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MEMS based device concept for future IMS instrumentation in breath research

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BACKGROUND

Biomarker detection is the key for new applications in medical diagnostics. Therefore, volatile organic compounds (VOCs) are interesting because they are easily accessible non-invasive from breath, urine or saliva. Low concentrations in the ppm to sub-ppb range and a large number of different analytes set high demands on the gas sensing instrumentation. Ion mobility spectrometry (IMS) seems to be a promising technique due to:

- High sensitivity and selectivity
- Portability and fast results within minutes
- Low-cost instrumentation and consumables

AIMS

- Development of a novel device platform for gas sensing in biomedicine and related areas
- Main component: a miniaturized IMS chip with FAIMS ion filter
- Development of methods for breath or head space analysis, sample preparation and gas transfer into IMS chip
- Adaptation of the device platform for specific applications together with industry partners

RESULTS

A miniaturized FAIMS chip with a unique design has been developed (Fig. 1). The chip includes the FAIMS ion filter and the ion detector with electrode gaps of a few 10 µm combined on one chip. This new device allows an easy modification of the geometric parameters of the filter and detector. Thus, it can be adapted towards the needs of a specific application.

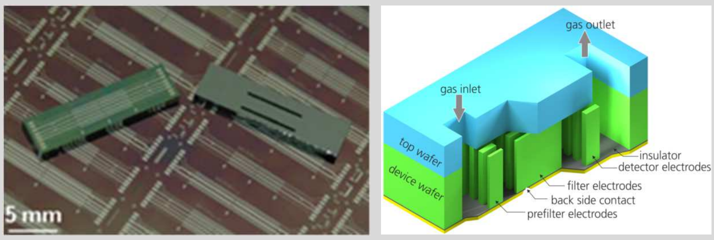
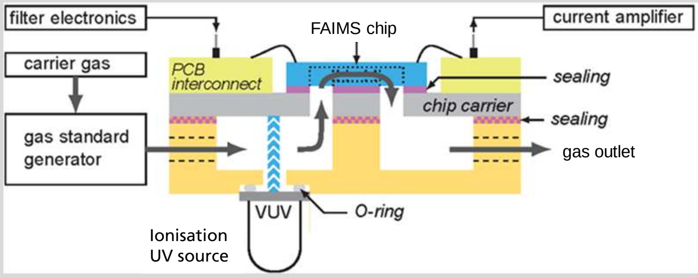


Fig. 1: FAIMS chip. Left: photograph. Right: schema. Filters were etched with deep reactive ion etching (DRIE). Silicondioxide (SiO_2) was used as electrical insulator between electrode structures. Every single electrode was contacted via special backside contacts.

Using this first generation FAIMS chip we built a proof of principle gas analyser according to Fig. 2. Analytes were ionised with UV light. Carrier gas was N_2. First of all, we tested the ion detector. The intensity of the detector signal was proportional to the concentration of our test gas acetone. This experiment showed



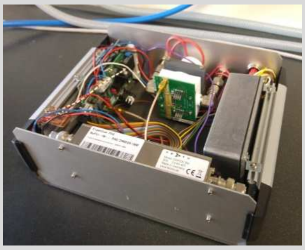


Fig. 2: Main components of our proof of principle gas analyser system with integrated FAIMS chip.

that the detector has a suitable sensitivity and repeatability in the range of at least 0.2 to 2.5 ppm. Subsequently, we tested the combination of ion filter and ion detector at low dispersion field strengths (5 kV/cm). As expected, the detector signal intensity is increasing with increasing concentration of the analyte (acetone, Fig. 3). Although the system shows a reasonable sensitivity the peak widths were unexpectedly large assuming a limited selectivity. This was even more pronounced at higher dispersion field strengths of 15 kV/cm (data not shown).

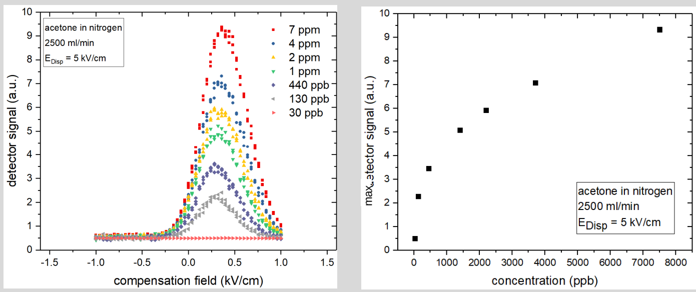


Fig 3: Ion filter and detector performance at low dispersion field strength.

CONCLUSION AND OUTLOOK

The achieved development level is a promising base for ongoing research. Currently, we are working on the second generation of FAIMS chips and improvement of the proof of principle gas analyser system. This system is expected to be a versatile platform that enables a customized adjustment for the use in biomedical applications. A typical application could be biomarker detection in breath for the diagnosis of cancer or infections. For this purpose we are looking for collaborators for future projects.

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