

# First Principles Optimization of Mass-producible Microscaled Linear Quadrupoles for Operation in Higher Stability Regions

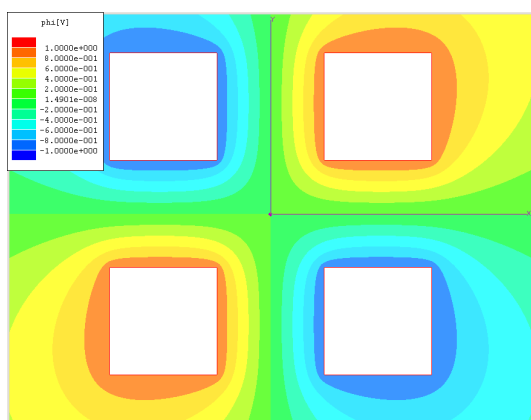
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Sponsorship: DARPA

In recent years, there has been a desire to scale down linear quadrupoles. The key advantages of this miniaturization are the portability it enables and the reduction of pump-power needed due to the relaxation on operational pressure. Various attempts at making microscaled linear quadrupoles met with varying degrees of success [1-2]. Producing these devices involved some combination of precision machining or microfabrication and downstream assembly. For miniature quadrupole mass filters to be mass-produced cheaply and efficiently, manual assembly should be removed from the process.

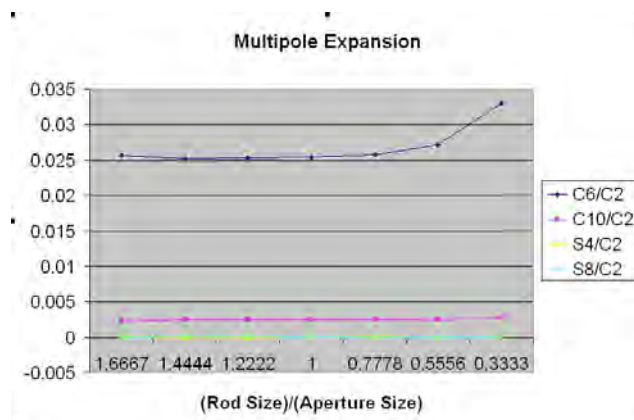
A purely microfabricated quadrupole mass filter comprising a planar design and a rectangular electrode geometry is proposed. Quadrupole resolution is inversely-proportional to the square of the electrode length, thus favoring a planar design since electrodes can be made quite long. Rectangular rods are considered since that is the most amenable geometric shape for planar microfabrication. This deviation from the conventional round rod geometry calls for optimization and analysis. Electrode designs were parameterized, and the potential fields were solved using Maxwell

3D (Figure 1). The fields were decomposed using a multipole expansion to examine the higher-order coefficients (Figure 2). This process was used to minimize the significant high-order terms, thus optimizing the design and determining the ultimate limitations of the device.

Higher-order field contributions arising from geometric non-idealities lead to non-linear resonances. These resonances manifest as peak splitting that is typically observed in quadrupole mass spectra. Reported work involving linear quadrupoles operated in the second stability region show improved peak shape without these splits [3]. It is believed that operating the device in the second stability region will provide a means to overcome the non-linear resonances introduced by the square electrode geometry. This study was conducted to justify a fully microfabricated, mass-producible, MEMS linear quadrupole mass filter. Successful implementation of such devices will lead into arrayed configurations for parallel analysis and aligned quadrupoles operated in tandem for enhanced resolution.



▲ Figure 1: Potential field solution generated by Maxwell 3D using a rectangular electrode geometry. Geometries were parameterized and solved.



▲ Figure 2: Dependence of the coefficients derived from a multipole expansion on the ratio of rod size to aperture size. The C2 refers to an ideal quadrupole field.

## REFERENCES

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