MINIATURE, HIGH RESOLUTION, QUADRUPOLE MASS SPECTROMETER ARRAY

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Miniature mass spectrometers find use in planetary-exploration missions where mass, volume and power are at a premium; and in the laboratory where experiments are often limited by sizes of vacuum chambers and pumps. Described herein is a miniature quadrupole mass spectrometer array (QMSA) in which the ionizer, rods, and detector regions were scaled downwards in size in such a way that mass range and resolution were not sacrificed, and the sensitivity was held comparable to that of its larger commercial cousins. The QMSA consists of 16 rods in a 4 × 4 array to form nine separate quadrupolar regions. Each rod is 25 mm long and 2 mm diameter. The ionizer is of a miniature Nier-type design, and the detector is a channel-type electron multiplier. The overall sensitivity to positive-ion detection is approximately 1×10^{12} counts/torr-sec. The demonstrated mass range is 1-300 amu, with a resolving power of $m/\Delta m = 600$. This corresponds to a resolution of 0.1-0.5 amu (FWHM). The entire unit is approximately 7 cm in length and 3 cm diameter, including separate shields around the rod array and the detector. Total system mass with shields is approximately 30 grams.[1] This system differs considerably from a commercial unit[2] in that the rods here are positioned to a 0.1% dimensional tolerance, all dielectric surfaces are shielded from electrons and ions, a Faraday cup or multiplier may be used as a detector, electrical contacts are rigidly attached without distorting the positional accuracy of the poles, and separate shields against stray photons, ions and electrons are provided around the quadrupole and detector regions.

To illustrate the low-mass and high-mass operation of the QMSA, Fig. 1 is a mass spectrum of a H_2-He mixture taken at a radio-frequency of 12.9 MHz. The resolution in the features is 0.1 and 0.2 u (FWHM), with the zero blast clearly separated from the m = 1 feature.

To illustrate the high-mass operation of the QMSA, Fig. 2 is a spectrum taken of C_6F_{12} (dodecafluorodimethylcyclobutane) with a molecular weight of 300 u. The operating frequency is 5.3 MHz, and the resolution at 300 u is 0.5 u, or $m/\Delta m = 600$.

Work is presently under way to increase the sensitivity of the system by redesign of the ionization-extraction section. Calculations are done in a full 3D geometry, with due regard to the space-charge loading of the ionizing electron beam.[3]

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References

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2. R. J. Ferran and S. Boumsellek, *J. Vac. Sci. Technol. A 14,* 1258 (1996).

3. M. Darrach, O. J. Orient, A. Chutjian, and V. Garkanian, unpublished results.

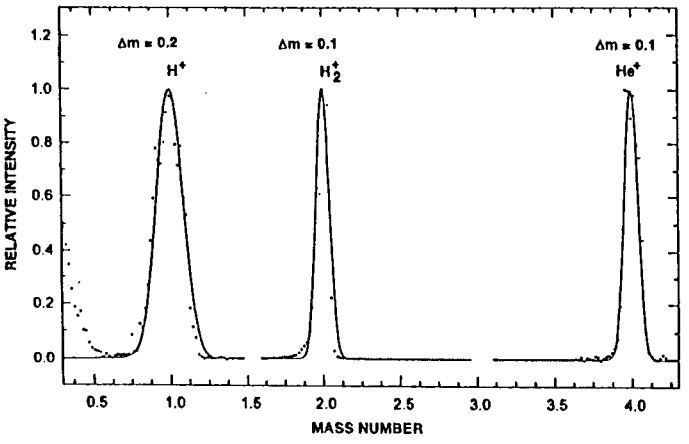

Figure 1. Spectrum of a H_2-He mixture. The rising portion toward zero mass is the zero blast.

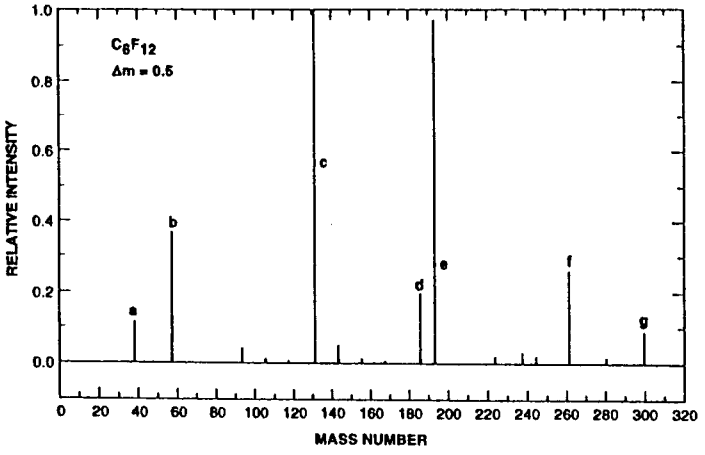

Figure 2. Mass spectrum of C_6F_{12}. Identification of the more intense features are: (a) F_2^+, (b) F_3^+, (c) $C_3F_5^+$, (d) $C_6F_6^+$, (e) $C_5F_7^+$, (f) $C_6F_{10}^+$, (g) $C_6F_{12}^+$.