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# In Situ Laser Desorption Mass Spectrometry (LDMS) for Constraining Planetary Composition

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Paradigms of planet formation and differentiation are built upon a large number of observation sets, including (but not limited to): orbital mechanics; hydrodynamic calculations and N-body simulations; geophysical evidence based on seismic waves, heat flow, magnetic fields, and/or gravity; and perhaps most importantly, compositional models that leverage empirical measurements and laboratory experiments. However, competing compositional models of the bulk silicate Earth, the most accessible part of the most accessible planet, refuse to converge (e.g., [1 – 4]). Restricted access to (and tenuous contextual information for) materials derived from the planet's deep interior (e.g., [5 – 6]) serves as a major limiting factor. Compositional models of Mercury [7], Venus [7], and Mars [8] remain even more poorly constrained given limited samples available for chemical analysis and low-resolution observations of the surface collected via remote sensing.

One promising way to boost our understanding of planetary systems is to characterize the chemistry of a wide range of surface materials, including samples sourced from depth (ideally), at higher spatial resolution than previously enabled by orbital observations. In the M-CLASS Laboratory, develop innovative laser desorption mass spectrometry (LDMS) protocols that enable in situ chemical analysis of diverse geological materials. We also build miniaturized LDMS instruments; our most compact design (an 8 kg package) integrates a small but high-power pulsed UV laser and an Orbitrap™ mass analyzer capable of achieving ultrahigh mass resolving powers ($m/\Delta m > 100{,}000$ at m/z 100, FWHM) and ppm-level mass accuracy [9]. Here, we will review the scientific reach of LDMS techniques, as demonstrated through measurements collected on both commercial and miniaturized instrument platforms.

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