Towards detection of life in space exploration missions by using a miniature laser ablation ionization mass spectrometer

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Since decades humankind sends spacecraft with high-tech instrumentation to Solar System objects, such as moons, planets and asteroids, to answer the question if there is any extinct or extant sign of life beyond Earth. However, until now, and starting with the first Viking landers on Mars in the 1970´s, no space mission was successful. This is partly due to the lack of adequate technologies and measurement techniques. Therefore, further improvement of current space instrumentation, development of new measurement protocols and advanced sample handling is of considerable interest for future space missions. In this contribution we present our recent advances in direction of Astrobiology by using our miniature laser ablation ionization reflectron-type time-of-flight mass spectrometer (60 mm x 160 mm, detection sensitivity down to 10 ppb, dynamic range of more than eight orders of magnitude) designed for in situ planetary research [1, 2]. A new developed measurement protocol [3], which will be presented and discussed in detail, allows us to investigate highly heterogeneous solid sample materials with a high lateral (~15 µm) and vertical (sub-nanometer) resolution, providing a fully 3D investigation of the chemical composition of the analyzed sample. The measurements were conducted using a fs-laser ablation ion source (λ = 775 nm, pulse width of ~190 fs, pulse energies < 10 µJ) which allows for stoichiometric ion production of the ablated surface layers [1]. High precision multilayer samples, produced by processes used in the semiconductor industry, were used for the development of the new measurement protocol and calibration of the ablation rate [3]. Various sample materials, including e.g., alloys, heterogeneous mineralogical samples, or micrometer-sized fossils embedded in a host matrix [2], were investigated in detail. Our measurement procedure provides quantitative 3D chemical analysis and allows detailed insights into the chemical composition of the sample.

***[1]** A. Riedo et al., "Coupling of LMS with a fs-laser ablation ion source: elemental and isotope composition measurements", J. Anal. At. Spectrom., 2013, 28, 1256 – 1269.* ***[2]** M. Tulej et al., "Chemical Composition of Micrometer-Sized Filaments in an Aragonite Host by a Miniature Laser Ablation/Ionization Mass Spectrometer", Astrobio., 2015, doi: 10.1089/ast.2015.1304.* ***[3]** V. Grimaudo et al., "High-Resolution Chemical Depth Profiling of Solid Material Using a Miniature Laser Ablation/Ionization Mass Spectrometer", Anal. Chem., 2015, 87, 2037 – 2041.*