Microscale Ion Traps: 2-Dimensional Arrays

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Experiments with ion traps with r_0 and z_0 of submillimeter dimension for mass spectrometry have achieved spectral linewidths of 0.2 Da or better for single mass scans of the trapped ions. Both laser ionization and electron impact ionization have been used, with either thermionic or field emission sources for the latter. The field emission electron source was a 2-mm diameter array of diamond-coated silicon whiskers, spaced 100 μm apart on a square grid. The substrate was a 1-cm square silicon wafer. A fine nickel mesh at ground potential served as a counter electrode. The ion trap ring electrode for most of the experiments was a stainless steel plate 0.9 mm in thickness with a 1.0-mm diameter hole. End cap electrodes were also stainless steel plates thinned in the central region with an axial hole of 0.4 mm diameter for passage of the ionization electron beam and for ion egress. Mica spacers were used for electrical insulation. For some of the laser ionization experiments, mesh end cap electrodes were used. The traps were typically operated with the end caps grounded and a radiofrequency voltage applied to the ring electrode. Mass spectra of the trapped ions were obtained by ramping the ring electrode voltage amplitude, with ejected ions detected by a Channeltron electron multiplier. Performance was not noticeably improved by adding axial modulation fields via the endcap electrodes, probably because the number of trapped ions was well below the space-charge limit.

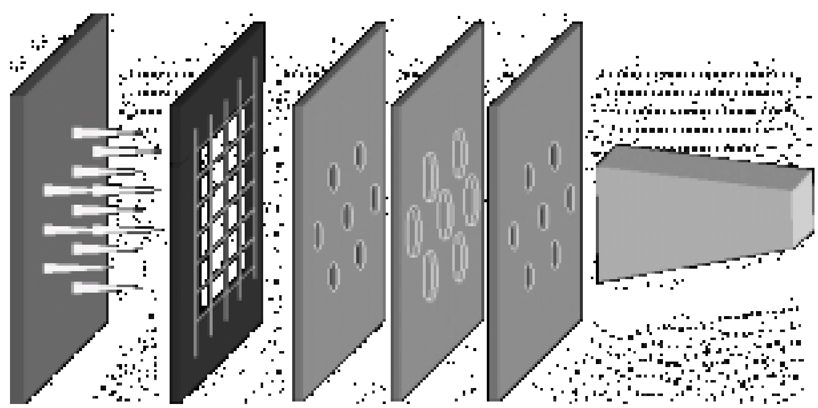

Fig. 1. Diagram of 2-dimensional ion trap array .

The planar geometry of the silicon whisker field emission electron source is compatible with a two-dimensional array of ion traps. We have fabricated an array of 7 traps by drilling 7 1-mm holes in a stainless steel plate in a close-packed array and with matching end cap electrodes. A diagram of the entire assembly is shown in Fig. 1. A single Channeltron detector was used to collect ions from all of the traps. The ion traps fabricated in this way were operated in parallel with essentially identical internal fields.

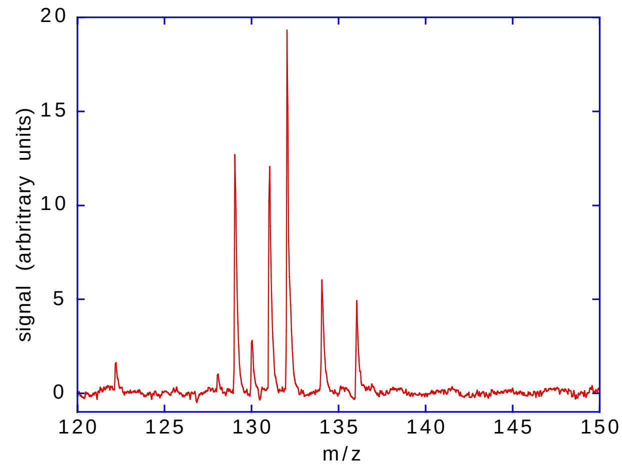

Fig. 2. Mass spectrum of xenon with 7-trap array

A mass spectrum of xenon gas obtained with the 7-hole ion trap array is shown in Fig. 2. The major isotopic ion peaks are clearly resolved in this single scan spectrum. These measurements were made with a higher detector time constant than for the single trap experiments so it is not possible to directly compare the mass resolution of the two configurations. However, the leading edge of the peaks in Fig. 2 is comparable in slope to the earlier measurements suggesting that the resolution for the array is not appreciably degraded. The signal in Fig. 2 was approximately twice that obtained with the single hole trap. We would not expect to achieve the full 7X in signal because the whisker array did not completely overlap the end cap apertures. The experiment demonstrated that an array of traps can be used to increase the ion storage capacity and signal to-noise ratio of microscale ion trap mass spectrometers.

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