doi: 10.1017/S1431927609098870
Microsc Microanal 15(Suppl 2), 2009

Development of a Micro Mass Spectrometer: Analysis of Particle Behavior in MEMS Ion Lens Systems

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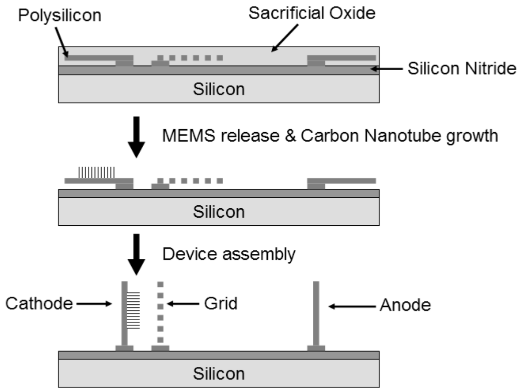
Utilizing microelectromechanical systems (MEMS) technology we have fabricated a variety of on-chip electrostatic ion lens systems for future integration into a micro mass spectrometer [Figure 1]. Our recent work has focused on the geometric optimization of designs for on-chip electron and ion sources. We extensively utilize the charged particle simulation program SIMION[1], both in the design phase, and in conjunction with testing and characterization of MEMS ion lens devices [Figure 2].

Our designs utilize iron catalyst multi-walled carbon nanotube (CNT) fibers bundled together to form cold cathode field emission electron sources and grown onto high voltage MEMS-platform electrostatic lens systems.[2,3] The electron sources consist of three MEMS electrodes (approx. 2 microns thick) arranged in the form of a triode electron gun with cathode to grid spacing of between 25 and 75 microns, and a grid to anode spacing of between 100 and 400 microns [Figures 3 & 4].

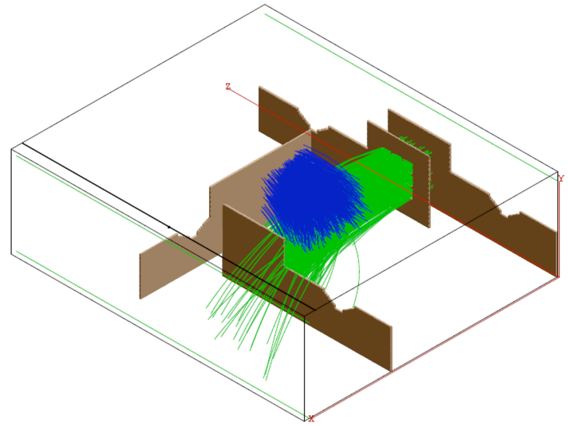
The MEMS electrodes are subsequently utilized as electrostatic ion lenses to control the flight paths and energies of the electrons. When the electrons are steered into a region containing a gaseous sample of interest, ionization events occur and the subsequently formed ions can also be steered into another region of interest in the form of a collimated or focused beam of ions [Figure 5].

Geometric lens optimization is critical for achieving adequate electron and ion currents for device applications. We are currently exploring a variety of geometries that we feel could optimize these parameters [Figure 6]. This work is an important aspect not only of our development of an on-chip "Micro Mass Spectrometer" (which should result in a total device size and power consumption reduction in mass spectrometry of more than two orders of magnitude) but also towards development of other future on-chip microanalytical devices.

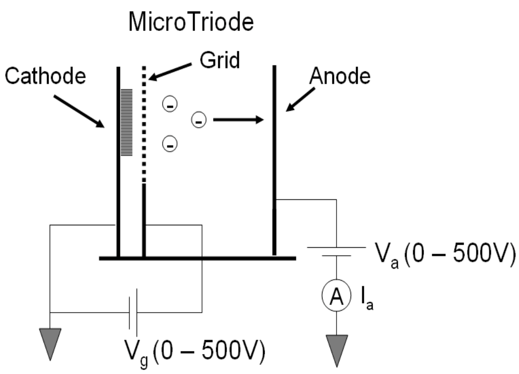
References:
[1] SIMION version 8.0.4 Scientific Instrument Services, Inc.
[2] High voltage MEMS-platform for on-chip vacuum electronic devices, S. Natarajan, J.R. Piascik, K.H. Gilchrist, C.A. Bower and B.R. Stoner, C.B. Parker and J.T. Glass, accepted for publication at Applied Physics Letters vol. 92
[3] On-chip electron-impact ion source using carbon nanotube field emitters, C.A. Bower, S. Natarajan, K.H. Gilchrist, J.R. Piascik and B.R. Stoner, C.B. Parker and J.T. Glass, Applied Physics Letters, 90, 124102 (2007)



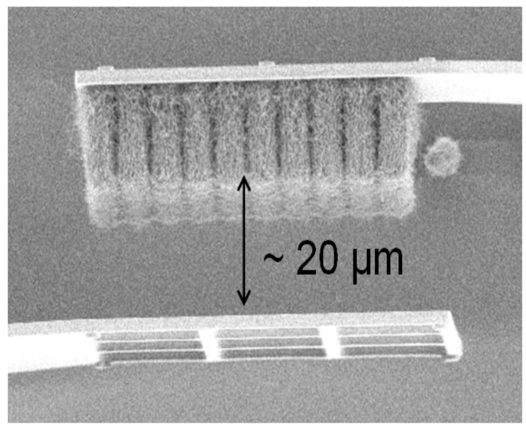
[Figure 1]



[Figure 2]



[Figure 3]



[Figure 4]

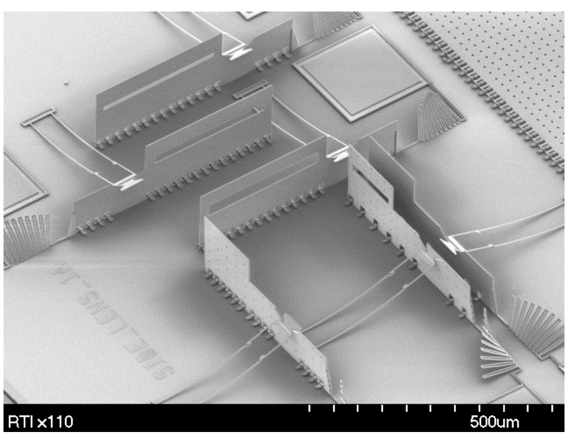
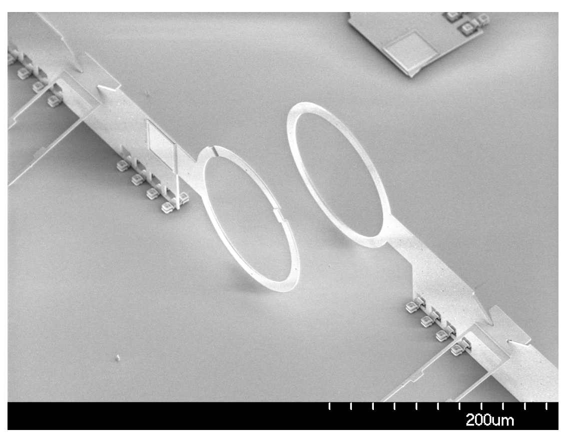


Figure 5]



[Figure 6]

[Figure 1] MEMS Electrode Fabrication Process
[Figure 2] SIMION 8.0 Simulation of 4-panel Ion Source
[Figure 3] Circuit Layout of Electron Source Triode Configuration
[Figure 4] SEM Micrograph of CNT Cold Cathode Field Emission Source
[Figure 5] SEM Micrograph of Ion Collimation Lenses
[Figure 6] SEM Micrograph of Circular Lens Geometry

https://doi.org/10.1017/S1431927609098870 Published online by Cambridge University Press