Analysis of geological samples by laser-induced breakdown spectroscopy at low atmospheric pressures

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Abstract

Several future space missions to planets, moons and asteroids in the solar system consider landers equipped with a laser-induced breakdown spectroscopy (LIBS) instrument. This technique provides an in-situ elemental analysis of all major and many trace elements on surfaces of the solar system bodies by identification of particular atomic transitions in emission spectra of laser-induced plasmas. Excitation and evolution of the plasma depends strongly on the environmental pressure [1]. Therefore, the capability of LIBS is studied for each individual space mission. We focus on LIBS at ultra-high vacuum for exploration of solar system bodies with thin atmospheres and demonstrate its usefulness at a pressure >1 mPa and with a laser excitation energy >1 mJ.

LIBS at ultra-low pressure

At low pressures, excited plasmas have smaller plumes and expand rapidly. To overcome these limitations one requires usually a relatively powerful laser source for plasma generation [1-3]. We focused on the study of LIBS emission spectra with a miniaturized low-energy laser (Nd:YLF, 1053 nm, 2.7 mJ, 2 ns), developed for future planetary missions. We used several basaltic rock and sediment standard materials first crashed into powder and then pressed into pellets. Despite a significant reduction of the number of observed atomic lines at pressures <1 mPa, the excitation energy of ~1 mJ from the laser (power density on the sample ~20 MW/mm²) remains sufficient for plasma generation with detectable atomic emission lines (Fig. 1) of elements with relative weight abundance above 10⁻³. Reduction of pressure and broadening of spectral lines compensates partly the decrease in signal-to-noise ratios for light elements and doublet/triplet atomic transitions.

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References

