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Chemical analysis of solid materials by a LIMS instrument designed for space research: 2D elemental imaging, sub-nm depth profiling and molecular surface analysis

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Direct quantitative chemical analysis with high lateral and vertical resolution of solid materials is of prime importance for the development of a wide variety of research fields, including e.g., astrobiology, archeology, mineralogy, electronics, among many others. Nowadays, studies carried out by complementary state-of-the-art analytical techniques such as Auger Electron Spectroscopy (AES), X-ray Photoelectron Spectroscopy (XPS), Secondary Ion Mass Spectrometry (SIMS), Glow Discharge Time-of-Flight Mass Spectrometry (GD-TOF-MS) or Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) provide extensive insight into the chemical composition and allow for a deep understanding of processes that might have fashioned the outmost layers of an analyte due to its interaction with the surrounding environment. Nonetheless, these investigations typically employ equipment that is not suitable for implementation on spacecraft, where requirements concerning weight, size and power consumption are very strict.
In recent years Laser Ablation/Ionization Mass Spectrometry (LIMS) has re-emerged as a powerful analytical technique suitable not only for laboratory but also for space applications.[1-3] Its improved performance and measurement capabilities result from the use of cutting edge ultra-short femtosecond laser sources, improved vacuum technology and fast electronics. Because of its ultimate compactness, simplicity and robustness it has already proven to be a very suitable analytical tool for elemental and isotope investigations in space research.[4] In this contribution we demonstrate extended capabilities of our LMS instrument by means of three case studies: i) 2D chemical imaging performed on an Allende meteorite sample,[5] ii) depth profiling with unprecedented sub-nm vertical resolution on Cu electrodeposited interconnects[6,7] and iii) preliminary molecular desorption of polymers without assistance of matrix or functionalized substrates.[8] On the whole, these results prove the adequacy of LMS as a powerful analytical tool able to address a great variety of topics in in situ space research.

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