Micro-ion Trap Mass Spectrometer for (pre)-biotic Organic Compound Analysis on Comets

Ashish Chaudhary[1], Friso Van Amerom[1], Timothy Short[1], Patrick Roman[2], William Brinckerhoff[3], Daniel Glavin[3], Paul Mahaffy[3]

[1]SRI International, St. Petersburg, Florida
[2]Florida International University
[3]NASA Goddard Space Flight Center, Greenbelt, MD

Comets are believed to be a mixture of interstellar and nebular material, and volatiles in comets are attributed to interstellar chemistry. Similar species of carbonaceous compounds are observed in ices in interstellar molecular (ISM) clouds. Comets are likely to be pristine reservoirs of primitive material and carbonaceous compounds in our solar system. They could be major contributors to the delivery of prebiotic organic compounds, from which life emerged through impacts on early Earth.

Mass spectrometers (MSs) are powerful tools for chemical analysis; when miniaturized, they are optimal for space applications. The goal of this work is to surpass current miniaturization of space-flight mass spectrometers by using MEMS technology to create a prototype MS based on micro-cylindrical ion trap (µ-CIT) array technology, as the next step toward the exploration of distributions of chemicals of astrobiological relevance in space.

We are using a microfabrication approach based on earlier work, in which ~ 60 micro-traps formed a closely packed hexagonal array in a silicon (Si) chip. Simulations were performed in SIMION to determine the optimum geometries for ring-electrode-to-endplate-electrode spacing. Deep reactive ion etching (DRIE) was used to etch cylindrical holes in the ring and endplate electrodes, and to etch a gap to create a stand-off structure, resulting in more space between the ring and endplate electrodes to reduce device capacitance and potential electrical breakdown. COMSOL was used to model the integrated µ-CIT array chip to confirm strategies to minimize capacitance. To operate all traps simultaneously, an ultraviolet-LED (UV-LED), coupled with micro-channel plates (MCPs), will be used as a broad-beam electron source in a fully packaged micro mass spectrometer assembly of ~ 20 cm^3. The shape of the µ-CIT array chip for this work was adjusted to fit a very small form-factor micro-ion trap MS assembly, with a miniature vacuum chamber (3 x 3 x 5 cm) to house the total MS assembly. The planned prototype MS assembly consists of a UV electron ionization source, a µ-CIT array chip, an MCP detector, and multi anodes to detect ions from each µ-CIT individually. Progress on the design, construction, and testing of the prototype MS will be presented.