Miniature Mass Spectrometer for Cometary Missions

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Mass spectrometry (MS) plays an instrumental role in many scientific space missions, such as investigation of the substances in comets to provide essential information about the nature of the universe. Comets carry interstellar and nebular materials that are pivotal to understanding the prebiotic molecules that could have initiated life on Earth. Since space missions are costly and provide limited launch opportunities, the miniaturization of scientific instruments for space applications is imperative to address the critical need to include more instruments and broader analytical capabilities in each mission. The objectives of the work presented here are to leverage MS miniaturization efforts at SRI and tailor/enhance the micro mass spectrometer (µ-MS) design and specifications for the exploration of chemical distributions in cometary bodies and comae.

We will discuss low-power µ-MS components, including a micro ion trap array and a broad-beam electron source with a ruggedized ion optics package. The silicon-based micro ion traps are implemented as a 4x4 array for higher sensitivity while targeting broader mass range (250 Da), lower capacitance, and maintained unit mass resolution of the collective ion signal across the array. The ion trap array, composed of micromachined ion traps (~r_0 325 µm), is operated in unison via a novel, broad-beam electron source for simultaneous ionization of analytes inside all traps in the array. Initial testing/optimization of the packaging strategy using photochemically etched stainless steel micro ion trap arrays indicates ultra-low-power (< 24 dbm) operation of ion traps and demonstrates operation of a 20-cc ion optics package with no electrical breakdown. We will discuss key challenges and solution paths to enhance the performance of the µ-MS required for cometary exploration.