A Fully Integrated Micro Mass Spectrometer

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Mass spectrometers (MS) are essential measurement tools for high precision chemical analysis. Presently available MS use mass separators with an ion path length in the range of 10cm. To prevent ion-ion collisions within the separator, the mean free path of the ions has to be larger than the dimension of the separator. To assure this, a vacuum pressure of 10^-2 Pa or less is required which is usually realized by a two-stage pumping system, e.g., a rotary roughing and a turbo pump. This pumping system contributes to the overall size and to the total cost of a MS.

A micro mass spectrometer (MMS) fabricated using microsystem technologies has several advantages. A mass separator length of about 2.5mm can be realized in MEMS as described in [1], so that the requirements for the vacuum are relaxed to pressures of about 1Pa. This pressure can be achieved by real micro vacuum pumps as described in [2]. Furthermore, the small dimensions ($<3cm^3$) of the MMS assure a low sample and carrier gas consumption and reduce the response time. Another advantage of the miniaturization is that high electric fields are achieved at low voltages, so the power consumption and supply complexity are reduced.

The MMS consists of five units which are an electron source, an ionization chamber, an ion optic, a mass separator and a secondary electron multiplier as detector. The sample gas is ionized in the ionization chamber by electron impact ionization. A high density electron beam ($1A/cm^2$) is provided by a micro plasma electron source, which generates a high density current of low energetic ions. Once the ions reach the extraction electrodes they are accelerated to a kinetic energy in the order of 100eV into the mass separator. A traveling dipole field (25MHz) is applied to the separation electrodes that affect the ions only perpendicular to the direction of the ion beam. Ions traveling at the same velocity as the dipole field will reach the integrated secondary electron multiplier where they initiate an electron multiplication. By varying the acceleration voltage for the ion beam a mass interval can be scanned. At a later stage mass flow control [3] and pressure monitoring [4] will also be integrated.

The entire system is mass producible and therefore very cost-efficient. Considering all advantages of a MMS it is predestined for mobile measurements, for portable applications as well as continuous process monitoring. Many further applications for the MMS, like emission monitoring, identification of CFCs, measurement of air contaminations for public authorities and rescue services, can be envisioned.

[1]G.Petzold et al.: "A micromachined mass spectrometer";
[2]M.Doms et al.: "A Micromachined Vapor Jet Pump";
[3]O.Krusemark et al. "Planares Membranventil in Mikrosystemtechnik";
[4] M. Doms et al."Micro pirani pressure sensor for atmospheric pressure"