spraying purpose. Solid glass micro-spheres of average sized 100 micron are used as the coating materials which are deposited at four different power levels on Al substrate. The coatings are characterized in terms of their thickness and adhesion strength and thermal conductivity. A significant reduction in thermal conductivity is achieved for these glass micro-sphere coatings and it is found that the coating-substrate interface adhesion strength is also reasonably good.

SA23

D-Region Ionospheric Plasma Electron Density During X-ray Solar Flares Evaluated From VLF Measurements

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Abstract

VLF transmitter signal has been used to study the D-region ionospheric plasma electron densities as a function of solar X-ray flux (measured on the GOES satellites) during a wide variety of solar flares occurred during the year 2011. The D-region changes are characterized by the two (Wait) parameters, H' virtual reflection height in km, and β(km^{-1}), a measure of the sharpness factor of the D-region. The flare-induced amplitude changes (usually enhancements) were determined using the method proposed by [1] and are modelled using Long Wave Propagation Capability (LWPC) waveguide codes to find the values of H' and β which match the measurements. Ionospheric plasma electron density profile of the D-region ionosphere during solar flare is modeled using exponential profile described by [2]. Results shows that there is a change

in H' and β during the flares and hence enhancement in the electron densities with the height profile. During the Flare events H' decreases with the increasing flare power while the sharpness parameter, β, is found to be increasing from around 0.43 km-1 (for the near midday NWC-Varanasi path) to a general saturation level of about 0.495 km^{-1}. This appears to be due to X-ray production swamping the unperturbed production from both solar Lyman-alpha and, in particular, galactic cosmic rays

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SA24

Zakharov-Kuznetsov (ZK) Equation For Electron-Acoustic Waves

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Abstract

Electron acoustic waves (EAWs) mostly occur in the plasmas having a co-existence of two distinct electron populations (cool and hot electrons). EAWs are observed in laboratory experiments and in space plasmas. It is also of a great importance to investigate the characteristics of the EAWs in magnetized plasma. A number of observation have confirmed the existence of superthermal particles in space/astrophysical environments and laboratory experiments. A generalized Lorentzian (kappa type) distribution function is most appropriate to model effectively the superthermal population of electrons. We have considered the magnetized plasma containing fluid cold electrons, hot electrons and

ions. The ZK equation is derived using reductive perturbation method. From the solution of ZK equation, we have

studied the effects of superthermality and hot electron concentration on the amplitude and width of electron acoustic solitary waves (EASWs). Only negative potential EASWs exist in the considered plasma systems. Amplitude and width of the solitary waves increase with decrease in superthermality of hot electrons. Amplitude remains same with change in magnetic field but width of solitary waves decreases. The findings of this investigation may be useful to explain the EASWs in space and astrophysical environments.

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SA25

Identification Of Solar Features Causing Geomagnetic Storm

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Abstract

A geomagnetic storm is a global disturbance in Earth's magnetic field usually characterized by a main phase during which the horizontal component of the Earth's low latitude magnetic field are significantly depressed over a time span of one to a few hours followed by a recovery phase that may extend over several days. These magnetic storms generally occur due to abnormal conditions in the interplanetary magnetic field (IMF) and solar wind plasma emissions caused by various solar phenomenons.

In the present study geomagnetic storm events are characterized by the Disturbance storm time (Dst) index measured in terms of nano Tesla (nT) during the periods 1996-2003. A storm is said to be weak if (Dst $\leq$ 50 nT), Moderate if (Dst51-150nT), Intense/great if (Dst151nT 250nT), Super storm if (Dst $\geq$ 251 nT).

The present work deals with a complimentary question mainly referring to solar and interplanetary features that causes very large and intense geomagnetic storms, for this purpose we have used the Dst index as an indicator of geomagnetic activities, using which we have classified the storm event in to two categories i.e.

Intense geomagnetic storms with Dst $\leq$ -300 nT, and

Supper intense storms with Dst index $\geq$ -301 nT.

SA26

The Study Of Solar Wind Plasma Signatures With Magnetic Cloud Events And Bi- Directional Electron Heat Flux Events

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Abstract

Present stud deals with the study of solar wind plasma signatures with a main focus on magnetic cloud events (MCE), bi-directional electron heat flux (BEHF) events and the geomagnetic activity associated with these plasma configurations. Geomagnetic variations are continuously recorded and monitored through the magnetogram of the Earth's magnetic field elements and their qualitative values are obtained by formulating various geomagnetic indices like Ap, Kp, aa, A_E, Dst, etc. These data are obtained from various geomagnetic observatories, which are the part of world network. We have extensively studied the magnetic cloud events and bi-directional events. An attempt has been made to correlate them with various geomagnetic activities, which are taking place during the period of study i.e. 1996-2003.

A magnetic cloud is a transient ejection in the solar wind defined by relatively strong magnetic field, a large and smooth rotation of the magnetic field direction over approximately 0.25 AU at 1 AU, and a low proton $\beta(=NkT/B^2/8\pi)$ and proton temperature. Magnetic clouds are ideal objects for solar terrestrial studies because of their simplicity and their extended intervals of southward and northward turning of the magnetic field (Burlaga, et al., 1990).

SA27

AN INVESTIGATION OF GRAVITY-INDUCED NONLINEAR EIGENMODES IN SELF-GRAVITATING SOLAR PLASMA

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Abstract

The nonlinear self-gravitational normal mode dynamics in the Sun and its atmosphere is likely to be modified due to the nonlinear, dissipative and dispersive nature of the self-gravitating solar plasma. We propose a new model to investigate the nonlinear self-gravitational eigenmode spectrum of the solar plasma system with the help of the plasma-based gravito-electrostatic sheath (GES) theory in a field-free hydrodynamic equilibrium in spherical geometry. The standard methodology of multiscale analytical technique is applied on the coupled normalized (by standard astrophysical parameters) structure equations over the pre-defined GES equilibrium structure. Accordingly, a unique form of Korteweg-de Vries-Burger (KdV-B) equation with a new type of self-consistent linear sink on the lowest order self-gravitational potential fluctuation is systematically developed. The origin of the sink is the spherically symmetric self-gravity contributed by the plasma inertial ions only. We demonstrate numerically that our model can sustain two distinct classes of new nonlinear eigenmode excitations evolving as oscillatory soliton-like and oscillatory shock-like structures under suitable conditions on the plasma parameters and reference frame. Their oscillation amplitudes get gradually damped outwards relative to the heliocentre due to the presence of the sink. The obtained results on comparison are found to be in good agreement with other model predictions, satellite data and experimental findings on the lowest order qualitatively. Possible results, physical discussions and main conclusions relevant to astrophysical application are briefly presented.

SA28

Interaction of Solar Plasma near-earth with Reference to Geomagnetic Storms during 2011

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Abstract

The coronal mass ejection is directed towards the Earth and reaches it as an interplanetary coronal mass ejection (ICME). The shock wave of the travelling mass of solar energetic particles causes geomagnetic storms that may disrupt the Earth's magnetosphere, compressing it on the day side and extending the nightside magnetic tail, when the magnetosphere reconnects on the nightside. It releases power on the order of terawatt scale, which is directed back towards the Earth's upper atmosphere.
In the present paper, we have analyzed three large geomagnetic storms occurred on 6 August 2011 (Dst <-113nT), 26 Sept. 2011 (Dst <-103nT) and 25 Oct. 2011(Dst <-123nT) respectively. We have used solar and interplanetary parameters and their relationship with geomagnetic parameters. We have also studied the correlation between them. Results will be discussed during the presentation.

SA29

Sailendra Nath

SA30

Investigation of Super Geomagnetic Storm (20 Nov2003 event) with Reference to Solar and Interplanetary Drivers

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Abstract

When solar ejecta impact the earth's magnetosphere, they cause large scale disturbances in the geomagnetic field known as geomagnetic storms. The event, being discussed here was one among the most intense events as recorded by space born satellite and in situ measurements made by geomagnetic observatories. This is the most intense magnetic storm (Dst min~ −422 nT) of the solar cycle 23. In the present work, we have considered interplanetary parameters like IMF B, Bz components, solar wind velocity, proton density, plasma temperature, proton flux (>10Mev) and solar parameter like sunspot numbers which affect earth's magnetic field on short term as well as on long term bases. The influence is measured in terms of various parameters like Ap, kp, Dst, AE, whereas the Dst index, which we have taken for our study, as the indicator of geomagnetic activity and its magnitude defines the strength of geomagnetic storm .On the basis of our results it has been observed that there is abrupt change in interplanetary and solar parameters resulting in the enhanced geomagnetic indices during the storm event. Which shows that IMF B, Bz components, solar wind velocity, plasma temperature, proton density, proton flux, sunspot numbers are mainly responsible for occurrence of this kind of highly intense geomagnetic storm.
This event had its source in small active region and was associated with M-class flare being observed by Goes X-ray satellite. Though the source of this event was the 18 November2003 CME yet speed of CME was quite small.

SA31

Oxidation of Carbon Monoxide in the Gas phase by catalytic Dielectric Barrier Discharge System

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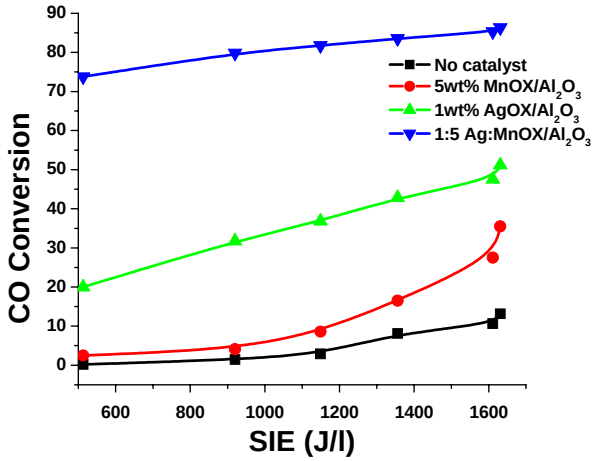
Abstract

Plasma induced catalytic oxidation of CO in gas phase was investigated by using non-thermal plasma combined with heterogeneous catalyst. It was found that plasma reactor with the addition of the catalyst is efficient in CO conversion to CO_2 gas phase. With the addition of 5wt% $MnOx/Al_2O_3$, $AgOx/Al_2O_3$ and $MnAgOx/Al_2O_3$ catalyst to DBD reactors, the conversion of 1000 ppm CO reached to 35, 50 and 85%, respectively at 22 kV. Influence of various parameters like applied voltage, discharge power, gas flow rate, humidity, CO_2 present in air and inlet CO concentration were studied and the results are compared with the thermal catalytic experiments. Typical results indicated the better performance of plasma system over thermal catalysis especially for such low concentrations. NTP catalytic system is stable and showed the same activity even after 5 h. indicating the potential of this process for practical applications. Humidity has positive effect in for NTP. Whereas no effect with catalyst resulting the same activity as that of NTP.



CO conversion with different catalysts with SIE

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SA32

Optimization Study of Dielectric Barrier Discharge Plasma Cells for Efficient UV/VUV Emission

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Abstract

Dielectric barrier discharges (DBD) are the popular sources of cold plasma operated at/near atmospheric pressure. At atmospheric pressure, the plasma remains in the glow discharge regime by discharge current limitation through dielectric charging. The wide selection of electrode configurations, gases, materials and applied waveforms etc. make it a highly scalable and flexible discharge source. Such DBD sources are found suitable for various industrial applications. These DBD sources are also capable to efficiently produce UV/VUV radiations with various gas mixtures. Hence they are being explored to plasma medicine for sterilization, air/water purification, discharge lamps and plasma displays etc. For their successful use, it is always required to increase the discharge efficiency of DBD plasmas that provide UV/VUV radiation efficiently.

We have performed studies on discharge efficiency improvement through optimization of co-planar DBD cell parameters. The plasma display panel filled with Neon + Xenon (10%) gas mixture at 450 Torr pressure is used to test the discharge characteristics. The electrode designs are aimed to provide high intensity electric fields through optimization of discharge gap, cell capacitance etc. The electric field intensity has been obtained through 2-D computer simulation. At discharge ignition, we have experimentally measured the intensity of light emission from discharge cells and simultaneously obtained the breakdown voltage and discharge delay time. The measured high luminous intensity, low breakdown voltage and low discharge delay time are direct signatures of high discharge efficiency and VUV production efficiency. A comparison of various electrode designs is presented. The optimized DBD cell designs with suitable gas mixtures can be successfully implemented portably as well as large scale DBD source formation for producing germicidal UV wavelength (240-280 nm) applicable to plasma medicine. The focus of our further research is the realization of large-scale DBD based plasma sources suitable to biomedical treatment and other sterilization applications.

SA33

Measurement of Electron Temperature and Electron Density in an Atmospheric Pressure Dielectric Barrier Discharge

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Abstract

A homogeneous dielectric barrier discharge (DBD) in argon was produced by applying high voltage A.C. source of potential difference (0-20) kV operating at a frequency of 10-30 kHz across two parallel plate electrodes with glass as

dielectric barrier. The discharge was characterized by optical emission spectroscopy and electrical measurement. Four argon emission lines from the discharge were analyzed and the electron temperature was estimated by line intensity ratio method. The electron density in the discharge was estimated by power balance method. An investigation of the effect of inter-electrode distance on the electron density was made. The results showed that the electron temperature is less than 1 eV and the electron density is of the order of $10^{11}cm^{-3}$which varied with the distance with electrode.

SA34

Title Of The Abstract: Modeling of phase changes of hypo eutectoid steels

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Abstract

Welding simulation is a coupled thermo - metallurgical - structural simulations. A model is needed for the micrstrucre evolution. One discritisation model is based on density. However, a solid state transformation for a fully austenised steel includes Carbon diffusion, precipitate size and grain growth. There are different models based on works by Leblond, Johnson-Mehl, Avrami etc. In this study, the Kirkaldy model used by Goldak & Akhlagi, Lingren & others is used. The model is presented in the form of a flow chart by Oddy. In this study three models are considered:

1) Diffusion controlled decomposition of Austenite,
2) Instantaneous austenisation model and the
3) Transient austenisation model.

A simulation model is quite complicated to get convergence in given time intervals. A simplified, with appropriate cooling at a given composition is made to get a working model. This simulation can be adopted later in welding simulation models using FEM software.

SA35

Nonlinear Waves in Magnetospheric Plasma with Temperature Anistropy

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Abstract

We report propagation of nonlinear waves in warm magnetospheric plasma with temperature anisotropy. This study is motivated by results of various space-born experiments (e.g. Clsuter spacecrfats [1]), which report existence of localized electrostatic potential structures or electrostatic solitary waves (ESW). We consider here anisotropic electron temperatures with the possibility of non-thermal (non-Maxwellian) electron distribution. We show that the deviation of electron velocity distribution function (VDF) from Maxweliian and temperature anisotropy has a sigbnificant effect on

the properties of these ESWs. Though this study is motivated by behaviour of magnetospheric plasmas, the results are

relevant in many other planetary atmosphere such the plasma torus of the Jovian satellite, Io.

IV. References

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SA36

Electrostatic Ion Waves In A Magnetized, Collisional Multi-ion Plasma

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Abstract

The stability of the electrostatic ion cyclotron waves has been investigated in a collisional, magnetized multi-ion plasma of hydrogen ions, oxygen ions and electrons. We assume that the hydrogen and oxygen ions drift respectively with velocities V_{0H} and V_{0O} perpendicular to the magnetic field; the electron temperature is not assumed a constant and hence we consider the heat conduction due to a temperature gradient perpendicular to the magnetic field. The derived dispersion relation is shown to reduce to simpler ones for various limiting conditions. The magnitude of the growth rate is dependent on the electron ion collision frequency. We find that the wavelength range of growth rate decreases with increasing oxygen ion densities while its magnitude decreases with increasing drift velocities. These results can qualitatively explain a few of the experimental observations.

SA37

R. B. Tyata

SA38

Pooja Gulati

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R.Goswami

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C. Das

SA41

Characteristics of nighttime VLF/ELF emissions with frequency drift and estimation of the large-scale electric field from the frequency drift observed at a low latitude Indian ground station Jammu

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Abstract

Characteristics of nighttime VLF/ELF emissions are examined on the basis of the data obtained at our low latitude ground station Jammu (geomagnetic. latitude., 22° 26/ N; L = 1.17). India during our VLF/ELF campaign. From the detailed analysis of huge amount of acquired VLF/ELF data at Jammu we have found three remarkable events which clearly exhibit a rise in their frequency in pre and midnight sectors during magnetically quiet and substorm periods. Our analysis shows that the frequency drift in VLF/ELF emissions seems to be a rare phenomenon at low latitudes during magnetically quiet and substorm periods in pre and post midnight sectors. This property of temporal frequency drift (regular frequency increase with time) in VLF/ELF emissions observed at our station Jammu are interpreted in terms of a quasi-linear electron cyclotron instability model for wave excitation. The initial frequency increase is believed to be due to a combind effect of L-shell drift of energetic electrons. Further the frequency drifts in VLF/ELF emissions observed at Jammu have been used to estimate the large scale electric field during quiet and substorm periods in pre and post midnight sectors. This study would be most useful for the study of the wave-particle interaction processes, magnetospheric plasma structure and particle dynamics, especially during quiet periods in pre-midnight sector at low latitudes.

SA42

Nightglow Observations Of OI 630 nm Emission During The Ending Phase Of Solar Cycle 22

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Abstract

OI 630 nm emission is a characteristic feature of the F- region of the earth's ionosphere. Ground based nightglow observations of OI 630 nm were carried out at Kolhapur (16.8° N. 72.2° E) during Nov 1994 to April 1996 using tilting-filter photometer. Herein, the observations of 48 nights have been presented. On most of the nights, the nocturnal behavior of OI 630 nm is marked by the movement of equatorial ionization anomaly. Sometimes, an increase of intensity

in the post midnight hours probably due to the midnight temperature maximum phenomena was noted.

SA43

Study of Whistler Mode Waves For Relativistic Subtracted Distribution Function in the Presence of Perpendicular AC Electric Field For Magnetosphere Of Uranus

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Abstract

Whistler mode waves have been studied for relativistic subtracted bi-Maxwellian distribution in the presence of perpendicular AC electric field by using the method of characteristic solutions and kinetic approach. The dispersion relation has been derived. The growth rate has been calculated for magnetosphere of Uranus. The effect of AC frequency on the Doppler shifting frequency has been discussed. The new results have been explained for a subtracted bi-Maxwellian distribution function rather than the bi-Maxwellian distribution function. The effective parameters for the generation of Whistler mode wave are not only the temperature anisotropy but also the relativistic factor, AC field frequency, amplitude of subtracted distribution and width of the loss-cone distribution function which has been discussed in result and discussion section.

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SA44

Unique whistler-triggered VLF/ELF emissions observed at low latitude station Jammu

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Abstract

A detailed analysis of the VLF/ELF wave data obtained during a whistler at our low latitude Indian ground station Jammu (geomag. Lat. = 22o 26/ N, L = 1.17) has yielded two types of unusual and unique whistler-triggered VLF/ELF emissions. These include (1) whistler-triggered hook emissions and (2) whistler-triggered long enduring

discrete chorus riser emissions in VLF/ELF frequency range during night time. Such types of whistler-triggered

emissions have not been reported earlier from any of the ground observations at low latitudes. In the present study, the observed characteristics of these emissions are described and interpretated. Dispersion analysis of these emissions show that the whistlers as well as emissions have propagated along a higher geomagnetic field line path with L-values lying ~ L = 4, suggesting that these triggered emissions are to be regarded as mid-latitude emissions. These waves could have propagated along the geomagnetic field lines either in a ducted mode or in a pro-longitudinal (PL) mode. The measured intensity of the triggered emissions is almost equal to that of the source waves and does not vary throughout the period of observation on that day. It is speculated that these emissions may have been generated through a process of resonant interaction of the whistler waves with energetic electrons. Parameters related to this interaction are computed for different values of L and wave amplitude. The proposed mechanism explains some aspects of the dynamic spectra.

OA01

Journey of Electron from Generation to Consumption (Lighting 21st century: A general treatise of Indian Electricity Sector)

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Abstract

Synthesized Energy is available in the form of fossils. Energy transport due to geo-climatic variations make available PE and KE of water, wind and thermal forms which are harnessed for use. The transport cycle manifests energy conversion in natural forms. The most suitable and useful forms of energy is electrical energy. All forms of energies available put electrons into motion during electromechanical conversion acting as energy transport agents from distant placed to distant places. The electromotive forces push electrons to move at the generators to carry energy. The electrons move through the grids, at various voltage levels, through long distance conductors, force themselves through windings, push through semiconductor devices, pass through filaments, drive heavy machines delivering energy at various levels and in various forms. As a main transporter, electrons move from generators to grid to transformers to our appliances completing the journey. With a promising future of fusion energy and the legacy of generation, the elements of generation, transmission, substations, distribution, consumption, metering, control etc, are covered to present an overview of whole electrical system in a simple way. Attempt is made to describe the Indian electricity sector and systems of electrical engineering in place through exciting journey of electrons. Latest advances in ICT, GIS etc and their application to Indian power sector in particular to smart grid and smart metering is also presented. Attempt is also made to explain the complexities of Load control, frequency control, demand side management, load forecasting, peak load management for consumer awareness.

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OA02

Estimation of permittivity and loss tangent of high frequency ceramics using free space method

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Abstract

In this paper, free space method is used to measure the permitivitty and loss tangent of different ceramics in the millimeter wave band (110 GHz-125 GHz). Free space method is very popular for determining the dielectric properties because it has got wide operation frequency range extending up to the millimeter wave region. Component dimensions limit the operational freedom of the frequency analysis in other conventional methods. This method also provides a complete contact-less and non-destructive environment and also here the measurements can be performed even in strong magnetic and electric fields. Materials like Teflon, Alumina are used to validate the measurement system. Vector

Network Analyzer (VNA) ranging from 110 GHz to 170 GHz is used as the RF source as well as receiver. The permitivitty and loss tangent are calculated directly by using the scattering matrix data obtained from the VNA. For the calculation of the dielectric properties a homemade code () is used. The experimental results of dielectric properties of Teflon and Alumina are in good agreement with earlier published data.

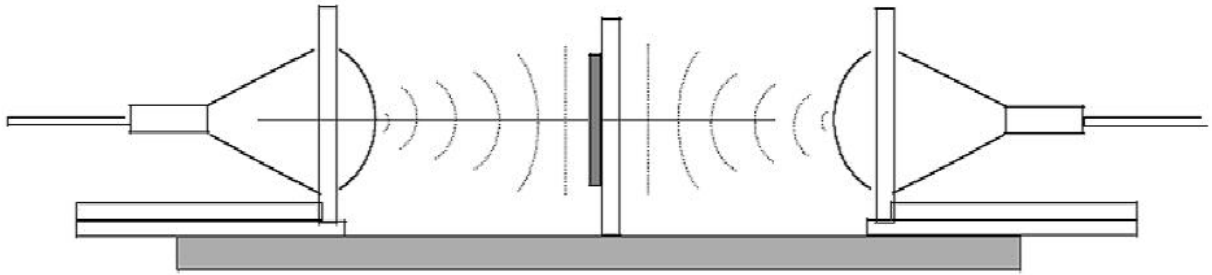

Figure: Experimental set up for free space method.

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OA03

Optical And Catalytic Properties Of Au/CeO_2 Nanoparticles

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Abstract

Cerium Oxide (CeO_2) nanoparticles play a vital role in many applications such as catalytic converter, electrolyte for solid oxide fuel cell, free radicle scavenging, etc. due to its high temperature stability, catalytic activity and Bio-compatibility. In spite of many potential applications, CeO_2 suffers from poor optical property. Gold (Au) nanoparticles have been investigated due to good optical and catalytic properties. Optical and catalytic properties of CeO_2 can be modified through the decoration of Au over CeO_2 nanoparticles. Our present work involves the synthesis of CeO_2 nanoparticle by combustion method using glycine as an oxidizer. Au coating was carried on the surfaces of CeO_2 nanoparticles by deposition - precipitation. To study the effect of Au loading, CeO_2 nanoparticles with varying Au surface coverage was studied. The samples were analyzed by X-Ray Diffraction (XRD), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-Ray Fluorescence (XRF), Thermo Gravimetric/ Differential Thermal Analyzer (TG

DTA) to understand the size, structural, thermal and surface properties. Optical absorption spectra were recorded using UV-Visible Spectrometer to understand the variations in optical properties. Also studies on water dispersibility of these nanoparticles were carried out. The effectiveness of the dispersed nanoparticles in the catalytic decomposition of H_2O_2 was studied by UV-Vis spectroscopy which confirms its catalytic activity.

OA04

Yogesh Sanjay Choudhary

A05

Magnetic And Optical Properties Of Doped Cerium Oxide Nanostructures

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Abstract

Rare earth oxides such as cerium oxide (CeO_2) play an important role in many applications such as three way catalyst, fuel cells, semiconductors, etc. Though CeO_2 exhibits poor magnetic properties, it can be improved by the addition of dopant into the host CeO_2 matrix which attracts a range of application from biomedical to spintronic devices. Present work focuses on the formulation of iron doped CeO_2 and resultant modulations in size, structural, surface, magnetic, and optical properties. Synthesis of Fe doped CeO_2 was carried out by combustion method using glycine as an oxidizer. The powders were characterized by X-ray diffraction (XRD) and scanning electron microscopy. XRD results indicated the presence of cubic fluorite structured CeO_2 nanoparticles and a shift in peak position was observed with an increase in dopant concentration. UV-visible spectroscopy was used for elucidating the changes in band edge and the absorption was found to be increasing with dopant concentration. Magnetic properties of the nanostructures were studied with dopant concentration. Effect of annealing and structural and magnetic properties of E beam deposited thin films will be discussed in the presentation.

OA06

Electronic Transport across a Ferroelectric Polymer

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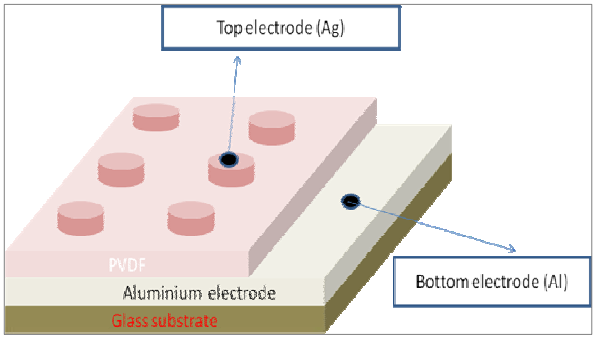
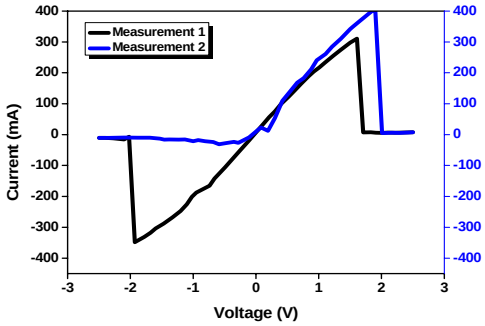
Abstract

Ferroelectric materials have been very attractive for the past several decades and the switchable electric polarization is interesting for the both technological and basic science community. In this paper, the main focus is on the electrical characterization of Polyvinylidene fluoride (PVDF) films grown using spin coat method. The electrodes are deposited by Thermal evaporation method. The PVDF films have been deposited at 2400 r.p.m on a glass substrate with Al as bottom electrode and Ag as a top electrode. Fig.1a shows the schematic diagram of the device. AFM and XRD have been utilized for the surface roughness and structural characterizations. Current-Voltage (I-V) and Electroresistance (ER) were measured to confirm the ferroelectric nature of the PVDF film. Fig.1b shows I-V curve of a single device with a clear ferroelectric polarization switching in both positive and negative electric field directions. The ferroelectric remanent polarization has been characterized using Positive Up and Negative Down method. Furthermore, the thickness dependent electrical transport and thickness dependent ferroelectric properties are discussed.



Device structure

Fig.1a



Current – Voltage curve

Fig.1b

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OA07

Optimization of $SrTiO_3$ Thin Films Grown Using Pulsed Laser Deposition

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Abstract

The wide varieties of properties of $SrTiO_3$ (STO), an incipient ferroelectric, make it an interesting candidate in research area both in bulk as well as in thin film forms. Also the possibilities of polarization switching in this ferroelectric find numerous applications in memory (recording) industries. In this paper we focus on the thin film growth of $SrtiO_3$ by Pulsed Laser Deposition and the optimization of $SrTiO_3$ films on various substrates. For this, the advanced thin film growth techniques like Pulsed Laser Deposition (PLD), DC Sputtering and Four-target Electron Beam Evaporator have

been utilized. A series of STO films of varying thickness were deposited on different substrates. These substrates include Si(100), oxidized silicon [SiO_2 (500nm)//Si(100)], Si with Pt electrode [Pt(50nm)//Si(100)] and Au deposited Si with a Cr buffer layer [Au(50nm)/Cr(15nm)//Si(100)]. DC Sputtering was utilized for Au and Cr deposition, where as Four-

target Electron Evaporator for Pt. Fig.1a shows the structural characterization of one sample using XRD. Fig.1b shows the AFM images that have been utilized to determine surface roughness and grain size. The results on the optimization of crystal structure and the in-plane strain transfer to the STO films are further discussed.

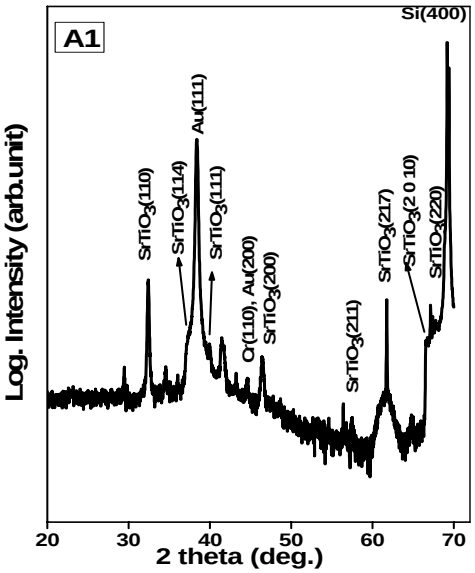

FIGURE.1a. Sample A1

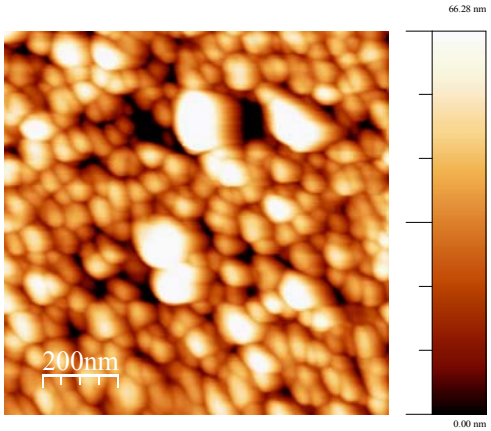

FIGURE.1b. Sample B1

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OA08

Recent Trends In Electrical Energy Storage Devices

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Abstract

Integration of electrical energy generated by wind or solar technologies in to grid depends heavily on the availability of adequate high capacitive electrical energy storage devices. Batteries and supercapacitors are key electrical energy storage technologies in modern society. The great demand for batteries with high power and energy densities promotes the need for advanced lithium-ion and lithium air battery technologies. Solid electrolytes promise the potential to replace organic liquid electrolytes and thereby improve the safety of next generation high energy batteries. Although

the advantages of non-flammable solid electrolytes are widely acknowledged, their low ionic conductivities and low chemical and electrochemical stabilities prevent them being used in practical applications.

The design of lithium batteries having a lithium anode and water or air cathodes for storage of electrical energy requires a solid electrolyte stable in contact with lithium and room temperature ionic conductivity greater than 10^{-4} Scm^{-1}. In the last few years, a series of garnet-like structural compounds have been investigated as a novel family of fast lithium ion conductors. Among them, $Li_7La_3Zr_2O_{12}$ (LLZ) have been paid much attention because of their stable nature against Li metal [1]. The total (grain+grain boundary) conductivity around 10^{-4} Scm^{-1} at 25 ^oC (Ea~0.3 eV at 18–300 °C), good thermal stability and chemical stability against molten lithium and high densification of cubic $Li_7La_3Zr_2O_{12}$ (LLZ) suggested that this zirconium containing lithium garnet is a promising solid electrolyte for Li^+ rechargeable batteries [1]. The stable lithium ion conducting solid electrolytes in aqueous solutions is necessary for application as a protective layer in lithium-air battery. Preliminary investigations reveal that LLZ may be a promising electrolyte for Li-air/water battery application.

In this lecture the recent developments in electrical storage devices and the present status of all solid state lithium and lithium-air rechargeable batteries based on garnet structured solid electrolytes will be discussed.

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OA09

Dynamics of Soliton Matter Waves in Trapped BEC with Time-dependent Two and Three-body Interaction

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Abstract

Using the Cubic-Quintic Nonlinear Schrödinger (CQNLS) equation, with the consideration of three body-interaction also, as a model we observe the dynamics of matter waves in a cigar-shaped trapping potential. The dynamics have been found using the exact solution of CQNLS equation. The results show a novel procedure to control the propagation of matter wave using Feshbach resonance techniques, or by controlling the trapping frequencies. Our study also show the limit of stability of the 1D CQNLS equation in the trapped potential.

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OA10

Udit Narayan Pal

OA11

Udit Narayan Pal

OA012

Comparative Characterization of Ion-Plasma Treated Polymer Nano Composites

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Abstract

Systematic study was carried out to characterize the effects of low temperature argon ion plasma on nano composite polymer membrane. Nano particles of TiO_2aresynthesized by chemical root. Using solution casting and spin coating method, nano composite polymeric membranes in the range of 20–40 micron were prepared andLow temperature argon ion plasma treatment was done. Variable ion energy and treatment time were used to modify the membrane surface and its characteristics. These membranes were characterized before plasma treatment and after plasma to make comparative study by different technique such as SEM- Scanning electron microscope, Photo Luminance, UV-Vis Spectrometry, Fourier transform infrared spectroscopy. Results contact angle measurement shows improvement in porosity and hydrophilicity of Ar plasma treated Membrane.

OA13

White Light Generation in Tb-Sm Codoped Oxyfluoride Glasses Under γ-irradiation

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Abstract

We report here an effect of γ-irradiation on Tb^{3+}-Sm^{3+} co-doped oxyfluoride glasses. The glasses were prepared by conventional melt-quenching technique and characterized by optical techniques such as absorption, luminescence and time decay analysis. As the irradiation dose increases, the conversion of Sm^{3+} to Sm^{2+} ion content increases. The addition of Tb^{3+} ion in oxyfluoride glasses led to the conversion of emitted light from orange to white light emission. This

conversion process has been discussed by varying the ratio of the intensities of orange-red ($^4G_{5/2} \rightarrow {}^6H_{7/2}$) to green ($^5D_4 \rightarrow {}^5F_6$) emission that facilitates the resonant energy transfer between Tb^{3+} ($^5D_4$) $\rightarrow$ Sm^{3+} ($^4G_{5/2}$) under γ-irradiation.

The Commission international de I' Eclairage (CIE color coordinates) and correlated color temperature have been evaluated and their relative variations explained with different irradiation doses. All the color coordinates are found to lie in the orange and white region of the chromaticity color diagram.

OA14

B. Hari Babu

OA15

Structural and Photoluminescence Studies of Pure and Eu_3^+ doped Y_2O_3 Oxide Nanoparticles

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Abstract

Yttrium oxide (Y_2O_3) and Europium doped Y_2O_3 ($Eu:Y_2O_3$) nanoparticles were successfully synthesized by a chemical method, namely hydrolysis assisted co-precipitation method. The precursors used for the preparation are the aqueous solutions of yttrium (III) nitrate hexahydrate [$Y(NO)_3{\cdot}6H_2O$] and europium (III) nitrate pentahydrate [$Eu(NO)_3{\cdot}5H_2O$]. The precursors were hydrolyzed in a condenser at 100°C for 20 hrs and the precipitate was formed after addition of appropriate amount of ammonium hydroxide solution to the cooled reactants. The precipitate was washed with water and centrifuged to be separated and was consequently annealed at 600°C and 900°C for 2 hr in air to obtain nanocrystalline yttrium oxide nanoparticles. Addition of three different concentrations of europium nitrates to the solutions resulted in doping of yttrium oxide with Eu^{3+} ions (1, 3 and 5 mol% of Eu^{3+}). The complete details of the method of preparations are presented in [1]. Structural characterization of $Eu:Y_2O_3$ was carried out by x-ray diffraction (XRD) and transmission electron microscopy (TEM). The as-prepared samples of $Eu:Y_2O_3$ were found to contain amorphous nanoparticles as expected to contain the hydroxides of yttrium. Once they were annealed at 600°C and 900°C, they become crystalline containing nanoparticles of size 13-23 nm in diameter. The particle sizes were estimated by using the Debye Scherrer formula [2]. The particle size was dependent on annealing temperatures and concentration of europium ions. TEM micrographs showed that the as prepared samples are agglomerated with different shapes and sizes. The composition analysis by energy dispersive spectroscopy (EDS) confirms the presence of europium ions in the yttria host. Photoluminescence (PL) studies were carried out in a Horiba spectroflurometer and the PL results showed a weak emission bands at 581, 587, 593, and 599 nm, corresponding to the $^5D_0 \rightarrow {}^7F_1$ transitions, and sharp peaks with a maximum intensity occurring at approximately 611 nm, due to the $^5D_0 \rightarrow {}^7F_2$ transitions of Eu^{3+} [3-5]. The complete results will be presented.

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OA16

Electronic Transport in Ferroelectric Tunnel Junctions using Density Functional Theory Calculations

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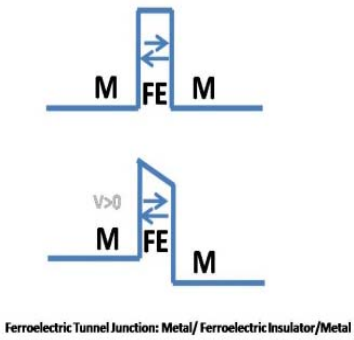
Abstract

Magnetoelectric tunnel junctions have recently attracted considerable interest due to their potential applications in spin-electric devices (magnetic field sensors and magnetic RAMs). In this work, the electronic transport across a ferroelectric thin film ($BaTiO_3$) is addressed. In detail, the electronic transport with respect to change in different electrode potentials at the interfaces, using the combination of Au, Pt ($Au/BaTiO_3/Au$, $Au/BaTiO_3/Pt$). The electronic transport is calculated by utilizing TranSiesta, which works upon Density Functional Theory and non-equilibrium Green's functions method. Furthermore, results on, Dependency of density of states with respect to different potentials at two interfaces and as well as, the electrode dependency on the Tunneling electroresistance will be presented. The figure on the right hand side shows the basic arrangement of a Ferroelectric tunnel junction in zero bias and at a finite bias.



Ferroelectric Tunnel Junction: Metal/ Ferroelectric Insulator/Metal

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OA17

VUV Assisted Advanced System for Testing and Calibration in Vacuum -The VAASTAV Facility

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Abstract

An advanced multipurpose mechanical system consisting of a cylindrical vacuum vessel sporting an automated movement mechanisms inside, has been designed to cater a range of experimental purposes such as calibration of AXUV photodiodes and photodiode arrays, in-vessel wireless communication development and VUV source calibration; many of which are envisaged to be used in the SST-1 tokamak. The system has been christened with a backronym- 'VAASTAV'. It comprises of a vacuum chamber, mechanism to manipulate position of photodiodes and drive automation controls. A calibrated vacuum ultraviolet (VUV) source provides the calibration standard for AXUV photodiodes. The drive mechanism, built on UHV compatible stepper motors has been designed to provide three degrees

of freedom to the mounted photodiodes. While variation of axial distance from source accounts for studying efficiency of diodes under scattering, the lateral movement helps calibrate each pocket of photodiode array. The rotational motion of diodes extends the capacity of the facility to measure reflectivity of thin metal foils. The said facility will also help in developing wireless communication over vacuum and metallic boundaries, quite frequently encountered in present day tokamaks. Experiments could be carried out in vacuum of the order 10^{-9} mbar.

OA18

A Novel 9-D Model For Determining Relativistic Momentum, Force And Energy Of A Particle Moving On A 4-Sphere

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Abstract

I propose an autonomous, non-linear, dynamical system of 9 second-order, coupled, ordinary differential equations $\left(\ddot{\boldsymbol{r}} = -(\boldsymbol{r}'\cdot\dot{\boldsymbol{r}}/r^2)\boldsymbol{r} - (\boldsymbol{r}'\cdot\dot{\boldsymbol{p}}/p^2)\boldsymbol{p} - 2(\boldsymbol{r}'\cdot\dot{\boldsymbol{\ell}}/\ell^2)\boldsymbol{\ell},\ \ddot{\boldsymbol{p}} = -(\boldsymbol{p}'\cdot\dot{\boldsymbol{r}}/r^2)\boldsymbol{r} - (\boldsymbol{p}'\cdot\dot{\boldsymbol{p}}/p^2)\boldsymbol{p} - 2(\boldsymbol{p}'\cdot\dot{\boldsymbol{\ell}}/\ell^2)\boldsymbol{\ell},\ \ddot{\boldsymbol{\ell}} = -(\boldsymbol{\ell}'\cdot\dot{\boldsymbol{\ell}}/\ell^2)\boldsymbol{\ell}\right)$
for determining relativistic, periodic/non-periodic motion of a particle of arbitrary mass moving on a 4-sphere of arbitrary radius. An exact analytic solution of these non-linear equations provides 3 orthogonal 3-D vectors $\boldsymbol{r}, \boldsymbol{p}, \boldsymbol{\ell}$ of arbitrary constant magnitudes satisfying the equation $\boldsymbol{\ell} = \boldsymbol{r} \times \boldsymbol{p}$. In general, rectangular components of these vectors are linearly-independent, phase-coupled, periodic/non-periodic oscillatory, composite functions of the 4 independent, real, space-time variables. A free periodic/non-periodic sequence or an array of real numbers in the interval $[0,1]$ controls the amplitude, phase and period of these 9 non-sinusoidal oscillatory, continuous, real functions. The vectors $\boldsymbol{r}, \boldsymbol{p}, \boldsymbol{\ell}$ provide a suitable orthogonal basis for obtaining relativistic (space-time dependent) functions of momentum $\boldsymbol{P}$, force $\boldsymbol{F}$ and energy E of a particle relative to an arbitrary inertial frame of reference. In general, $\boldsymbol{P}$ is a well-defined function of $\boldsymbol{p}, \boldsymbol{\ell}, t$ and $\boldsymbol{F}$ is a function of $\boldsymbol{r}, \boldsymbol{p}, \boldsymbol{\ell}, t$. $E(t)$ and $|\boldsymbol{P}|$ are continuous while $|\boldsymbol{F}|$ is a piecewise continuous, non-sinusoidal oscillatory real function of t. For a non-relativistic (i.e. with stationary background) case, particle moves on a circle with linear force and constant angular momentum, speed and energy.

Salient features of this model are:

- $r \cdot F + E = 0$.
- A time average of $E(t)$ has the same form as $E = mc^2$.
- $\nabla \cdot v = 0$ where $v = dr/dt$ is non-linear velocity.
- $\nabla \cdot F \prec 0$ where $F = dP/dt$ is non-linear, non-central force.
- $r \cdot \ddot{r} + |\dot{r}|^2 = 0$, $p \cdot \dot{p} + |\dot{p}|^2 = 0$, $\ell \cdot \dot{\ell} + |\dot{\ell}|^2 = 0$.
- Divergence of flow in the 9-D phase space is zero.

OA19

Doped ZnO Anode Material for Organic Light Emitting Diodes

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Abstract

ZnO is a wide-band gap II-VI oxide semiconductor. ZnO has several good properties like optical transparency, high electron mobility, luminescence at room temperature so that it can be used in many applications [1]. When doped with metal ions it becomes optically transparent and can be used as an anode materials in organic light emitting diode (OLED) which will be the ultimate display technology in near future [2-3]. Its disadvantages are being unveiled step by step by selecting suitable materials for rapid commercialization. The ZnO with aluminum doping has been emerged as anode materials to replace the most popular transparent conducting electrode ITO. This work focuses on the preparation of ZnO and Al doped ZnO nanoparticles and study of its structural and optical properties. Nanocrystalline ZnO was prepared by hydrolysis assisted chemical precipitation method [4]. The precursors used for the preparation was zinc nitrate solution. After hydrolysis, ammonium hydroxide solution was added as precipitating agent. The precipitate was heated at 400°C for 2 hr in air. Structural studies were performed by using x-ray diffraction (Rigaku, Ultima IV) using Cu-k_α radiation and ZnO was found to contain hexagonal crystal structure. Optical properties were measured by UV-vis spectrometer (Perkin Elmer, Lamda) and spectrophotometer (Jobin Horiba) and showed transparency in the optical region. The results based on this study will be presented.

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OA20

S. Kannan

OA21

Large Volume Double Ring Penning Plasma Discharge Source and Its PIC Simulation

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Abstract

Penning plasma discharge (PPD) proposed by Penning as a low-pressure manometer (penning gauge) [1]. This has many applications as charged particles trapping [2], light emitting sources [3], etc. In the applications of light emitting sources it has recently been proposed that the PPD device can be used to calibrate a VUV spectrometer-detector system [4] which will be an easy and low cost method in comparison to the commonly known branching ratio method used in Tokamak plasmas [5,6]. The PPD device can generate spectral radiations in the visible and VUV region simultaneously and visible radiations analysis can help in VUV intensity calibration once the desired basic plasma parameters are obtained from the visible spectra. Before establishing this as precise method, certain physics issues have to be addressed [4]. Therefore, a simple large dimension penning discharge device has been developed for efficient light emissions. In the developed PPD source we have used double anode rings which are fitted at the discharge centre between end cathodes. The experiment is performed at various discharge conditions like different pressures (10^{-5} to 10^{-3} mbar), filled gases (He, Ar, Ne) and applied voltages (up to 2.5kV). The performance of the developed source is evaluated using electric discharge characteristics and observed spectra. Also, the spectral line ratio technique [7] is used to calculate the plasma electron density, which is ~$2x10^{11}$ cm^{-3} in the developed PPD source for double ring configuration. The discharge mechanism is understood for actual geometry of the developed PPD device using particle-in-cell (PIC) simulation code "VORPAL" and the obtained results find good correlation with the experimental observations. The outcome of these efforts will be presented.

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OA22

Structural, Morphological and Optical Properties of Na and K Dual Doped CdS Thin Film

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Abstract

Cadmium sulfide (CdS) compound semiconductor with a direct band gap of 2.42 eV has many excellent physical and chemical properties. Owing to its direct band gap, high optical absorption and simple deposition have made CdS attractive for wide range of applications such as photochemical catalysis, gas sensor, detectors for laser, solar cells, nonlinear optical materials and various optoelectronic devices [1, 2].

Doping of CdS films by incorporating various elements such as Sn, Sb, Cu, B, Mn, Fe, Co, In and Ni have already been studied. The effects of incorporating simultaneously two types of dopants into CdS thin film with the aim of optimizing the properties of the film for solar cell application were interesting. However the research work on the effect of dual alkali dopants on CdS is scanty [3]. Hence a detailed investigation on CdS, Na doped CdS, K doped CdS and Na, K dual doped CdS thin films deposited on glass substrate by chemical bath deposition (CBD) were investigated in this work. Structural, morphological and optical properties of the CdS and doped CdS films were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDAX), atomic force microscopy (AFM), ultraviolet visible (UV-VIS) and photoluminescence (PL) spectroscopy techniques. The XRD pattern shows that 'as-deposited' CdS, CdS:Na, CdS:K and CdS:Na,K dual doped thin films exhibits cubic phase. Scanning electron microscopy indicates the surface of the films were uniform, densely packed and spongy. AFM studies indicated that the surface roughness of CdS:K, CdS:Na,K films are relatively small compared to the CdS and CdS:Na films. In the optical absorption spectra, the absorption edge for doped films exhibited a blue shift compared to that of the CdS thin film. The band gap value of CdS, CdS:Na, CdS:K and CdS:Na,K was found to be 2.31, 2.35, 2.38 and 2.34 eV, respectively. PL spectra of 'as-deposited' films shows a broad emission peak in the region 2.1 to 2.3 eV, which corresponds to yellow emission band. The present study indicated that dual alkali dopants in CdS helps to optimize the properties of film for device applications.

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OA23

Synthesis and characterization of various sized ZnO nanoparticles prepared by different methods

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Abstract

Over the past decades, various types of wide band gap semiconducting materials have been developed due to their potential applications in optoelectronics and microelectronic devices. Of all the available, ZnO has more technological importance due to its wide and direct band gap of 3.3 eV as well as high binding exciton energy of 60 meV. Hence, it has been widely used for optical, electrical, mechanical, piezoelectric, electrochemical, etc., applications as hydrogen storage, solar cells, gas sensors, piezoelectric, inorganic fillers in solid polymer electrolyte, etc., materials. The above properties are strongly dependent on their sizes, structures and morphology of the ZnO material and hence, synthesis methods play an important role in developing the different size (nanosize) and morphologies materials suitable to various applications. In this paper, we report the synthesis of four different sizes and shapes of pure crystalline ZnO nanoparticles by polyol process, sol gel, sol-gel combustion and co-precipitate methods. The synthesized four different sized ZnO nanoparticles were characterized by powder X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), BET surface area, optical studies. The XRD results of all the four different sized ZnO samples were compared with the standard JCPDS data and confirmed the formation of pure nanocrystalline phase with wurtzite hexagonal structure. The average crystallite size of all the four samples prepared by polyol, sol gel, sol-gel combustion and co-precipitate, calculated using Scherrer formula are respectively found to be ~54.7 nm, 51.6 nm, 45.5 nm and 43.1 nm. The SEM images for all the samples showed and agglomeration of spherical sized ZnO nanoparticles. All the four different sized ZnO samples were degassed at 200 ^{o}C for 1 h in vacuum and

determined their surface area by the adsorption method at liquid nitrogen (LN_2) temperature using BET surface area analyzer, Quantasorb (Quantochrome, USA) and their surface areas are found to be 8.51 m^2/g, 5.83 m^2/g, 4.42 m^2/g & 2.40 m^2/g respectively. The optical properties of all the ZnO samples were studied by UV-visible spectroscopy. The UV-vis absorption spectra of all the four different sized ZnO nanoparticles showed the four different intensities and absorption peaks in the UV region and their calculated band gaps are found to be 3.19 eV, 3.21 eV, 3.22 eV & 3.16 eV respectively. Detailed results will be presented and discussed.

Keywords: ZnO nanoparticles, Polyol, Sol-Gel, Sol-Gel combustion, Co-Precipitate, BET, Optical studies.

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OA24

Preparation and Characterization of Dy^{3+} doped $SrMoO_4$ Nanoparticles

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Abstract

Oxygen ion conducting solid electrolytes have many device applications such as Sensors, solid oxide Fuel cells, oxygen pumps, electrochemical reactors and steam electrolysis cells. Among these, solid oxide fuel cells (SOFCs) have attracted great attention in electrochemical devices because of their high energy conversion efficiency, little pollution and widely flexible fuel choices [1, 2]. Several families of oxygen ion conductors are being investigated for intermediate temperature solid oxide fuel cells (ITSOFCs) like fluorite type (stabilized ZrO_2, CeO_2 and δ-Bi_2O_3) oxides, pervoksite type ($LaGaO_3$, $BaCeO_3$ and $SrCeO_3$) oxides, brownmillerite type ($Ba_2In_2O_3$) oxides, aurivillius type (BIMEVOX) oxides, pyrochlore type ($Gd_2Zr_2O_7$) oxides and scheelite type ($PbWO_4$) oxides [3-5]. Scheelite type based oxide ion conducting materials like $PbWO_4$, $BaMoO_4$, $SrMoO_4$ having more ion conductivity, which are comparable with the yttria stabilized zirconia and it can also be used as electrolyte for intermediate temperature solid oxide fuel cell (ITSOFC) applications [6]. The nanocrystalline metal oxide compounds have the small grain size, which lead to the increase of ionic conductivity and also the stabilization of high temperature crystal structure. In recent years, nanostructured ceramics have been investigated due to the presence of a large fraction of grain boundaries that can lead to remarkable or enhanced electrical, magnetic, mechanical, optical, sensing and biomedical properties compared with the microstructured samples [7]. Dy_2O_3 is one of the rare earth oxides and it has high mechanical and thermal stability, suitable for glass, optic and ceramic applications [7]. In the present study, Scheelite type dysprosium doped $CaMoO_4$ compounds were prepared by using acrylamide assisted gel combustion process and also all the compounds were characterized by TG/DTA, XRD, FTIR and SEM-EDX techniques. Detailed results will be presented and discussed.

Keywords: Sol-gel combustion; schellite type nanocrystalline oxide; TG/DTA; XRD; FTIR; SEM-EDX.

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OA25

Dye-sensitized Solar Cell Based on Natural Dye Extracted from Flowers of Red Frangipani

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Abstract

The world is in great need of technologies providing renewable energy. Although sun is arguably the most abundant source of energy on Earth, harnessing solar energy in an efficient, low-cost way remains a challenge. Low cost solar cells have been the subject of intensive research activities for the last few decades. Every year the use of solar energy is increasing and photovoltaic cells will play key role in future sustainable energy systems. More recently, photoelectrochemical Dye-sensitized Solar Cells, also known as DSSCs or Grätzel cells, have been proposed as an inexpensive, easy to manufacture and an alternative to conventional solar cells [1]. The record efficiency of DSSCs has been reported as 7% in 1991, 10.4% in 1993, 11.1% in 2006 and 13.3% now. Due to cost expensive and long term unavailability of organic dyes, natural sensitizers have been strongly needed. Several natural dyes were studied as possible sensitizers for dye sensitized solar cells and reaching conversion efficiency up to 2% [2].

Herein we present the photo-electrochemical properties of dye sensitized solar cell fabricated using a natural dye which is extracted from the flowers of Red Frangipani. Ethanol was used as solvent to extract the dye from flowers. The prepared dye has been characterized using UV-Vis, FT-IR and LC-MS spectroscopy. Dye sensitized solar cell was fabricated using TiO_2 thin films as working electrode, Pt-layered counter electrode, electrolyte composed of 0.5 M LiI, 0.05 M iodine (I_2), and 0.5 M 4-tert-butylpyridine (TBP) dissolved in methoxypropionitrile and flowers of Red Frangipani extracts as natural sensitizer. Photovoltaic parameters like J_{sc}, V_{oc}, FF were evaluated and found to be 0.94 mA, 495 mV, 0.64, respectively, with resulting conversion efficiency (η) of 0.3%.

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OA26

Surface Modification of $LiCoO_2$ Particles

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Abstract

Li ion batteries have potential applications in portable electronic devices such as, laptops, mobiles, i-Pads etc. $LiCoO_2$ is the most preffered cathode material for lithium ion batteries, because of its high energy density and high theoretical capacity [1-3]. However $LiCoO_2$ exhibits capacity fading at high rates due to structural instability [4-6]. Inorder to mitigate this problem, attempts have made through doping of metal ions (Al, Mg, Co, Cu, etc.) and coating of metal oxides (ZrO_2, Al_2O_3, TiO_2, SiO_2,B_2O_3, etc.) over $LiCoO_2$ particles. The coating reduces the direct contact with electrolyte and protects the original structure during charging/discharging process [7-10]. Hence, in the present work, $LiCoO_2$ particles were prepared by acrylamide assisted polymeric citrate process and La_2O_3 coated $LiCoO_2$ was prepared using newly developed polymeric resin process. In novel polymeric resin process, polyacrylic acid (PAA) and ethylene glycol (EG) will act as coupling and chelating agents. The strong attraction between polyacrylic acid species and $LiCoO_2$ particles surface was effectively used for an efficient thin uniform coating of La_2O_3 over $LiCoO_2$ particles. The synthesized powders were characterized using thermo gravimetric analysis (TG) / differential scanning calorimetry (DSC), fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscope (SEM) and X-ray fluorescence (XRF). The electrical conductivities of bare and La_2O_3 coated $LiCoO_2$ particles are studied through impedance measurements and their conductivities are found to be 5.346 x 10^{-5} $ohm^{-1}cm^{-1}$ and 8.771 x 10^{-6} $ohm^{-1}cm^{-1}$ respectively. Detailed results will be presented and discussed.

Keywords: Cathode material, Surface modification, XRF, electrical conductivity.

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OA27

Mn doped Tin Oxide Nanoparticles – A Structural Study

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Abstract

In the present work, pure and Mn (x=1,3,and 5 mol%) doped SnO_2 nanoparticles were prepared by chemical co-precipitation method and characterized by X-ray diffraction, transmission electron microscopy, and X-ray photo electron spectroscopy. The crystal structure and size of the SnO_2 nanocrystals were determined by x-ray diffraction and transmission electron microscopy revealing that all the samples have single phase of tetragonal structure. The XRD results showed that the doping of manganese ions could efficiently inhibit the grain growth and Transmission electron micrograph shows uniform and spherical SnO_2 nanoparticles of diameter 7–13 nm. The particle size obtained from the TEM coincide with the same obtained from the XRD. The high resolution TEM images showed the inter-planar spacing as 0.25nm and 0.234 nm that correspond to the (101) and (200) planes of tetragonal SnO_2 **[1-3**]. The XPS measurements of all the samples were carried out to determine the electronic states. From the XPS studies, the oxidation state of manganese was found to be 4+ state in the Mn-doped SnO_2 nanoparticles. And the particle size induced implications in the core level XPS peaks of Mn 2p and O 1s have been analyzed [**4-8**].

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OA28

Boya Venugopal

OA29

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OA30

Tribo-Performance Prediction of Glass Micro-spheres Coatings Using Artificial Neural Network

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Abstract

This article proposes the application of artificial neural networks (ANN) to a Taguchi orthogonal experiment to develop a robust and efficient method of analyzing and predicting the solid particle erosion wear response of a new class of metal-glass coatings. An ANN model based on data obtained from experiments performs self-learning by updating weightings and repeated learning epochs. In this work, plasma-sprayed coatings of solid glass micro-spheres are deposited on aluminum substrates at various input power levels of the plasma torch. Erosion wear characteristics of these coatings are investigated following a plan of experiments based on the Taguchi technique, which is used to acquire the erosion test data in a controlled way. The study reveals that the impact velocity is the most significant among various factors influencing the wear rate of these coatings. An ANN approach is then implemented taking into account training and test procedure to predict the tribo-performance under different erosive wear conditions. This technique helps in saving time and resources for a large number of experimental trials and successfully predicts the wear rate of the coatings both within and beyond the experimental domain.

Keywords: Plasma spraying; Glass micro-spheres; Erosion Wear; Taguchi Technique; ANN.

OA31

Electrical Breakdown study of Liquid Dielectrics under Pulsed Conditions

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Abstract

In an effort to develop compact pulsed power systems, many researchers using water as a dielectric. But water has low charge holding capability [1], typically in micro second range. If a way can be found to increase the charge holding capability and breakdown strength, then there will be more applications for water. In this process glycerin is selected to use as a controlled impurity to mix-up with water. Properties like moderate dielectric constant, high viscosity and easy solubility in water makes glycerin as a suitable liquid to mix-up with water. In present work effect of viscosity on charge holding capability and breakdown strength of glycerin/water mixture with variation in temperature will be studied. It is expected that as the temperature decreases dielectric constant, resistivity and

viscosity [2] of liquid mixture increases. Effect of variations in these parameters on breakdown strength Glycerin/water mixtures will be studied. Temperature of liquid [3] will be varied from room temperature to 5ºC. Effects of voltage polarity, applied pulse duration and electrode material will be studied. To perform this study suitable experimental setup is developed. Expected results and experimental results will be presented in presentation.

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OA32

Thangdurai

OA33

Characterization of Plasma Treated ZnO Nano Composites Polymer Membranes

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Abstract

Systematic study was carried out to characterize the effects of Nitrogen ion plasma on nano composite polymer membrane. Nano particles of ZnOaresynthesized by chemical root. Using solution casting and spin coating method, nano composite polymeric membranes in the range of 20–40 micron were prepared. Nitrogen ion plasma treatment was done for these membranes. Variable treatment time were used to modify the membrane surface and its characteristics. These membranes were characterized before plasma treatment and after plasma to make comparative study by different technique such as optical microscopy, SEM- Scanning electron microscope, UV-Vis Spectrometry, Fourier transform infrared spectroscopy, I-V measurement. Results of gas permeation shows improvement in porosity N_2 plasma treated Membrane. The permeability of these membranes also depends upon thickness, ion energy and etching time. So the Plasma treatment is a quite effective tool for improving the properties of composite membranes with unique characteristics. These results are discussed in this paper.

OA34

OA35

Influence Of Sputtering Pressure On Structural, Morphological And Optical Properties Of RF Magnetron Sputtered MoO_3 Thin Films

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Abstract

Thin films of MoO_3 were formed on glass substrate at room temperature by sputtering of molybdenum target in

oxygen partial pressure of about $4x10^{-2}$ Pa and sputtering power of 150 W. The effect of varying sputtering pressure on the structure, morphology and optical properties of MoO_3 films have been investigated by characterization techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM) and VU-Vis-NIR spectroscopy respectively. XRD analysis of the thin films exhibit polycrystalline nature with (020) peak corresponds to the orthorhombic MoO_3 phase. The intensity of (020) peak increased with increase of sputtering pressure. The crystallite size increased from 16 nm to 25 nm with increase of sputtering pressure from 2 Pa to 6 Pa. Micro structural analysis reveals that the dense blurred grains was observed at low sputtering pressure of 2 Pa and it transform into needle like structure in the films deposited at higher sputtering of 6 Pa. Nano flower like structure can be observed at sputtering pressure of 4 Pa. The optical transmittance of the films was about 85 % at low sputtering pressure and it decreased with increase of sputtering pressure. The optical band gap increase from 2.86 to 3.12 eV and the refractive index of the films increased from 2.02 to 2.12 with increase of sputtering pressure from 2 Pa to 6 Pa.

OA36

Structural and Electrical Characterization of CuO Nano Particles Synthesized by Co-precipitation Method for Ethanol Gas Sensing Application

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Abstract

CuO nano powders were prepared from the aqueous solution of copper chloride ($CuCl_2$) for various concentrations (0.1M,0.2M and 0.3M) using sodium hydroxide pellets by co-precipitation method. X-ray diffraction (XRD) pattern showed that the obtained powders are nanocrystalline with monoclinic structure. Microstructure of the powders were

analyzed using Scanning Electron Microscope (SEM).The Electrical parameters and their variations with respect to cationic ratios and temperature were obtained from the Two-Probe measurement and the activation energy were calculated for various concentration as 1.58 eV,1.07 eV,0.81 eV. The Ethanol gas sensing mechanism of these nano powders were also analyzed and the results were obtained.

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OA37

Doped Cerium Oxide Nanostructures as Thin Film Electrolyte For ITSOFC

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Abstract

Energy demand of the world increases day by day due to rapid industrialization and population growth. But due to faster depletion of the fossil fuels, it is essential to venture alternative and renewable clean energy systems. Solid oxide fuel cell (SOFC) is one of the most efficient clean energy solutions with an additional advantage of fuel flexibility. But SOFC suffers from high operating temperatures, which limits the application due to material degradation. Reduction of operating temperature of the SOFC to intermediate temperature (300-700ºC, ITSOFC) minimizes the material degradation. Among the various components of SOFC, electrolyte plays a vital role in determining the efficiency of SOFC. The challenge is to design electrolyte material with minimum ionic conductivity of $0.1 Scm^{-1}$. Present work

focuses on the synthesis of cerium oxide and 20mol% of samarium doped cerium oxide nanoparticles (SDC) electrolytes through co-precipitation technique and thin film deposition of these powders as precursor material using e-beam evaporation. . XRD, SEM, XRF, optical absorption studies and impedance spectroscopic analysis were used to analyze both synthesized powder and thin film. XRD results indicated the presence of cubic fluorite structure for both ceria and

SDC without any phase separation and a shift in the peak position towards lower angle was observed for SDC due to lattice expansion while XRF results confirmed the presence of the stoichiometric amount of samarium (20mol%) for SDC. XRD and XRF results indicated the complete doping of samarium in the host lattice of cerium oxide. Optical absorption spectra exhibited a slight shift in band gap energy for SDC (2.80 eV) compare to that of pure cerium oxide (2.88 eV). Study of surface morphology of thin film with respect to the annealing temperature carried out through the SEM. The film thickness and porosity changes were estimated by using reflectance spectra of the deposited film. CeO_2

and $Ce_{0.9}Sm_{0.2}O_{2-\delta}$ precursor nano powders were annealed at different temperatures to investigate the influence of grain size and surface morphology of the deposited thin film.

OA38

Dynamics of Dipolar Bose–Einstein condensate (DBEC) with time-dependent trapping potential

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Abstract

We investigate the dynamics of Dipolar Bose–Einstein condensate (DBEC) with time-dependent trapping potential. Using variational and numerical solutions of the mean-field Gross-Pitaevskii equation, we discuss the stability properties of DBEC with time-dependent external trap. Our semi-analytical results were also confirmed through direct numerical simulations.

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OA39

Synthesis of Nanocrystalline Li_2TiO_3 by High Energy Ball Milling

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Abstract

The Nanocrystalline Li_2TiO_3 ceramic powder has been prepared by high energy ball milling method. The powder was calcinied at different temperatures 400^0C to 800^0 C for 2hrs. It is observed from the XRD study that the single phase monoclinic structure occurred at temperature 700^0C and the crystallite size is around 88 nm. Then the ceramics were sintered at three different temperatures 700 °C, 800 and 900 °C for 2hrs by conventional sintering technique. The scanning electron microscope shows homogeneous distribution of grain size and the grain size increases with increase in sintering temperature. The frequency dependent dielectric constant and dielectric loss is studied within a temperature

range 30^0C-500^0C. The dielectric constant increases with increase in sintering temperature. The Nyquis plots show both grain and grain boundary effect. The frequency dependent ac conductivity at different temperatures indicates that the conduction process is thermally activated and the spectra follow the universal power law. The hopping frequency shifts toward higher frequency with increase in temperature, below which the conductivity is frequency independent. The variation of DC conductivity confirms that the ceramic exhibits a negative temperature coefficient of resistance behavior in high temperature.

OA40

Power Generation from Biomass and Waste

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Abstract

Biomass is the (living or recently dead) biological material from which bio-energy is extracted. Biomass is often plant matter grown to produce heat or generate electricity. Electricity has today become a basic necessity for not only developed world, but also for the developing and underdeveloped countries. The average electricity consumption in India is still among the lowest in the world at just 630 kWh per person per year and this is expected to grow to 1000 kWh in the near future. Biomass contributes as the world's fourth largest energy source today up to 14% of the world's primary energy demand. In developing countries it can be as high as 35% of the primary energy supply. The environmental problems are associated with the generation of conventional sources of energy. Therefore, renewable source of energy is an alternative to conserve the natural resources and reduce the pollution problems. This paper discusses eco-friendly power generation technology by using biomass and waste. In this technology biomass /waste is used in boilers to produce directly heat and/or steam to generate electricity. Because biomass is available in almost all places, and especially in rural areas, power production can be done on small scales at remote locations, this process can be used for distributed generation of power as against the centralized power production method followed today. Biomass based power generation is well suited to remote villages with no access to grid but access to significant amounts of biomass.

OA41

Calcium Silicate Coating On Metallic Implant For Orthopaedic Surgery

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Abstract

Biocompatibility of orthopaedic surgical implants with bone tissue allows adequate osseointegration between the bone and implant. Several materials involving Metals, Ceramics and polymers are being used for such applications[1]. Although metallic materials have been used as bone material for long time, they are still detected as foreign bodies by human immune system and the disadvantage of releasing corrosion products have limited their usage. In this context,

coating of bioceramic on metallic implants is intended to possess dual advantages of increasing the bioactivity of coated ceramic and the sufficient mechanical strength is being provided by the underlying metallic surface. A lot of reports are being available on Hydroxyapatite coating on metallic surface[2],[3]. However, the studies on calcium silicate ($CaSiO_3$) coating on metallic implant are being minimal. A variety of coating methods are available and the extensively studied one is the plasma spray technique which usually is operated at high temperatures (over 16,000 ºC) that results in the phase transition of the compound and also affect the surface quality, microstructure of the implant [4],[5]. Hence, low cost technique called Electrophoretic deposition (EPD) is used as one of the effective methods to deposit $CaSiO_3$ on to the metallic implant which avoids phase transition of the compound due to its low operating temperature. The present study is being aimed at the development of $CaSiO_3$ coating on 316L SS surface. $CaSiO_3$ was prepared by aqueous precipitation method with the aid of ammonium hydroxide as a precipitating agent. The as prepared sample was found to be amorphous and hence heat treatment was necessitated to improve the phase pure formation of $CaSiO_3$ and with the simultaneous improvement of crystallinity. The results have shown that single phase $CaSiO_3$ has been formed at 800 ºC. The resultant powder was taken for a coating on a very fine polished 316L SS surface using Electrophoretic deposition technique. The coating procedures including applied voltage and time of deposition were optimized. The characterization of the synthesized powder and coated specimens were optimized using the techniques involving X-ray diffraction, Thermal analysis, FT-IR spectra and scanning electron microscopy.

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OA42

Synthesis, Characterization and Fabrication Hydroxyapatite/Titania Composites for Biomedical Applications

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Abstract

Hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$, HAP] is one of the most attractive ceramic materials for vertebrate and dental implant applications due to their compositional and biological similarity to native hard tissues [1,2]. However, the synthetic HAP possess the demerits of brittle behavior that limits its usage for load bearing orthopaedic applications. In this context, several attempts are being made for the past two decades to improve the mechanical properties of HAP. As a part of the above mentioned investigation, composites with HAP have been developed to improve the strength of the resultant material. In this regard, many reinforcements such as alumina (Al_2O_3) [3], zirconia (ZrO_2) [4], bioglass [5] and titania (TiO_2) [6] have been used in HAP materials. Among the different HAP-based composites, HAP/ TiO_2 composites have attracted considerable attention in recent years, mainly due to the assumption that TiO_2 is able to enhance osteoblast adhesion and can induce cell growth [7,8]. It has been recently shown that adhesive and cohesive strength of the HAP implants could be increased significantly by adding TiO_2 as the reinforcing agent [6,7].Various processing techniques such as sol–gel [8], hydrothermal [9] and microwave hydrothermal [10] method have been utilized to synthesize HAp/TiO_2 nanocomposites.

In this study, a simple aqueous precipitation has been used to produce HAP/ TiO_2 composites. The level of TiO_2 reinforcement in HAP matrix has been varied to obtain a wide range of HAP/ TiO_2 composites. The thermal stability of the different HAP/ TiO_2 composites with the resultant influence on their mechanical behavior has been investigated systematically. The characterization techniques involving X-ray diffraction, Thermal analysis, FT-IR spectra and

Scanning Electron Microscopy and Nanoindentation will be employed to for a thorough characterization of the HAP/ TiO_2 composites.

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OA43

Development of Nanocrystalline Indium Tin Oxide (ITO) Thin Films Using RF-Magnetron Sputtering

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Abstract

Indium Tin Oxide (ITO) is known as degenerate metal-oxide semiconductor exhibits wide band gap, high optical transmittance and electrical conductivity. Due to the fact, it is being extensively used as transparent window electrodes in variety of devices including optoelectronic devices such as Solar cells, display devices, LASER diodes, LEDs etc., [1]. Generally, all the devices are utilized thin films with amorphous or polycrystalline structures for the purposes. There are few reports about the preparation and characterization of nanocrystalline ITO thin films using chemical methods and reported that the structure changes from the normally observed BCC structure [2, 3]. In this work, we intent to prepare nanocrystalline ITO thin films using radio-frequency magnetron (RF-magnetron) sputtering from the pre-synthesized ITO target towards the fundamental studies about the structural and confinement properties. To this, thin films of ITO have been deposited on Glass substrate using RF Magnetron puttering Technique. The sputtering parameters

such as the deposition temperature, gas composition and the RF power densities were varied. Films deposited on glass substrates were further characterized using XRD, UV-Visible spectrophotometer, Atomic Force microscope (AFM) and scanning electron microscope (SEM). It is found that the crystallization of the films is mostly depending on the RF power density and substrate temperature. X-Ray diffraction studies, showed that the preferred orientation of the polycrystalline film shifted from (111) plane to (100) plane at specific conditions along with better electron mobility. Deposition conditions were optimized to obtain nanocrystalline ITO films on larger area. Different morphologies of nanocrystallites were observed with BCC structure different from the reports on nanocrystalline films. Details will be reported during the presentation.

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OA44

Optical Properties Of Spin Coated ZnO Films

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Abstract

The effect of concentration of dopant and the thicknesses of the film on the band gap of Mn doped ZnO films were investigated. Mn doped ZnO thin films are prepared by Sol-Gel technique. Mn doped ZnO thin films are deposited on the glass substrate using Spin Coater. The films are coated on the sample in two ways- by dropping the sample exactly at the desired rpm(3000 and 5000 rpm) and by dropping the sample when both time and rpm equals zero. Uv- Visible studies were conducted for each film and the optical band gap of each film are calculated from the Tauc plot. The results show that 1%Mn doped ZnO films show strong dependence of band gap on film thicknesses. The variation of band gap with respect to the doping concentration shows their dependence on crystal structures. Further, comparison has been made on the variation of band gap w.r.t the thickness of the films. The higher band gap in thinner films has speculated due to the quantum confinement phenomena.

OA45

STUDY OF PARAMETERIC OPTIMIZATION ON ELECTRO-EXPLOSIVE OPENING SWITCH PERFORMANCE

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Abstract

Opening switch technology has various potential applications. One of them is to develop a compact device which can generate relativistic electron beams (REB). By proper tuning of parameters, these electron beams can be used to generate High Power Microwaves (HPM). These switches can be used to exploit the advantages of an Inductive Energy Storage Scheme (IESS) which is that the overall system can be made compact. Detailed study and review of various opening switch schemes have been carried out [1]. Based on these studies, efforts have been directed to develop such technology. Objective of such a switch is to generate fast rise time nanosecond duration high voltage pulse. Higher the voltage, higher the power of HPM generated. Based on available literature [1], electro-explosive opening switch (EEOS) have been chosen for direct generation of such high voltages. A description of experiments performed is presented in this paper.
The experiments conducted are an extension of study performed earlier on EEOS [2]. In the present work, effect of variation of storage inductance has been studied. Effect of using thin foils and wires as electro-explosive opening switches has been studied. Material chosen for the opening switch has been copper and aluminium. Effect of variation of length on generation of voltages across the opening switch has also been studied. Effect of quenching medium such as de-moisturized sand and very fine glass beads have been observed. It has been observed that lower storage inductance leads to higher output voltage. Thin foils lead to smaller opening time and thus, generate voltages having faster rise-time than voltages obtained using thin wires. However, magnitude of output voltage is almost of same order and appreciable

improvement has not been observed. Similarly, using very fine glass beads instead of sand do not improve the magnitude of output voltage.

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OA46

Electrothermal Efficiency and Characteristics of Plasma Sprayed Alumina-Titania Composite Coatings in a DC Plasma Spray Torch

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Abstract

Plasma torch has various noteworthy features such as protective coating to prevent degradation, extremely high temperatures, low environmental impact, short processing time which makes suitable technique for synthesizing composite materials. Electrothermal efficiency of the DC plasma torch was measured by using energy balance equations. The plasma torch input power, flow rates of primary gas were optimized for better electrothermal efficiency. Commercially available Alumina and Titania powders was ball milled for 8h to obtain composites for the ratios 50:50, 60:40, 30:70 which effectively participate in atmospheric plasma spray process. Composite coatings of Alumina-Titania were prepared by using DC atmospheric Plasma Spray Torch. The ball milled powder and the composite coatings were analysed by using X Ray Powder Diffractometer and microstructure of the coating is analyzed by Scanning Electron Microscope. The spraying parameters affect the electrothermal efficiency of the torch. The detailed results will be reported in manuscript.

OA47

Investigation Of Thermophysical Property For The Design Of Latent Heat Thermal Energy Storage Container Based On Phase Change Material

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Abstract

The storage of thermal energy in the form of sensible and latent heat has become an important aspect of energy management with the emphasis on efficient use and conservation of the waste heat and solar energy in industry and buildings. Latent heat storage is one of the most efficient ways of storing thermal energy. Solar energy is a renewable

energy source that can generate electricity, provide hot water, hot air, and provide electricity. The optimum capacity of an energy storage system depends on the expected time dependence of solar radiation availability, the nature of loads in the process, the degree of reliability needed for the process, the manner in which auxiliary energy is supplied, and an economic analysis that determines how much of the annual load should be carried by solar and how much by the auxiliary energy source. The size of storage is related to the 'energy density', or the amount of energy stored per unit mass (or per unit volume) of storage material. Acetamide is considered as phase change material due to its thermo-physical, chemical, kinetic and economical properties match the energy requirement for agricultural products drying. The experiments are dealt with the performance and evaluation of Acetamide in different containers and in different conditions to investigate the melting point of Acetamide. Acetamide has high latent heat of fusion with recommended temperature for drying of most of agricultural product around 60-70oC. Acetamide needs a suitable container or a heat exchanger to transfer the heat to the point of use. The amount of energy required to dry the products can be estimated with a suitable Phase Change Materials container using energy equations during freeze-melt cycle. The instruments and devices used to measure the temperature and solar radiation are Temperature sensors and pyranometer. The first step adopted is finding out the energy requirement for drying a specific amount of the product. Later it is assumed that 80% of the total requirement is expected to get from solar energy and 20% through storage medium. The quantity of energy requirement is calculated as 8300 kJ. The contribution of Phase Change Material is 1660 MJ and the quantity of Phase Change Material required is calculated as 4.5 kg. A container is designed with adequate heat transfer mechanism to be well utilized for solar drying applications for partial energy requirement during night hours.

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Unique whistler-triggered VLF/ELF emissions observed at low latitude station Jammu

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Abstract

A detailed analysis of the VLF/ELF wave data obtained during a whistler at our low latitude Indian ground

station Jammu (geomag. Lat. = 22^{o} $26^{/}$ N, L = 1.17) has yielded two types of unusual and unique whistler-triggered VLF/ELF emissions. These include (1) whistler-triggered hook emissions and (2) whistler-triggered long enduring discrete chorus riser emissions in VLF/ELF frequency range during night time. Such types of whistler-triggered emissions have not been reported earlier from any of the ground observations at low latitudes. In the present study, the observed characteristics of these emissions are described and interpretated. Dispersion analysis of these emissions show that the whistlers as well as emissions have propagated along a higher geomagnetic field line path with L-values lying ~ L = 4, suggesting that these triggered emissions are to be regarded as mid-latitude emissions. These waves could have propagated along the geomagnetic field lines either in a ducted mode or in a pro-longitudinal (PL) mode. The measured intensity of the triggered emissions is almost equal to that of the source waves and does not vary throughout the period of observation on that day. It is speculated that these emissions may have been generated through a process of resonant interaction of the whistler waves with energetic electrons. Parameters related to this interaction are computed for different values of L and wave amplitude. The proposed mechanism explains some aspects of the dynamic spectra.

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