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A miniature laser ablation time-of-flight mass spectrometer for sub-ppm analysis of planetary surfaces: performance studies

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Mass spectrometers are important part of the instrumentation used in space research for studying of chemical composition of gaseous media. Recently, a few of miniaturized time of flight mass spectrometers based on laser ablation ion source have been developed for a direct analysis of the chemical composition of solid of solar bodies.[Rohner, et al. 2003] In this number, LASMA instrument will be used in PHOBOS sample return mission launched in October 2011.[Managadze et al., 2010] The laser ablation mass spectrometry is a well accepted method for the acquisition of elemental and isotopic composition of solid materials. The instrument offer rapid analysis of the entire elemental and isotopic composition of well spatially resolved sections of the surface (10-20 mm). High spatial resolution provides opportunities for in-depth profiling and microanalysis of grain-sized material.

We will demonstrate performance of a miniaturized laser ablation time-of-flight mass spectrometer (LA-TOF MS) developed in our group for measurements of elemental and molecular composition of planetary surfaces.[Rohner et al., 2003] The instrument is a small size reflectron-type time-of-flight mass spectrometer and can be used in both laser ablation and laser desorption modes providing possibilities for elemental (isotopic) and molecular analysis of the surface material with minimal sample manipulation and preparation.

The quantitative performance of our instrument was investigated using either UV (266 nm) or IR (1064 nm) laser beam for the ablation and ionization of NIST samples. Although the method can be considered as a quasi-quantitative for the measurements of heavier elements (amu>39), the quantitative detection of the lighter elements (e.g., C, P, S) is less accurate when IR laser beam is used for ablation. Nevertheless, from the measurements of elemental and isotopic composition of the NIST samples the detection limits of $\sim$1 ppm or lower could be determined.[Tulej et al., 2010] The isotopic fractionation effects are found to be negligible and the error of their determination is generally smaller than 1 %. Improvements of the quantitative performance is observed when UV beam is applied. In addition, clusters abundances observed in IR approach are considerable reduced. The measurements can be prepared with a high resolution (m/Dm) exceeding 800.

In studies of minerals and meteoritic materials, the elemental composition of major, minor and trace elements can be obtained together with their isotopic pattern proving that this approach can be powerful in the investigation of the composition of airless surfaces of asteroids, planets, and their moons on in situ and sample return missions. These information are of particular interest because it can be used to investigate the origin and evolution of the solar system.

References:

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