A Microfabricated Cylindrical Ion Trap Array for Batch Production of Small Chemical Sensors

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Portable miniature mass spectrometers are in demand for continuous monitoring of field sites for hazardous chemicals. Toward this goal, microelectromechanical systems (MEMS) fabrication techniques allow for batch production of very small structures in silicon (Si) with a precision necessary for miniaturized mass spectrometer components. In this abstract, we report on our improved fabrication method for a 5 × 5 □-cylindrical ion trap (□-CIT) array in a 1 x 1 cm2 Si die, with ro of 360 □m and ratio zo/ro of 0.97. Preliminary mass spectral results are also presented.

Our initial approach to use two symmetrical half-CIT array structures in Si, bonded back-to-back, was modified to remove excess bulk Si in order to achieve lower capacitance, while maintaining conductive endplate surfaces to avoid surface charging. Several iterations of the fabrication process were carried out to optimize critical design parameters, such as thickness of the insulating SiO2 layer, thickness of the Si3N4 endplate layer and ring electrode verticality. The fabricated μ-CIT array was then tested in an ion trap mass spectrometer experimental test setup.

Ionization of analytes was performed using a rasterable electron gun to individually address each μ-CIT in the array. This allowed investigations of mass spectral shifts among the traps and relative changes in intensities of the ejected ions. Mass spectra of trichloroethylene and perfluorotributylamine were obtained from the μ-CIT array using the mass instability scan, with trapping voltage (Vrf) frequencies in the range of 5.5 to 6.5 MHz and amplitudes of 10 to 80 V for trapping and ejection of ions. Resulting (FWHM) peak widths were on the order of 4-5 Th. These initial results indicate the feasibility of using MEMS fabrication techniques for the production of miniature CIT mass spectrometers in Si. Future strategies will include further optimization of mass resolution and characterization of operation of all □-CITs together as an array.