A Micro-fabricated Quadruple Mass Spectrometer

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Micro-fabrication techniques can be used to create sub-millimeter features with high precision and are well suited for mass production. The goal of the development effort described here is the creation of a micro-scale mass filter for use in a field deployable instrument. Potential advantages of a micro-machined mass spectrometer are high pressure operation (10^{-2} Torr), high-g impact-robust construction, and reduced instrument mass and volume. Disadvantages of a micro quadruple mass spectrometer are the power associated with high frequency operation (up to 40 MHz) and a reduced mass range and resolution . In order to achieve performance of even marginal utility from a micro-quadrupole mass spectrometer, tolerances on critical dimensions must be held to better than 1 %, and preferably to better than 0.1 o/o. Maintaining 10/0 tolerances is the central challenge to the design and fabrication of a micro-q uadrupole instrument, and the primary focus of our research efforts thus far.

A serious draw back of small quadruple designs is the reduced beam aperture area which decreases in proportion to the square of the pole length. The reduced ion current which results can be overcome by running an array of quadruples in parallel. A design for a mass spectrometer based on a parallel array was proposed by Paul', and was first applied **in a miniature instrument** by **Ferran.[2] A similar device of comparable** size **has been recently developed at** JPL[3]. The scale of a micro-fabricated quadruple is an order of magnitude smaller than these centimeter size devices.

We have designed and assembled several quadruple structures using two different micro-machining methods. The designs are intended to test the feasibility of fabricating and operating sub-millimeter quadruples, and it is expected that the final design for a working micro-mass spectrometer will incorporate a two-dimensional quadruple array. The LIGA process uses masked X-rays and selective etching to produce a mold in acrylic which is then filled by electroforming to create high precision metal structures. A linear array of nine nickel quadruples was created with LIGA. Each quadruple is 2.5 mm tall and has a 100 micron radius. (Fig.1). Wire electro-discharge machining (EDM) was used to create a single 6 mm tall quadruple structure with a 200 micron radius. (Fig. 2)

1) Paul, W., Reinhard, H. and Zahn, U.v. "Das Elektrische Massenfilter als Massenspektrometer und Isotopentrenner" Z. Physik, Bd. 152, p.148 1958
2) Ferran, R. and Boumsellek, S. "High-pressure effects in miniature arrays of quadruple analyzers for residual gas analysis from 10^{-9} to 10^{-2} Torr"
J. Vat. Sci. Tech. A 14(3) p1258 1996
3) Orient, O., Chutjian, A. and Garkanian, V. "Miniature, high resolution, quadruple mass spectrometer array" Rev, Sci. Instrum. 68(3) p.1393 1997

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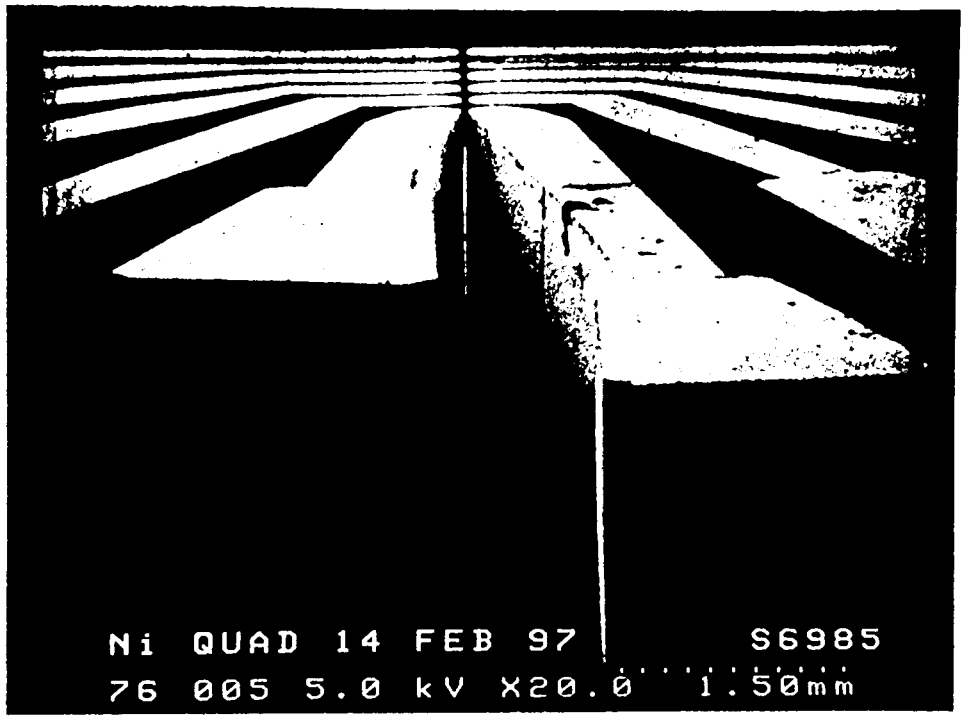
Ni QUAD 14 FEB 97 S6985
76 005 5.0 kV X20.0 1.50mm

Fig. 1

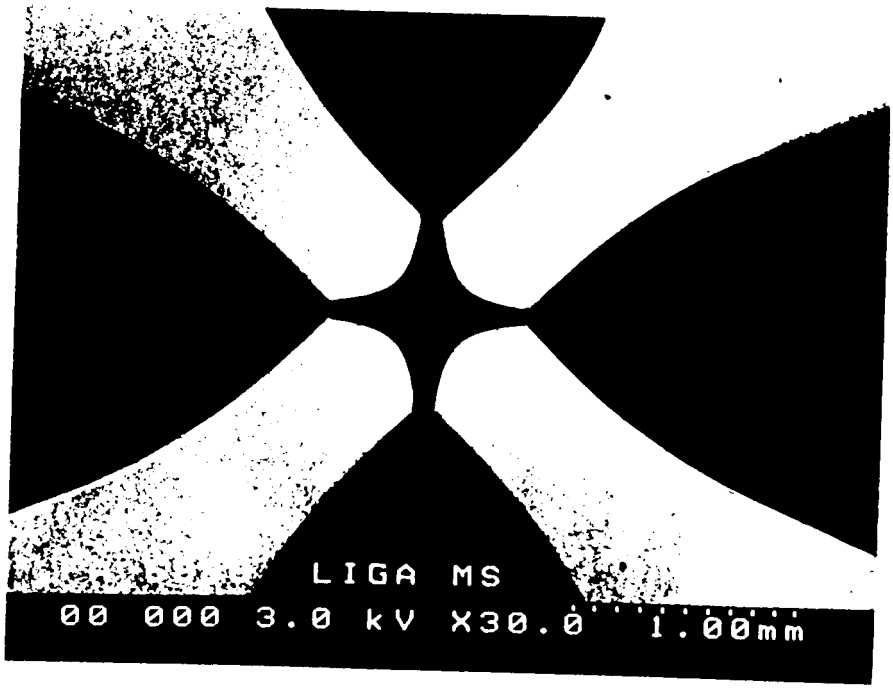
LIGA MS
00 000 3.0 kV X30.0 1.00mm

Fig. 2