# Soft X-ray Ablation Mass Spectrometry for Chemical Composition Imaging in Three Dimensions at the Nanoscale

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**Abstracts:** *We demonstrate three dimensional (3-D) molecular composition imaging of inorganic and organic samples by soft x-ray laser ablation mass spectrometry. The method has a lateral resolution of 75 nm and a depth resolution of 20 nm. Results of imaging of a single micro-organism will be presented. This novel nanoscale resolution analytical chemical imaging method has potential applications in materials research, biology and medicine.*

Analytical probes capable of mapping molecular composition in 3-D at the nanoscale will transform materials research, biology and medicine. Mass-spectral imaging (MSI) is one of the most powerful methods to visualize the spatial organization of multiple molecular components on solid samples. However, it is challenging for MSI to map molecular composition in 3-D with submicron resolution. We have recently demonstrated a new MSI method that combines soft x-ray laser ablation with mass spectrometry to obtain 3-D composition images with nanoscale resolution.[1] In soft x-ray laser ablation MSI, bright laser pulses from a compact 46.9-nm-wavelength laser[2] are focused into nanometer size spots to ablate craters a few nanometers deep on selected regions of the sample. Elemental and molecular ions in the laser-created plasma are extracted and identified by their mass-to-charge ratio (m/z) using a time-of-flight mass spectrometer. Analysis of the spatially resolved mass spectra obtained as the sample is displaced with respect to the focused laser beam enables one to construct 3-D composition images with nanoscale resolution. In this talk I will describe recent advances of soft x-ray MSI that show the unique capabilities of the method to identify low concentration actinides in glass matrices, efficient ionization in dielectrics and that is capable to map molecular composition of single micro-organisms in 3-D at the nanoscale. These first results open up attractive opportunities to visualize composition in biological systems with unparalleled spatial resolution.

1. I. Kuznetsov et al, "Three dimensional nanoscale molecular imaging by extreme ultraviolet laser ablation mass spectrometry, " Nature Communications, **6**, Article No. 6944(2015).

2. S. Heinbuch et al, "Demonstration of a desk-top size high repetition rate soft x-ray laser," Opt. Express **13**, 4050-4055 (2005).