A Miniaturized Laser-Ablation Mass Spectrometer Designed for In-Situ Measurements on Planetary Space Missions

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The in-situ analysis of extraterrestrial material onboard planetary rovers and landers is of considerable interest for future planetary space missions. With spectroscopic instruments, e.g. α-particle X-ray spectrometers, γ-ray spectrometer, flown on previous spacecrafts it was due to their low detection sensitivity only possible to measure major elements and no isotopes in solid state material. However, for the further understanding in the formation and evolution of solids in our planetary system a deeper investigation into minor and trace elements is essential. High accuracy and sensitive measurements on bio-relevant trace elements, i.e., sulphur or phosphorus and others, play an important role in the field of astrobiology. Anomalies in isotopic pattern of bio-relevant elements found on planetary surfaces can be useful for the identification of possible past and present extraterrestrial life. Age dating of solids can be achieved by a detailed analysis of isotopic pattern of radiogenic elements.

In this respect our group has designed a self-optimizing miniaturized laser ablation time-of-flight mass spectrometer (LMS) of reflectron type for future space applications. An Nd:YAG laser with 266nm wavelength, pulse length of 3ns and a repetition rate of 20Hz is used to ablate surface material. The beam is focused within 20µm onto the sample and more than 100 GW/cm2 can be achieved. The instrument with a length of only 120 mm, a diameter of 60 mm and a weight of about 500gr (all electronics included) has with a typical resolution of

m/Δm~600 and the high dynamic range of about 107 a similar performance than large laboratory systems. Furthermore, the more than ten voltages applied on the instrument and the laser fluence are computer optimized by using a self-written software based on a swarm, scanning algorithms respectively. High accuracy, sensitive, and reproducibility measurements in sub-ppm range are therefore possible.