Microfabrication of Cylindrical Ion Trap Mass Spectrometer Arrays

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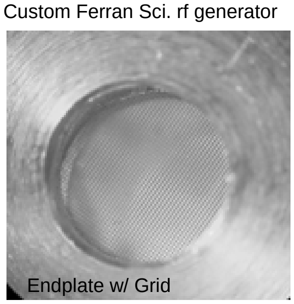
Recent interest in cylindrical ion trap (CIT) mass spectrometers[1-3] stems primarily from the ease with which the cylindrical geometry can be miniaturized and fabricated as compared to the hyperbolic surfaces found in conventional quadrupole ion trap mass spectrometers. Since the rf voltage needed to eject a given mass/charge ion scales as the square of the ion trap radius (r_0^2), a decrease in ion trap dimensions provides a significant reduction in electronics requirements, thereby providing a pathway for overall system miniaturization.

A drawback of ion trap miniaturization, however, is a severe reduction in sensitivity due to decreased ion storage capacity. Higher ion capacity can be achieved by assembling an array of identically sized CITs, thus improving overall sensitivity[4]. Key factors in optimizing the performance of CIT arrays are the uniformity of CIT dimensions (e.g., hole size and shape) and flatness of endplates and transmission grids (if used).

Microfabrication techniques can be used to provide excellent uniformity of holes and structures through, e.g., photolithography techniques and batch fabrication processes, leading to the possibility of low-cost high-performance CIT-array devices. We present progress in the design, fabrication and testing of CIT arrays using two separate microfabrication approaches. One approach involves deep reactive ion etching (DRIE) of silicon to form arrays of "ring electrode" holes and endplate structures. These structures will be "metallized" to create conducting surfaces and then bonded, with insulating layers between them, to form monolithic CIT array devices. A separate approach uses micro-electric discharge machining (µEDM) of metal plates to form the "ring electrode" and endplate structures, and subsequent bonding with insulating layers to form the CIT arrays. A key feature in both designs will be use of microfabricated endplates that provide high transmission rigid grid-structures for each CIT of the array. This construction should optimize electron and ion transmission into and out of the CIT, while providing high-quality electric field definition within each CIT.

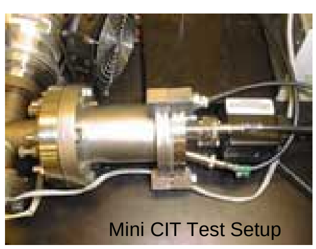
Mini CIT

Conventional Mini CIT
r_o = 2.0 mm
Ring Thickness = 3.48 mm
Gap = 0.125 mm
(%A4/A2 = 11.6)
Custom Ferran Sci. rf generator



Endplate w/ Grid

CIT Assembly



Mini CIT Test Setup

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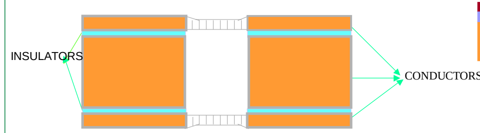
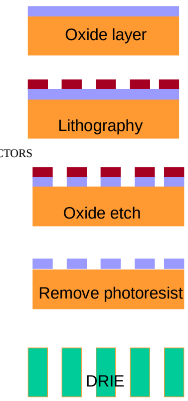
2. Oleg Kornienko, Peter T. A. Reilly, William B. Whitten, and J. Michael Ramsey, Review of Scientific Instruments, Vol. 70, No. 10, pp. 3907-3909, 1999.
3. Ethan R. Badman, Rudolph C. Johnson, Wolfgang R. Plass, and R. Graham Cooks, Analytical Chemistry, Vol. 70, No. 23, pp. 4896-4901, 1998.
4. Ethan R. Badman and R. Graham Cooks, Analytical Chemistry, Vol 72, No. 14, pp. 3291-3297, 2000.

ACKNOWLEDGEMENTS

Technical assistance from Ethan Badman, Richard Arkin and Said Boumsellek is gratefully acknowledged. Financial support for this project was provided by the U.S. Army, Space and Missile Defense Command to the University of South Florida through grant DASG60-00-C-0089.

Structure of Micro-Ion Trap

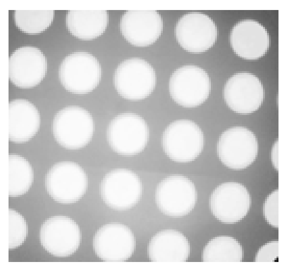




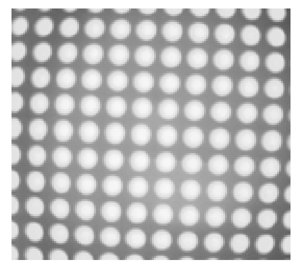
(or Porous Silicon)

Microfabrication Strategy
Ring electrode array plates and endcap plates will be etched (silicon), "metallized" (e.g., n+ diffusion), and bonded with an insulating layer (e.g., Cytop) between each conducting layer.

Masks for CIT Arrays

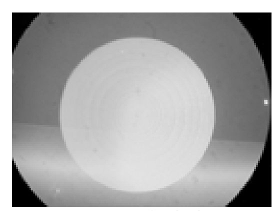


1600 micron thick wafer
1744 micron dia traps

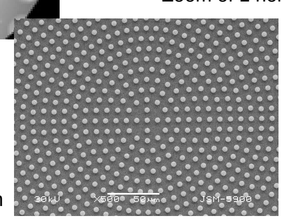


750 micron thick wafer
818 micron dia traps

Array of Endplate Grids
for 1744 micron traps



Zoom of 1 hole



SEM zoom

Micro-EDM Holes in Stainless Steel