MEMS Fabrication Techniques for Miniaturization of Cylindrical Ion Trap Arrays

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Increasing emphasis has been placed on detection of warfare agents and thus, the necessity to deploy small on-site sensors with the capability of real-time chemical analysis. Mass spectrometers have proven to be powerful, sensitive instruments for the detection of a wide range of hazardous and explosive chemicals. To develop small handheld, low-power mass spectrometers miniaturization of the associated components is crucial. Microfabrication provides techniques to build integrated miniature 3-d structures for high precision, low cost mass analyzers.

This research describes a novel microfabrication approach for arrays of miniature cylindrical ion traps in silicon substrates from two half structures that are bonded back to back. A layer of 3 to 8 um SiO_2 was grown on a 4" Si wafer followed by a deposition of a 3 um LPCVD Si_3N_4. On one side of the wafer, apertures were obtained in Si_3N_4 using photolithography and RIE. On the opposite side, holes with a radius corresponding to the cylinder electrode were obtained in Si_3N_4 and SiO_2, using photolithography and RIE. To obtain the cylinder electrode DRIE was applied to etch the Si through the wafer, exposing the SiO_2 under the aperture. A hanging Si_3N_4 membrane with a centered aperture was obtained by prolonged wet chemical etching of SiO_2. The prolonged etching also formed a recess in SiO_2 between the cylinder and membrane. Cr/Au was sputtered on both sides of the processed wafer to form conductive layers 1) on both sides of the Si_3N_4 membrane and 2) inside the cylinder in Si, to obtain the conductive electrodes. The recess prevented shortage of the conductive layer inside the cylinder with the conductive layers on the endplate membrane. Two half structures were bonded back to back in a flip chip bonder by Au thermal compression bonding.

The design included CIT's with r_0 ranging from 100 um to 350 um and the process flow was characterized for any size with only a slight adjustment of etching parameters for geometry optimization.