Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24197

Laser-Based Mass Spectrometry

BENJAMIN J. FARCY[1] AND RICARDO AREVALO JR.[2]

[1]University of Maryland, Department of Astronomy
[2]University of Maryland

Presenting Author: benjamin.j.farcy@nasa.gov

Laser-based methods of chemical analysis are routinely used in commercial and academic laboratories to characterize the elemental chemistry, isotopic composition, and organic inventory of solid materials in situ. Here, we provide a brief review of the fundamental physics behind laser microprocessing, including: photon-substrate coupling in geologic materials; ablation of the sample and generation of melt, vapor, and solid particulates; modes and efficiencies of atomization and ionization; and, laser-induced elemental fractionation (LIEF). Commonly employed laser-based analytical techniques are explored, with a particular focus on laser ablation (LA) inductively coupled plasma mass spectrometry (ICP-MS), laser desorption mass spectrometry (LDMS), and resonance ionization mass spectrometry (RIMS). Mass spectrometers that are typically interfaced to laser sources are discussed, including time-of-flight (TOF), quadrupole, sector field, ion trap, and Orbitrap analyzers.

We also discuss recent technological advances and emerging applications for laser-based mass spectrometry. The integration of multiple chemical sensors in hybrid instruments with only a single laser source, such as tandem laser ablation/laser-induced breakdown spectroscopy (LA/LIBS) or laser ablation split-stream (LASS) systems, facilitates access to multiple geochemical systems simultaneously. Femtosecond laser systems offer enhanced ionization efficiencies and attenuated LIEF through the production of smaller particle size distributions. Improvements in the washout times of laser ablation cells, coupled with the emergence of LA-ICP-TOF instruments, enable the construction of 2D maps and/or 3D images of sample composition with micron-scale lateral resolution and nm scale depth profiling. The miniaturization and ruggedization of key subsystems, including pulsed UV laser systems and low-power microwave-induced plasmas, are positioning laser-based mass spectrometry techniques for deployment in the field, both on Earth and on other planetary bodies.