Multi-mass microscope mode imaging mass spectrometry: Application of the Pixel Imaging Mass Spectrometry (PImMS) Sensor

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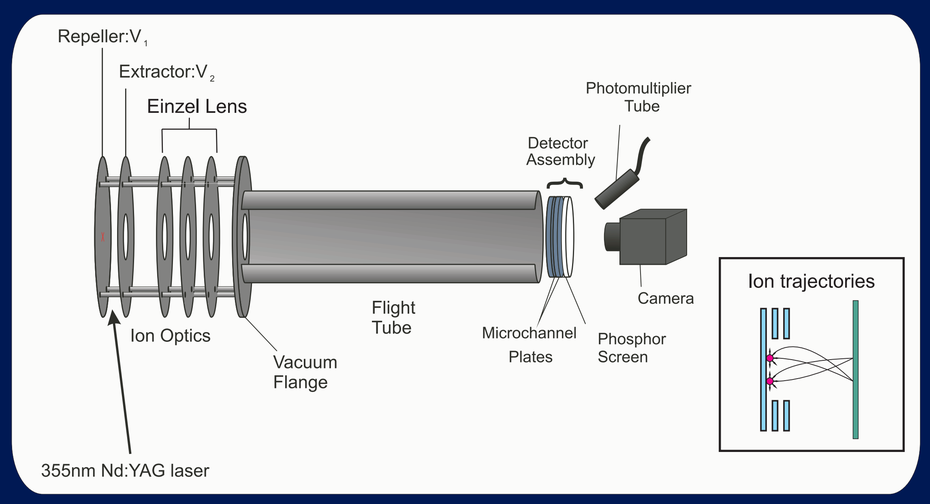
Motivation

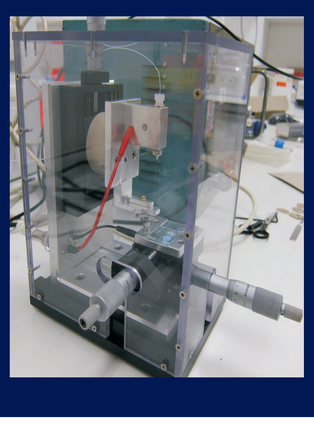
- Microscope mode imaging mass spectrometry (IMS) offers new possibilities in the analysis of biological and tissue samples.
- Microscope mode IMS is limited by the detection systems which allow the acquisition of only a single image per experimental cycle.
- Application of the fast multi-hit PImMS (Pixel Imaging Mass Spectrometry) camera offers the simultaneous detection of all masses within a single acquisition cycle [1,2].

Imaging Mass Spectrometry - Microscope

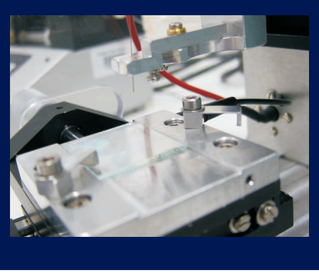


- A large area of the sample is desorbed and ionised using a defocussed laser beam.
- Extraction and mass separation is achieved with a simple linear setup.
- All molecules with the same initial position on the sample plate are detected at the corresponding position on the detector.

Sample preparation using an electrosprayer

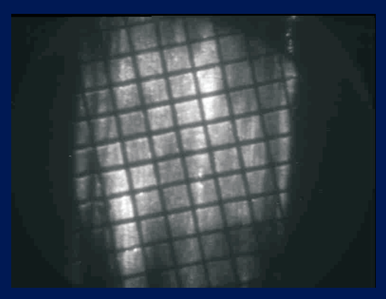


- Home built electrospraying device
- Controllable layer thickness and spot diameter
- Reproducible samples
- 90 nm layer thickness



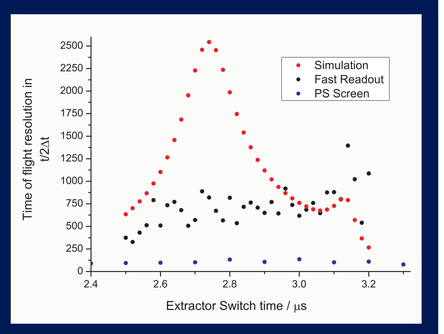
Spatial map image

- Ion Image of crystal violet.
- Spatial resolution down to ~ 14 µm.
- 10 x magnification, square pitch size 500 µm.
- Samples reproducible.
- Major limitation is the laser profile.



IMS with improved time resolution

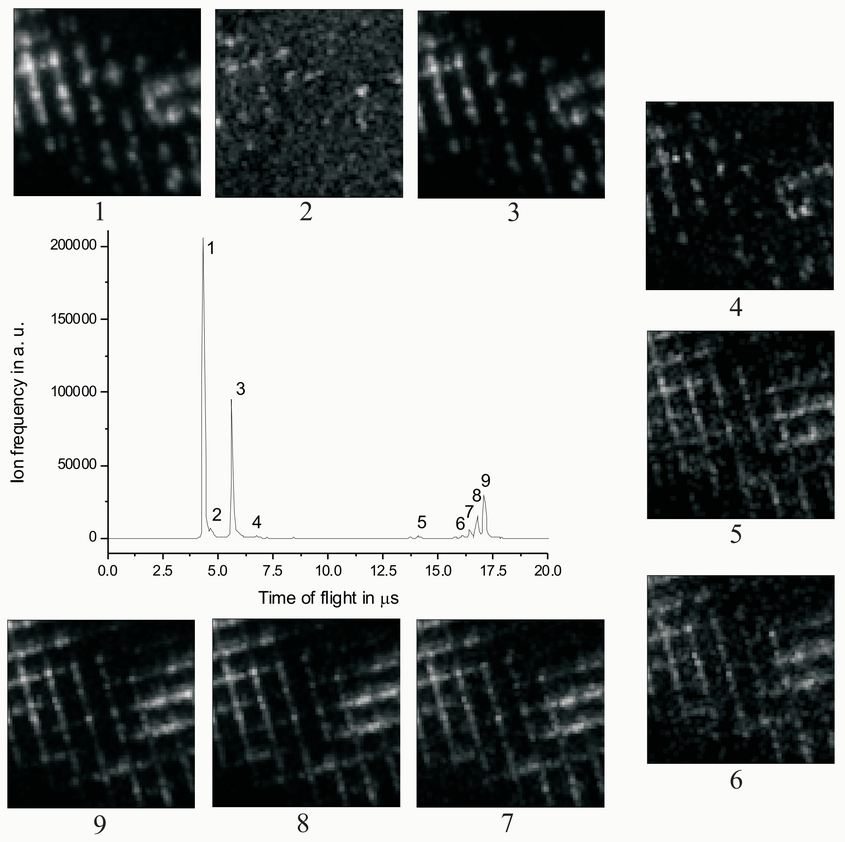
- Post extraction differential acceleration (PEDA) involves pulsing the extractor potentials to a higher voltage once the ions have passed the extractor plate [3].
- Velocity focussing leads to an improved mass resolution over non-PEDA techniques.
- Setup optimised for a 4 mm field of view.



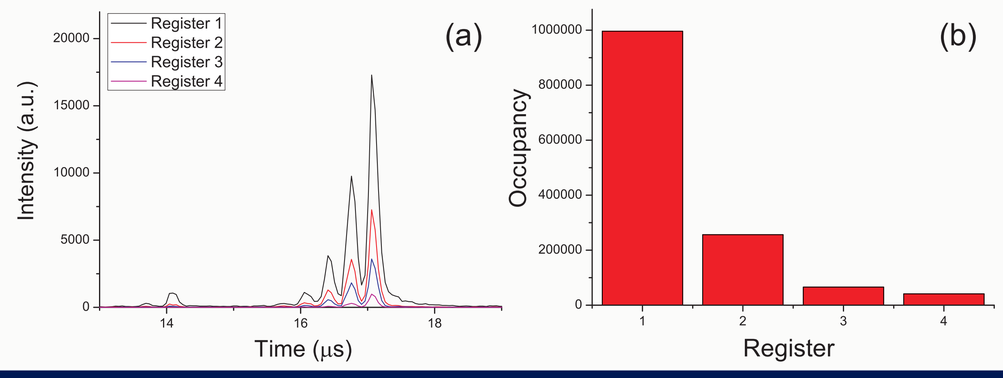
PImMS for spatial imaging

- 72 x 72 Pixel time stamping camera [1,2].
- 4 registers in each pixel for multi event detection.
- Time resolution down to 25 ns [4].
- Maximum repetition rate up to 500 Hz.
- Based on INMAPS-CMOS technology[5].
- Representative IMS images and TOF spectrum.

PImMS Camera

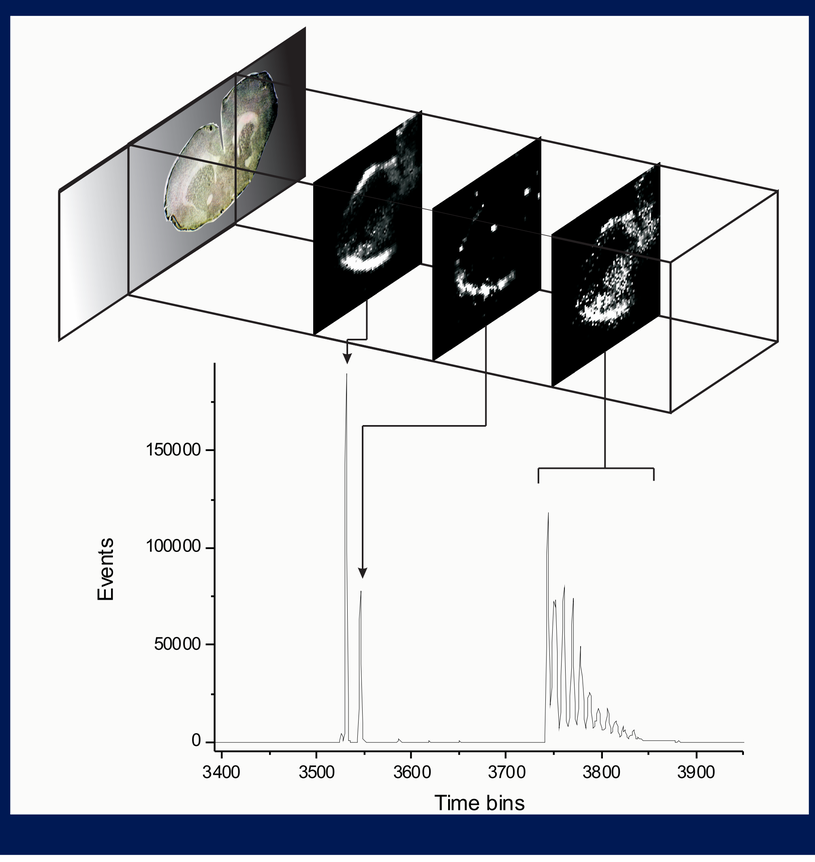


Above: Time of flight spectra taken with PImMS. The images were obtained by reading out the time bins for the single peaks.
Below: Register analysis for each peak (a). No saturation of all registers is observed. As the occupancy diagram (b) shows, the most events occur in the first register.



Imaging of biological samples

- A major area of interest of IMS is the analysis of bio samples.
- Initial experiments with PImMS have demonstrated that it can be applied to bio imaging.
- Phospholipids were imaged simultaneously using PImMS and micro-scope mode IMS.
- Further peaks were cut out of the spectra by pulsing the detector.
- Later PImMS version with 324x324 pixels in advanced stage of development.
- Time resolutions ⩽ 25 ns



This work is subject to a patent application by ISIS Innovations ltd. the development company for the University of Oxford. UK patent number 0724295.1. International patent pending.

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