MicroMS – New Electrostatic Resonator Ion Trap with Multiple Inductive Charge Detection for Mass Spectrometry

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Present day mass spectrometers are either bulky and come at very high costs or they lack mass resolving power. There is a substantial market potential for miniaturized, portable MS and new high resolution detectors with better mass range and linear dynamic range. The MicroMS MIP aims at developing a cost-efficient, small, high-resolution MS, based on CSEM ultra-low noise charge detection technology. Potential applications are point-of-care diagnostics, metabolic profiling, VOCs monitoring or identifications of toxins and pollutants in the environment.

High resolution mass spectrometry (MS) is a powerful tool to detect and identify chemical and biological compounds. Traditionally, it requires bulky, expensive equipment, and is therefore restricted to large laboratories. In addition, instruments are complex and require specially trained and qualified personnel. These drawbacks limit the penetration of MS into further markets such as point-of-care diagnostics. However, the compelling advantage of MS over other techniques is its intrinsic identification of chemical and biological entities, without requiring any markers or labels.

MicroMS aims at developing a miniature mass analyzer with high resolution detection, based on cost-efficient hybrid MEMS technology, without losing the resolving power of large MS.

Figure 1: 3D visualization of a portable MS based on the MicroMS analyzer and detector technology revealing the miniaturization potential.

The resonator-type MS is based on a purely electrostatic ion trap, that has been previously described[1], where ions oscillate between two isochronous reflectrons. The ion bunches flying by mirror charges on central pick-up electrodes that can be amplified and sent to the data acquisition system. The oscillation frequency is proportional to sqrt(z/m), with m and z being the ion's mass and charge and thus by performing *e.g.* a Fourier Transformation all masses of specific ions in the resonator can be revealed at once.

Due to CSEM core competencies in microtechnology and electronics this system can be miniaturized. In combination with CSEM patented ultra-low noise charge detection technology with single-electron detection capability at room temperature the system is able to detect a large range of masses with high dynamic range, *i.e.* from very low to high concentration and with high mass resolution.

First ion-optical simulations of the analyzer and electrical simulations of the charge detection and amplification circuit show promising results and reveal the geometric scaling potential.

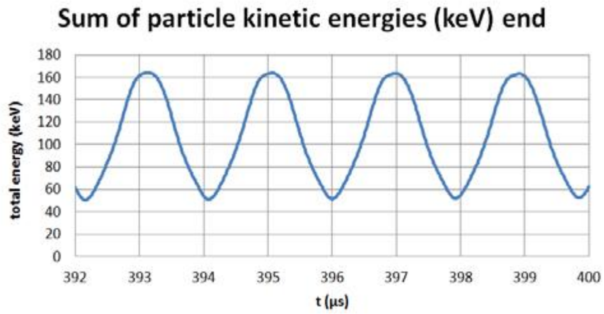

Figure 2: Sum of particle kinetic energies in the resonator taken from ion-optical simulations reveals stable oscillation of ions between isochronous mirrors.

For both high mass resolving power and cost-effective production, the detection electronics circuit is being fabricated using macro-MEMS hybrid technology combining CMOS based ASIC with sub-mm 3D pick-up structures.

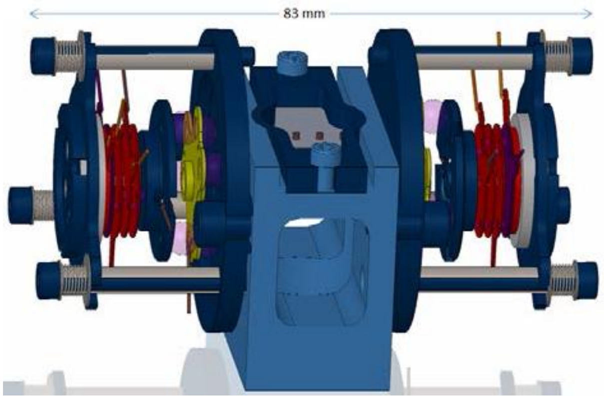

Figure 3: CAD of the <10 cm resonator with electrostatic mirrors on the left and right and the pick-up region in the middle.

The first technology demonstrator has a length of <10 cm and a discrete detection circuit bonded directly to the pick-up rings.

[1] D. Zajfman, et *al.*, "High resolution mass spectrometry using a linear electrostatic ion beam trap", Int. J. Mass. Spec. 229 (2003) 55