MS-MET–Integrated Inductive Charge Detection Sensor and Analyzer for Mass Spectrometry

D. Schmid, L. Hofer, M. K. Augustyniak, D. Z. Bayat, S. Bitterli, S. Grossmann, A. Hoogerwerf, I. Kjelberg, V. Revol, P.-F. Rüedi, G. Spinola Durante, S. Widmer

Mass spectrometry (MS) is a powerful analytical tool and the market is growing steadily. New components are needed to further push MS towards small, affordable but still powerful instruments. The MicroMS technology developed at CSEM provides nondestructive charge detection means (patent pending) together with a miniaturized standalone setup based on a linear electrostatic ion trap. Small, robust and high resolution instruments could profit from these elements in applications such as space, large molecules and nanoparticle identification, and ion mobility spectrometry.

Today's MS instruments are either powerful (high sensitivity, high resolution), but complex and delicate or small and robust, but lacking high resolution and versatility. Having a small and truly robust analyzer and detectors could be a game changer.

Existing commercial sensors fail to detect charges nondestructively, which would allow for higher mass resolution [1] or coupled further analysis of the ions, i.e. in sequential tandem-MS and they only work in ultra-low vacuum.

CSEM's MicroMS technology features a nondestructive low-noise charge detection sensor [2] (patent pending) and a test setup including a miniaturized 8-cm linear electrostatic ion trap [3], an electron impact storage ion source from Bern University's Space group, a 30 cm vacuum system with turbomolecular pump for fast evacuation (down to 10^{-9} mbar) as well as external data acquisition system (NI PXI) and custom developed data analysis algorithms.

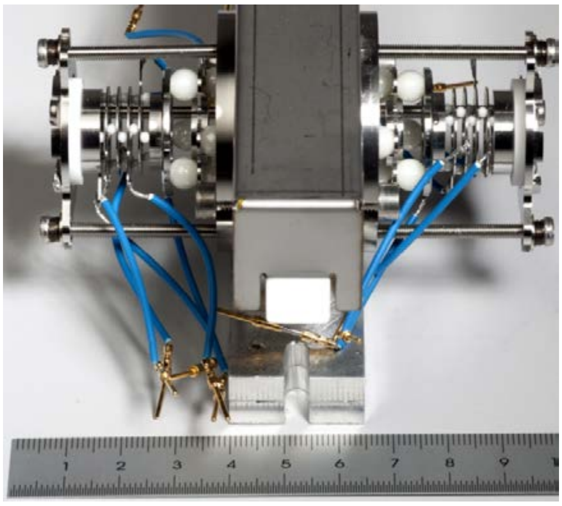

Figure 1: MicroMS linear electrostatic resonator, featuring the charge detection unit in the middle, covered by an electric shield.

The charge detection sensor features multiple independent inductive charge pick-up rings that can sense the mirror charge generated by ions flying through them. Thanks to CSEM's expertise in ultra-low noise charge detection technology, a new integrated sensor could be developed that does not suffer from noise limitations and with a limit of detection as low as 117 e^-, compared to a LoD 3'100 e^- for state-of-the-art solutions [4].

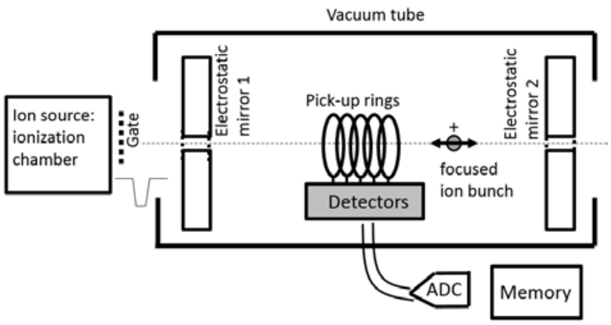

Figure 2: MicroMS linear electrostatic resonator, featuring the charge detection unit in the middle, covered by an electric shield.

Furthermore, the detectors don't' need cooling and even work at atmospheric pressure, thus application in ion mobility spectrometers or for large molecules detection with high background gas pressure is possible. The analyzer on the other hand is intrinsically robust and of low complexity and predestined for applications in harsh environment or space.

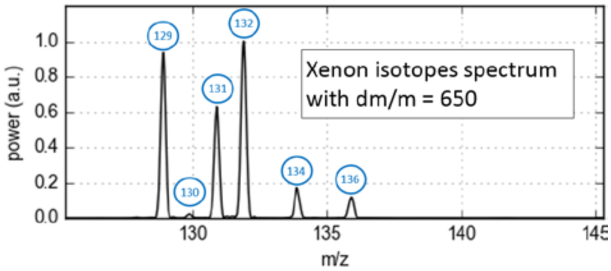

Figure 3: Measurement of Xenon, displaying the natural isotopes.

Feasibility was confirmed with this setup. Current results:

- Characterized with noble gas mixture (Ar, Xe), isotopes resolved
- Mass resolving power: 10^3 m/dm, expected to reach 10^4
- Limit of detection (10^3 extractions): 20 e^-
- Dynamic range: 10^4, potential to reach 10^6
- Mass range: not restricted (limited only by ion source)

As a next step, the MicroMS technology will be further developed to reach higher sensitivity, and will be characterized with various test environments (different ion sources, combination with GC and/or LC).

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

[2] M. K. Augustyniak, *et al.*, "Sensor Interface for a Resonator-type Mass Spectrometer", in this report, page 128.

[3] M. Dahan, *et al.*, "A new type of electrostatic ion trap for storage of fast ion beams", Rev. Sci. Instrum. 69, 1998.

[4] J. D. Alexander, *et al.*, "Determination of absolute ion yields from a MALDI source through calibration of an image-charge detector", Meas. Sci. Technol. 21 (2010).