Laser-Induced Breakdown Spectroscopy (LIBS)

LIBS Characteristic

LIBS technique employs focused high energy laser pulse to ablate small amount (few ng) of object surface and to generate luminous laser-induced plasma (LIP). Characteristic spectral lines detected in LIP radiation provide qualitative and quantitative information about chemical composition of investigated object.

Advantages of LIBS analysis

- real-time, no need for sample preparation and contactless,
- ability to provide analysis of samples in gaseous, solid and liquid states,
- capability to identify most of chemical elements, depending on the element and material matrix the detection limits could be lower than 1 ppm,
- mainly, capable of mobile *in-situ* remote/stand-off sensing (up to 100 m) in inaccessible or hazardous environments.

LIBS Applications

In general, LIBS can be utilized wherever the real-time chemical analysis of materials is demanded, with primary aim on investigation of solid samples chemical composition and their remote sensing. Possible applications:

- biological and environmental diagnostics (detection of heavy/toxic metal contamination),
- metallurgy (fast on-line quality control),
- homeland security (detection of explosives and chemical residues, narcotics),
- mining and extraterrestrial research (rock identification),
- medicine, archaeology, forensics, etc.

Laboratory of Laser Spectroscopy has been involved in numerous projects so far, e.g. analysis of algal biomass for industrial biotechnology, tracing the nanoparticles in organic materials for pharmacology, estimation of the corrosion degree of metals, investigation of the metal accumulation in vegetal tissues, depth profile analysis of zinc-coated steel, multielemental analysis of prehistoric animal teeth, classification of brick samples and igneous rocks, etc.

LIBS Laboratory

Laboratory of Laser Spectroscopy has more than 17 years of experience with the development of LIBS methods and disposes of all necessary devices for the implementation of single-pulse LIBS and also double-pulse LIBS (with increased detection limits), LIBS + LIFS (Laser Induced Fluorescence Spectroscopy), LIBS of liquids and remote samples: remote LIBS (by optical fibre) and stand-off LIBS (via air). In 2014 a CEITEC BUT LIBS spin-off company (AtomTrace), dealing with stand-off/remote LIBS and table-top LIBS systems and industrial LIBS applications development and production, has been established.

The key equipment:

- Stand-off system (rLIBS) specially designed for *in-situ* and real-time analysis of hard to reach or hazardous/toxic samples. This device is composed of high energy laser BigSky Ultra CFR 400, Newtonian telescope for the collection of LIP radiation, spectrometer Catalina EMU and EMCCD detector Raptor Falcon.
- Modular LIBS interaction chamber was developed in the frame of Czech national grant project in cooperation with Tescan company (Czech Republic, focusing on electron microscopy). This interaction chamber is a suitable expansion of conventional table-top LIBS system enabling precise positioning of the sample, measurement in vacuum conditions and atmospheres of He, Ar, N and CO_2, optimized collection optics and special software for analysis of detected spectra.
- Despite the LIBS interaction chamber, the table- top LIBS system at CEITEC consists of high energy Nd:YAG solid state lasers Quantell Brilliant B, Solar LQ-529a and tunable Ti:Sa laser Solar Carat LX-325 (utilized for LIFS analysis), spectrometers Andor Mechelle 5000 and (echelle configuration), Lot Oriel 260 (Czerny-Turner configuration), ICCD detector Andor iStar, ICCD detector Princeton Instruments Pi-MAX3 and ICCD Jobin Yvon Horiba.

Left: LIBS interaction chamber, right: rLIBS device.

Laboratory can also offer the comparative measurement by the Laser Ablation - Inductively Coupled Plasma - Mass Spectrometry (LA-ICP-MS) technique in the collaborating laboratory at the Department of Analytical Chemistry at Masaryk University (Brno, Czech Republic).

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