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Concept and first results of a miniaturized IMS chip with integrated DMS ion filter and detector

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Introduction and Aims

The detection of volatile organic compounds (VOCs) is of common interest in the field of biomedicine and environmental sensing. In these applications is a need for small sized systems that can detect harmful substances in the lower ppb concentration range. This requires highly sensitive and selective detection methods.

Ion mobility spectrometry (IMS) combined with microfabrication promises to be a good base for the development of handheld systems that allow the detection of single VOCs. The overall aim is the development of a chip device with an adaptable differential ion mobility (DMS) ion filter. Current measurements of the ion filter and the reached development status are presented.

Differential Ion Mobility Spectrometry DMS

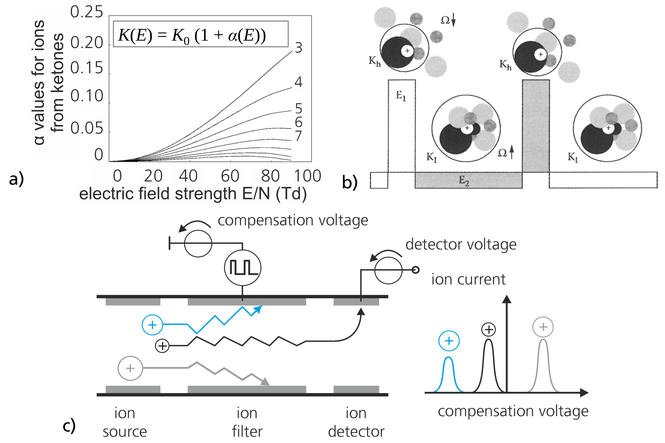

Fig. 1 - FAIMS basics
a) change of the alpha value for different ketones [1], b) de- and reclustering of ions during high and low field conditions [1] and
c) characteristic ion trajectories in the ion filter due to field dependent ion mobility K(E) and the resulting spectrum.

Concept of a miniaturized IMS chip and Setup

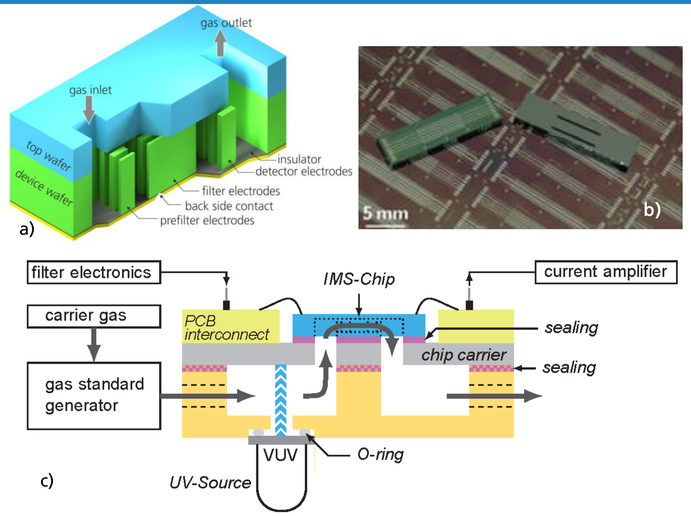

Fig. 2 - IMS chip with filter and detector and the used test setup, a) Chip concept, b) picture of the developed IMS chip, c) test setup with UV source for ionization.

Measurements and Results – Peak Width

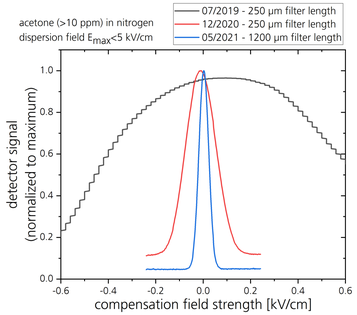

Fig. 3 – Peak widths of measured FAIMS spectra.

Measurements in 2019 showed very large peak widths. Modifications of the test setup and electrical parameters of the compensation voltage sweep resulted in a narrower peak width. The implemented change of the filter length also led to better results. This was an important step for demonstrating the basic functionality.

Measurements and Results – Peak Shift

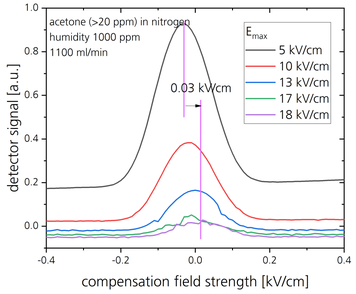

Fig. 4 – Measured spectra at different dispersion field strengths.

Measurements at different dispersion field strengths shows the characteristic peak shift in the DMS spectrum. The measured shift fits the expected data very well. The ion trajectories are simulated with given alpha values from the literature [2]. Due to the ongoing development of the electronic components the dispersion field strength was limited.

Conclusion and Outlook

The presented measurements show the state of development of the new miniaturized chip device. Next steps will be performed with an updated electronic. However, the shielding of the filter and detector stage is very demanding. This is an unique characteristic of the presented chip design. However, the reasons for the current voltage limitations are found and will be fixed in the next electronic setup. This will allow further measurements on the presented IMS-Chips with the longer filter length. It is expected that this step will enable the separation of a gas mixture. Thus an overall evaluation of the achieved level of development will be possible by the end of 2021.

Literature

[1] G. A. Eiceman et al., Ion Mobility Spectrometry, CRC Press, 2014

[2] M. A. Chavarría Varón, PhD Thesis, 2016, DOI: 10.5075/epfl-thesis-7128

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