

Theory and Instrumentation for LIXS

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Laser ablation (LA) is a spatially resolved technique enabling fast sampling of any kind of matrix without sample preparation. Laser-induced breakdown spectroscopy (LIBS) is a rapid in-situ microanalytical technique. However, it has reached its maturity due to the poor precision that is caused by the plasma expansion. The ability to measure important elements such as H, C, N, O or Li, Be, B, F, P, Cl, makes laser-induced breakdown spectroscopy (LIBS) complementary to established laboratory techniques such as X-ray Fluorescence spectroscopy (XRF) or Laser

Ablation ICP-MS (LA-ICP-MS). LA-ICP-MS is very sensitive for quantitative analysis, while XRF is extremely specific and precise with calibration-free quantification. LIBS, while poorer on the target analysis, offers a substantial potential for non-target qualitative analysis, if precision and specificity would improve consistency. Although LIBS has the unique advantage to be operable in situ, i.e. in the field and/or in a low-pressure environment for space exploration, its susceptibility to the conditions limits its impact for heterogeneous materials.

Laser-induced XUV spectroscopy (LIXS), similarly to LIBS, collects the stable plasma emission in the extreme ultraviolet. LIXS signal is generated from the early hot and dense laser-plasma, giving selective prevalence to ion lines. These make the spectrum cleaner, stable and intense, with modest noise. The information capacity of a XUV spectrometer is shown to be quadratically increased.

Specific electron-ion processes in the LIXS plasma are discussed, showing how LIXS improves the limits of detection and the precision. A higher precision means the capability to spot trace heterogeneities in materials. The generation of a LIXS spectrum requires a high-fluence laser pulse, and a vacuum spectrometer for the short wavelength. The degraded resolving power at shorter wavelengths makes it generally difficult to collect a non-distorted (stigmatic) spectrum below 100 nm. We have addressed this technical challenge by using a flat-field corrected grating. The application of LIXS to characterize the heterogeneity of energy and valuable materials is discussed. Furthermore, we have hints that the LIXS signal can resolve the oxidation state of target analytes. This is important in solid microanalysis. The sensitivity to halogen and light elements makes LIXS a promising method. The occurrence of UTA spectral features is addressed by means of chemometrical data analysis.

