Influence of the experimental geometry on LIBS efficiency for in-situ planetary measurements

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Inherent features of Laser Induced Breakdown Spectroscopy (LIBS), such as fast in-situ determination of the rich elemental composition of materials, high lateral resolution and depth profiling, have been considered for the development of miniaturized LIBS instruments for the next planetary missions to Mars[1], Europa [2] and the Earth's moon[3]. Due to the strict mass limitations, the laser for plasma excitation will provide not more than a few mJ per a few ns radiation pulses. Remote LIBS analysis implies that preparation of rock materials is not possible and that changing local atmospheric and radiation conditions have to be taken into account. For the interpretation of planetary LIBS data it is therefore mandatory to study in detail the experimental conditions which may occur on a planetary surface.

We have investigated analogues of Martian rocks under Martian conditions using two infrared lasers for plasma excitation. Martian atmospheric conditions have been simulated in a dedicated experimental chamber. When a conventional Nd:YAG laser (1064 nm, 220 mJ per 8ns pulse and repetition rate of 10 Hz) was used, the angle between the excitation and plasma light collection directions was ~5°. For the planetary prototype instrument a Nd:YAG laser was developed by the Laser Zentrum Hannover (1064 nm, 2 mJ per 2 ns pulse and repetition rate of 14 Hz) and installed at the simulation chamber. The excitation and observation directions formed an angle of ~15°. The investigated probes were either naturally shaped rocks (volcanic lava stone from Etna, Sicily, Italy) or pressed powder pellets of the same rock material, as well as plane-polished andesite SRM rock samples. We have measured the LIBS plasma intensity as function of the incident angle to the probe with a flat surface, as well as lateral scans over the surface of natural stone in comparison with the same for the pressed sample with a flat surface. Additionally, the dependence of the LIBS signal intensity on the defocusing of the laser output beam waist relative to the probe surface has been investigated. Plasma temperature dependences were analyzed for different experimental conditions.

We have found the significant tolerance (up to ± 5 mm) of the LIBS plasma emission for the laser defocusing in the case of relatively large depth of focus and small angles between excitation and plasma collection directions[4]. Plasma intensity ceases with increasing of this angle, as well as for the tilted probe. Up to 80 % modulation of the LIBS intensity has been found in the lateral scans on the natural volcanic rock.

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[1] See the ESA's homepage for the AURORA ExoMars mission: http://www.esa.int/SPECIALS/Aurora/SEM1NVZKQAD_0.html

[2] E. K. Jessberger, I. Rauschenbach, H. Henkel, S. Klinkner, H.-W. Hübers and S. G. Pavlov, in the Abstract book of *the Int. Workshop „Europa Lander: science goals and experiments“,* Moscow, Space Research Institute, 9-13 February 2009 (2009) 39.

[3] I. Rauschenbach, E. K. Jessberger, H. Henkel, S. Klinkner, H.-W. Hübers and S. G. Pavlov, in the Abstract book of *the Symposium “Lunar Base“,* Kaiserslautern, Fraunhoferzentrum, 12-13 March 2009 (2009) 16.

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