

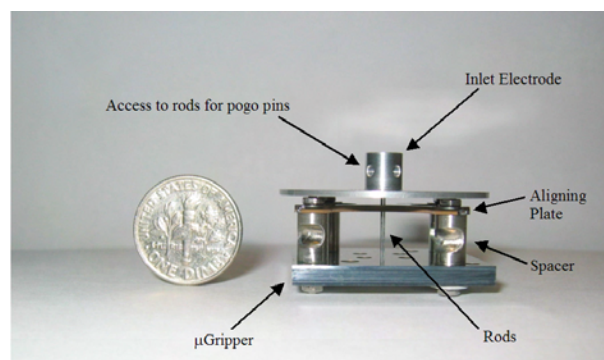
# A Versatile MEMS Quadrupole Platform for Portable Mass Spectrometry Using the First and Second Stability Regions

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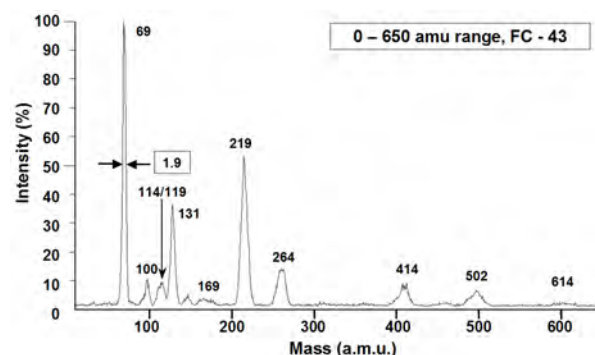
The Micro Gas Analyzer Program aims to develop portable, low-power, fast and low-false-alarm-rate gas analyzer technology for a wide range of applications. One of the subsystems of the gas analyzer is a mass filter. An array of micro-fabricated quadrupole mass filters is being developed for this purpose. The quadrupoles will sort out the ions based on their specific charges. Both high sensitivity and high resolution are needed over a wide range of ion masses, from 15 to 650 amu. In order to achieve this performance, multiple micro-fabricated quadrupoles, each operating at a specific stability region and mass range, are operated in parallel.

The proof-of-concept device is a single, linear quadrupole that has a micro-fabricated mounting head with meso-scaled DRIE-patterned springs. The mounting head allows micron-precision hand assembly of the quadrupole rods [1] –critical for good resolution and ion transmission. The micro-fabricated mounting head can implement quadrupoles with a wide range of aspect ratios for a given electrode diameter. The springs can be individually actuated using spring tip handlers. The current version of the spring-

head is able to interact with rods with diameters from 1588  $\mu\text{m}$  down to 250  $\mu\text{m}$ . The quadrupoles that have been implemented thus far span the aspect ratio range from 30 to 60. The choice of electrode diameter takes into account the dimensional uncertainties and alignment capabilities with respect to the expected resolution and transmission goals. Figure 1 shows an assembled MEMS quadrupole with 250-micrometer diameter rods. Figure 2 shows the experimental data of one of these quadrupoles using FC-43 as a calibration compound, where a mass resolution of 2 amu and a full mass range of 650 amu are demonstrated, while using a 1.44 MHz RF power supply to drive the quadrupole with a constant-width circuit made by the Extrel company (Pittsburgh, PA). To obtain better resolution, the MEMS quadrupoles have been driven with up to 4 MHz RF sources, resulting in 0.7 amu peak width. Also, the devices have been driven in the second stability regions to obtain 0.4 amu of peak width and smoother peaks. Current research efforts concentrate on developing RF power supplies of higher frequency and further exploration of the second stability region to obtain better performance.



▲ Figure 1: A micro-fabricated quadrupole with electrode diameter equal to 250 micrometers, near a dime for size comparison. The micro-fabricated part of the device is the square base, which contains a system of meso-scaled DRIE-patterned springs.



▲ Figure 2: Experimental characterization of a MEMS quadrupole, using the compound FC-43 to get peaks in the 1 – 650 amu mass range. The peak width is estimated at 2 amu, using a 1.44-MHz-RF-power supply. Peak widths as small as 0.4 amu have been obtained.

## REFERENCES

- [1] L.F. Velásquez-García and A.I. Akinwande, "Precision hand assembly of MEMS subsystems using DRIE-patterned deflection spring structures: An example of an out-of-plane substrate assembly," *Journal of MicroElectroMechanical Systems*, to be published.