PlasmaIndia

A newsletter of Plasma Science Society of India
Vol. 18 No. 3 (2003)

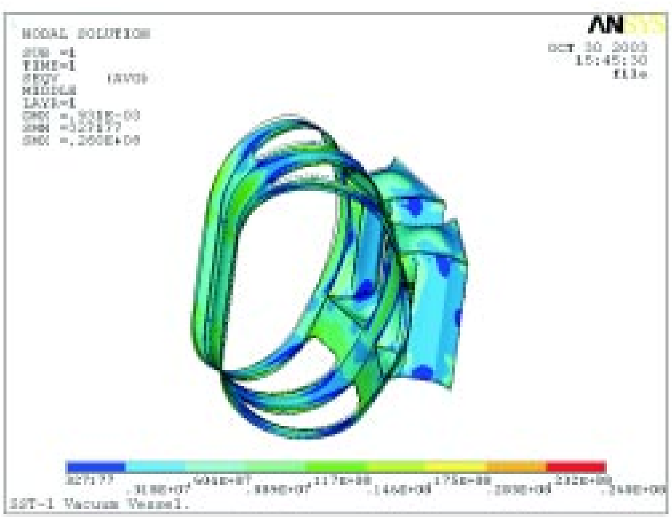
Numerical Techniques in Engineering

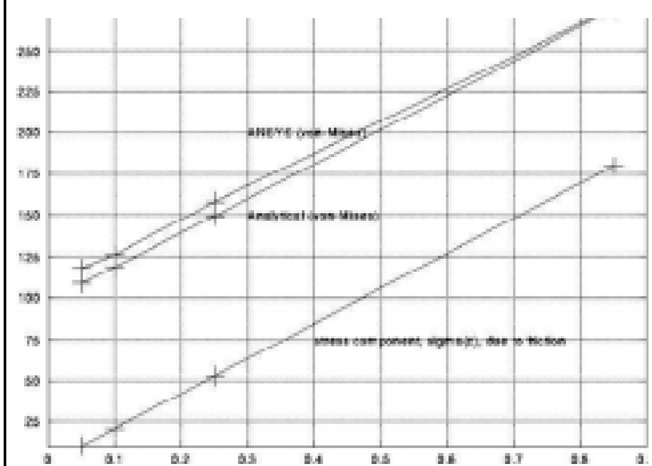
In solving the present day engineering problems, numerical techniques (NTs) are playing a vital role. Either the problem is simple or complex most of the engineers are depending on NTs. Widely used NTs in engineering practice are Finite Difference (FD), Finite Element (FE) and Finite Volume (FV) (especially used in Computational Fluid Dynamics). Many commercial softwares are available in the market based on the NTs. ANSYS is one of such software makes use of FE method.

In IPR we have 24 ANSYS Multi-physics licenses mounted on IBM and Solaris workstations. This software is vastly used in analyzing tokamak SST-1 and it's sub-systems. The problems handled are non-linearities, transients, static and steady state in structures, thermal, fluid and electromagnetics. *Now, IPR has started consultancy projects based on FEA and Solid Modeling.*

The below figures show some of the analysis results of tokamak SST-1 carried by using ANSYS at IPR.

Contributed by: Ramdas Chennamsetti (ramdas@ipr.res.in)





Inside This Issue...

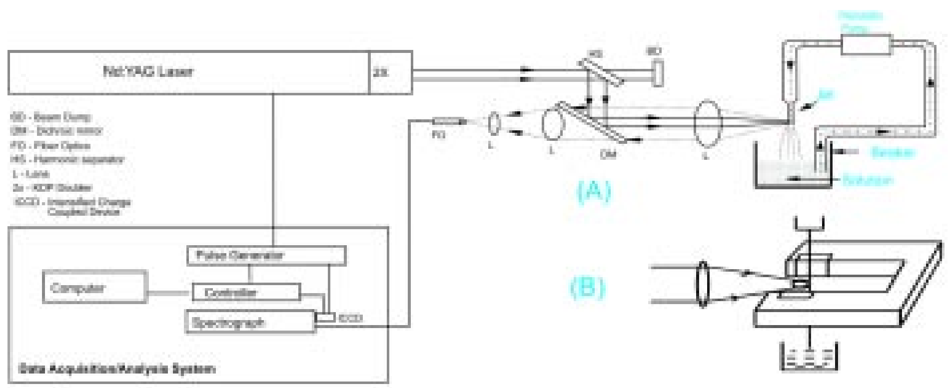
PLASMA SCIENCE SOCIETY OF INDIA

Registered Office: Physical Research Laboratory, Ahmedabad
Institute for Plasma Research, Bhat, Gandhinagar-382 428

E-mail: pssi@ipr.res.in Phone: (079) 3969031-35
URL: http://www.ipr.res.in/-pssi Fax: (079) 3969017

Environmental and Industrial Application of Laser Induced Breakdown Spectroscopy

Laser-Induced Breakdown Spectroscopy (LIBS) [1] is an elemental analysis technique that is an alternative to established analysis methods that include X-ray fluorescence, atomic absorption spectroscopy, atomic emission spectroscopy (ICP, arc-spark, glow discharge etc.) as well as neutron activation analysis [2]. Relative to these established technologies, LIBS has less sensitivity in the elemental analysis applications such as in the assessment of naturally available and the commercially manufactured materials.



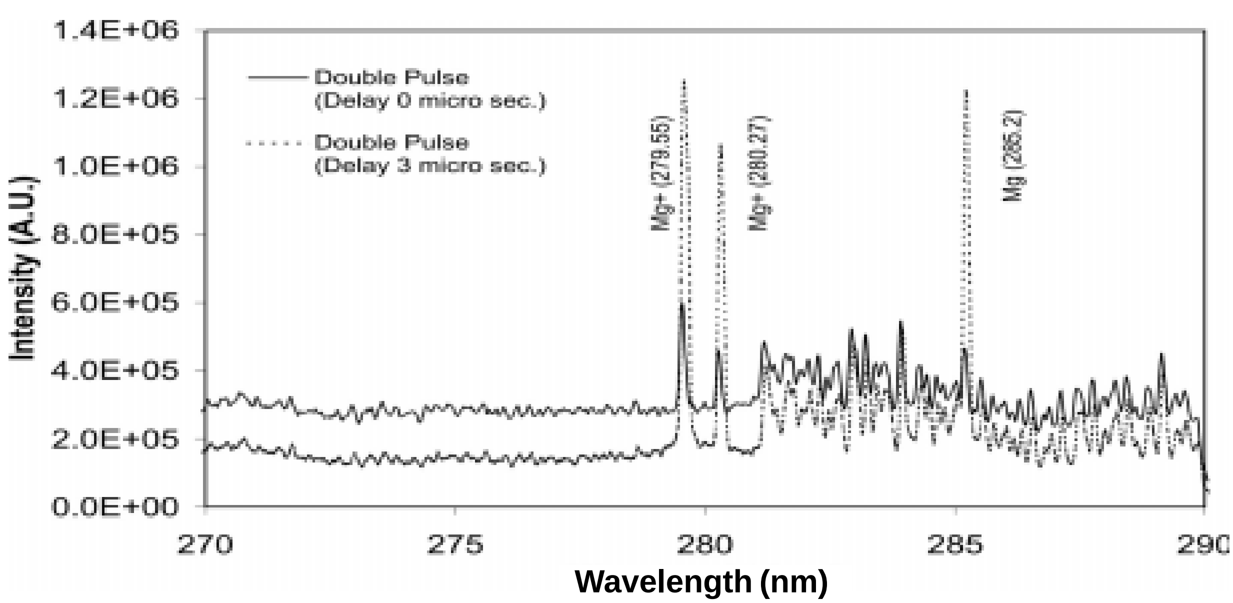
In this technique atomic emission from laser-produced plasma of different types of target material is collected with the help of a collimating lens (same as focusing lens) and sent to the detection system via a dispersing system (Fig.-1). The intensity of atomic emission lines recorded in the LIBS spectrum is then used to infer the composition of the target materials. It has been used to analyze solid, liquid, gas and aerosol samples even if it is present in a harsh and difficult environmental condition [2]. It can significantly reduce the time and cost associated with the sample preparation required by the conventional analytical techniques and is therefore a promising technique for environmental monitoring and process control. Another important factor is that it can be operated at a remote distance from the target material.

LIBS has been used to perform in-situ off gas monitoring by focusing the laser beam in the gas stream through a window and collecting the optical emission through an optical fiber. Neuhauser et al. [3] tested an on line lead (Pb) aerosol detection system with aerosol diameters ranging between 10 and 800 nm. A detection limit of 155 mg m^{-3} was found. LIBS has been demonstrated as a process monitor and control tool for waste remediation [4]. The toxic metal from three plasma torch test facilities have been monitored and was found that

LIBS can be integrated with a torch-control system to minimize toxic metal emission during plasma torch waste remediation.

Detection of contaminated soil and concrete is another important area of research for LIBS. Yamamoto et al. [5] have used a portable LIBS system to detect toxic metals in soil. LIBS has also been used to monitor the level of radioactive elements in a process stream; Watcher and Cremers [6] found a detection limit of l00 ppm for uranium in solution. LIBS is preferable to other radiological measurements because nuclear detector may not be able to differentiate the radio nuclides U, Pu and Np

Detection and characterization of metallic species in the exhaust plume of hydrocarbon-fueled rocket engines can indicate the presence of wear and / or corrosion of metal in the rocket engine. This information on engine wear obtained during engine operation is very useful, allowing the possibility of engine shutdown before any catastrophic failure. It has been observed that a catastrophic engine failure is generally preceded by a bright optical emission, which result from the erosion of metal from the engine parts. This is because of high temperature in the rocket plume (~2000 K), which partially vaporizes and atomizes the metal species, leading to atomic emission in the near ultra violet and visible spectral range (300- 760 nm). The performance of LIBS was evaluated in detecting the trace of elements in the fuel plume of a hybrid rocket engine simulator at Stennis Space Center, USA [7].



Various techniques have been used to improve the sensitivity of LIBS, such as application of pulsed and dc magnetic field, double pulse excitation and the use of purge gas around the liquid jet target. An enhancement of 1.5-2 times in the emission from the laser produced plasma was obtained using a steady magnetic field of ~5 kG. In order to further enhance the sensitivity of LIBS double laser pulse excitation technique was successfully used [8]. In this experiment the inter-pulse separation between lasers was varied from 0 to 20 ms. The measurements showed an enhancement in the emission by a factor of more than six times for the inter pulse separation of 2-3 ms (Fig.-2).

These experimental results and observations have shown that LIBS can work as a process monitor and provides online and real time information about the concentration of toxic and hazardous elements in different types of matrices. It has various applications in different other field of research and analysis, which is not possible to include here. However, further improvement in its sensitivity will make this technique even more versatile

References:

1. L. J. Radziemski, D. A. Cremers (Ed.), "Spectrochemical analysis using plasma excitation," in: Laser Induced Plasmas and Applications, Marcel Dekker, New York, NY, 1989, ch. 7, pp 295-325.
2. F. Y. Yueh, J. P. Singh and H. Zhang, Laser-induced breakdown spectroscopy: Elemental analysis. Encyclopedia of Analytical Chemistry, John Wiley & Sons, Ltd. Vol. 3 2065-2087 (2000).
3. R. E. Neuhauser, U. Panne, R. Niesner, G. A. Petrucci, P. Vavalli, N. Omenetto, "On line and in- situ detection of lead aerosols by plasma spectroscopy and laser excited atomic fluorescence spectroscopy," Anal. Chim. Acta, 346, 37-48 (1997).
4. J. P. Singh, F. Y. Yueh, H. Zhang, R. L. Cook, "Study of laser-induced breakdown spectroscopy as a process monitor and control tool for hazardous waste remediation," Process control Quality, 10, 247-258 (1997).
5. K.Y. Yamamoto, D. A. Cremers, M.J. Ferris and L.E. Foster," Detection of metals in the environment using a portable laser-induced breakdown spectroscopy instrument," Appl. Spectrosc. 50, 222-233 (1996).
6. J. R. Watcher and D.A. Cremers, " Determination of uranium in solution using laser-induced breakdown spectroscopy," Appl. Spectrosc. 41, 1042-1048 (1987)
7. V. N. Rai, J. P. Singh, C. Winstead, F. Y. Yueh and R. L. CooK, "Study of hydrocarbon fueled flame and rocket motor simulator plume using laser-induced breakdown spectroscopy" Paper # AIAA-2002-2240, 33rd Plasmadynamics and laser conference & 14th International conference on MHD power generation and high temperature technology, Maui, Hawai, May 20-23 (2002)
8. V. N. Rai, F. Y. Yueh and J. P. Singh, " Study of laser-induced breakdown emission from liquid sample under double pulse excitation," Appl. Opt. 42, 2094-2101 (2003)

Contributed by: V. N. Rai (vnrai@cat.ernet.in)

UPCOMING CONFERENCES AND SYMPOSIUM IN 2004

28 June – 1 July
31st IEEE International Conference on Plasma Science (ICOPS2004)
Hyatt Regency Hotel, Baltimore, Maryland, USA
Contact: Robert Commisso, NRL, Washington DC, USA
Email: commisso@suzie.nrl.navy.mil
URL: http://www.ieee.org/icops2004

28 June – 2 July
31st EPS conference on Plasma Physics
Imperial College, London
Contact: P. A. Norreys
Email: p.a.norreys@rl.ac.uk

20 – 24 September
23rd Symposium on Fusion Technology, Venice, Italy
Contact : Alessia Grava, Cosorzio RFX, Corso Stati Uniti, 4
35127 Padova, Italy
Fax: +39 049 8295051