Ion Trapping in Microfabricated Ion Trap Arrays

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In this work we describe the microfabrication and testing of cylindrical ion trap arrays. The ion trap has become an essential tool in several areas of physical science, including mass spectrometry, atomic frequency standards, studies of fundamental quantum dynamics, and quantum information science. Many of these applications benefit from miniaturized ion traps at dimensions several orders of magnitude below the current centimeter and millimeter scale. Our design of the individual trap array element consists of two endcap electrodes, one ring electrode, and a detector/collector plate, fabricated in seven tungsten metal layers, by molding tungsten around SiO_2 features (0.5µm minimum dimension) using standard lithography and plasma etching techniques. Each layer of tungsten is then polished back in damascene fashion. The SiO_2 is removed using a standard MEMS release processes to realize a free-hung ion trap element. Common anchor points of adjacent elements allow for the entire array of traps to be operated in parallel.

Four different sized traps were fabricated with inner radius (r_0) of 1, 2, 5 and 10 µm and heights ranged from 3-24 µm. After release the traps were packaged using rf glass packages and electrical connections were made via wirebonds. We focused our testing on the 5-µm sized ion trap array to trap toluene (C_7H_8), mass 92 amu. We discerned the electrical characteristics of the packaged ion trap arrays through vector network analyzer measurements. We drove the traps using a 200 MHz sine wave with amplitude of ~4 $V_{0\text{-}P.}$ We ejected the ions by turning off the rf and noted a current insertion into the collector electrode. We were not able to fully determine that our signal was all due to trapped ions. However, we attained favorable trapping conditions; i.e. a significant pseudopotential well and an ionization rate twice the ion loss rate determined by simulation.

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