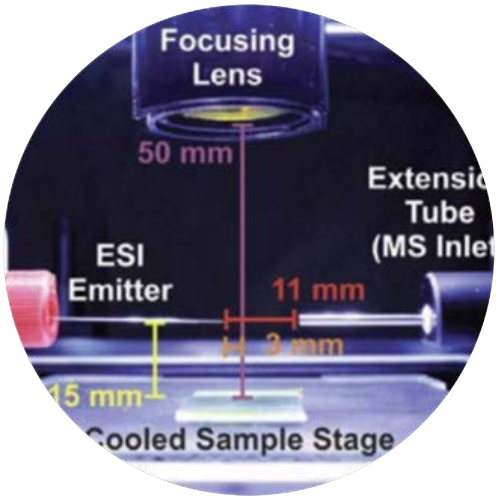
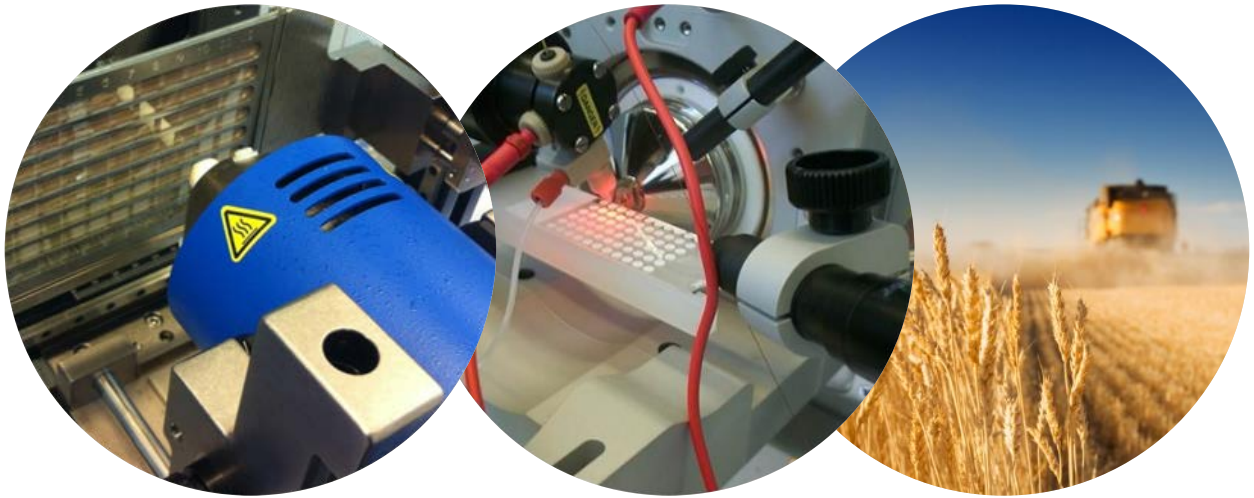
Introduction to Ambient Mass Spectrometry Imaging

Michel Nielen

October 5, 2017





WAGENINGEN UNIVERSITY & RESEARCH

Just a few research questions.....

- Can we associate macro- and microscopic tissue damage with certain metabolic pathways?
- Can we correlate material defects with surface treatments?
- Can we explore real-time chemical signalling between different cell colonies?
- How do crop protection agents distribute on/in plants?
- When did exposure to a food contaminant occur?
- Why is my sensor surface showing poor performance?
- ……..

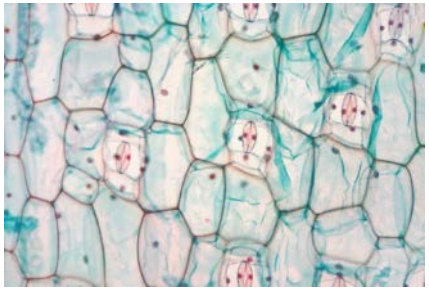
WAGENINGEN
UNIVERSITY & RESEARCH

Outline

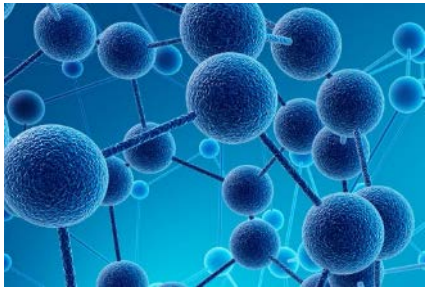
- Chemical ‘microscopies’
- Mass Spectrometric Imaging (MSI)
- Ambient versus vacuum
- Available ambient MSI technologies

Chemical ‘microscopies’: mapping chemical compositions in 2D and 3D

- Labeling/staining approaches:
  - Light microscopy
  - High content cell imaging
  - FRET



- **Label-free approaches:**
  - Elemental information
    - XRF, SEM-EDX, XPS, Auger, ……
  - Molecular information
    - Mass Spectrometry Imaging (*m/z*):



chemical identity *per* pixel

WAGENINGEN UNIVERSITY & RESEARCH

Mass Spectrometric Imaging (MSI), 2D, 3D, ...

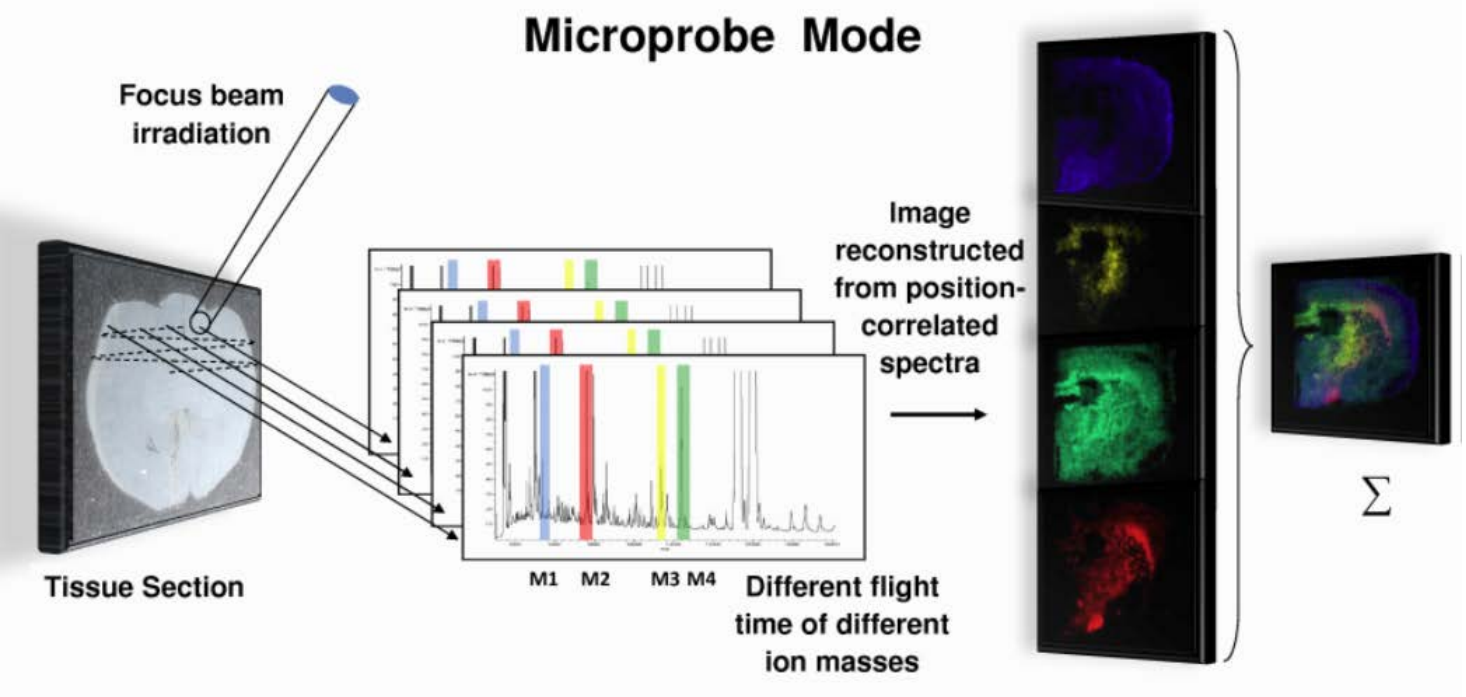
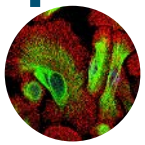


Figure courtesy from Prof. Ron Heeren, Maastricht University

3D, 4D, 5D data sets....

MSI, ambient versus vacuum options

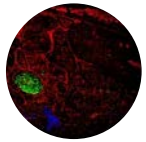
Microprobe MSI



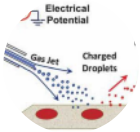
odd-shaped samples, native, *in vivo*

better ion transmission, more sensitive

Ambient

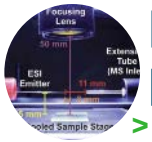


Vacuum



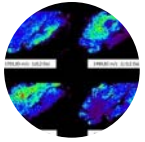
No surface damage, soft ionization, reactive DESI. Limited spatial resolution

DESI, DART



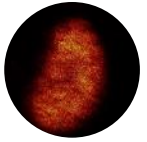
Laser + ESI or Plasma

>150 µm spatial resolution, ionization and desorption decoupled
Limited ionization efficiency



MALDI

Large bio-molecules, fast, >10 µm spatial resolution.
MALDI matrix, interferences,
<u>not for low MW</u>



SIMS

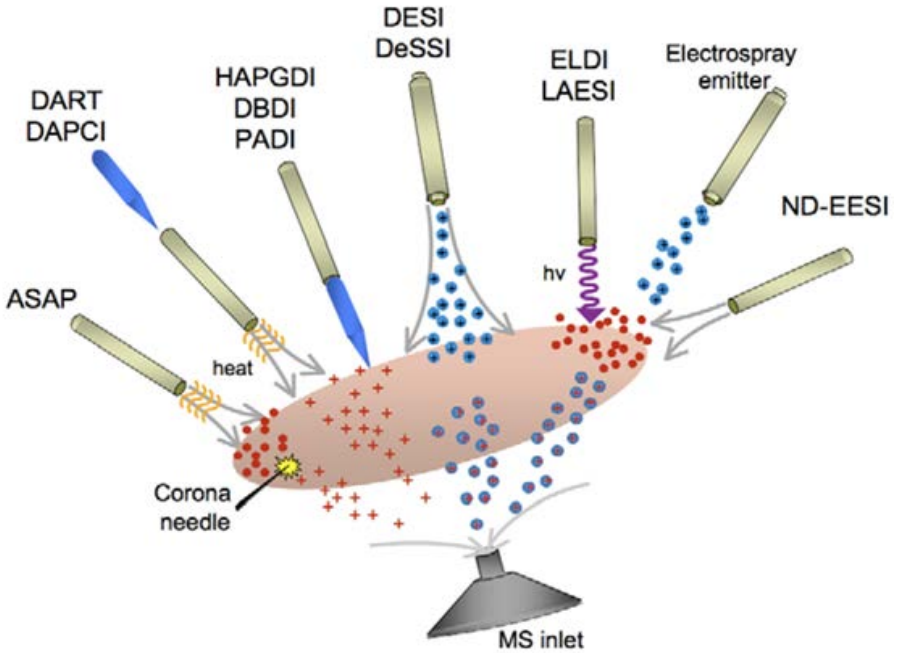
Sub-µm spatial resolution.
Fragmentation, low mass resolution, low sensitivity

WAGENINGEN UNIVERSITY & RESEARCH

Dozens of ambient ionization options for MSI

In common:

Direct probing and analysis of sample objects *without* any pre-treatment, *no* labeling, *no* vacuum, often under native conditions



- **using particles**:
  Desorption and ionisation via charged solvent droplets, or metal particles, example **DESI**
- **using gas**:
  Desorption and ionisation via excited gas, aided by ambient air, example **DART**
- **using Photons**:
  example **LAESI**

Figure from: Venter et al., Trends Anal. Chem., 27 (2008) 284

Ambient Mass Spectrometry Imaging @ WUR

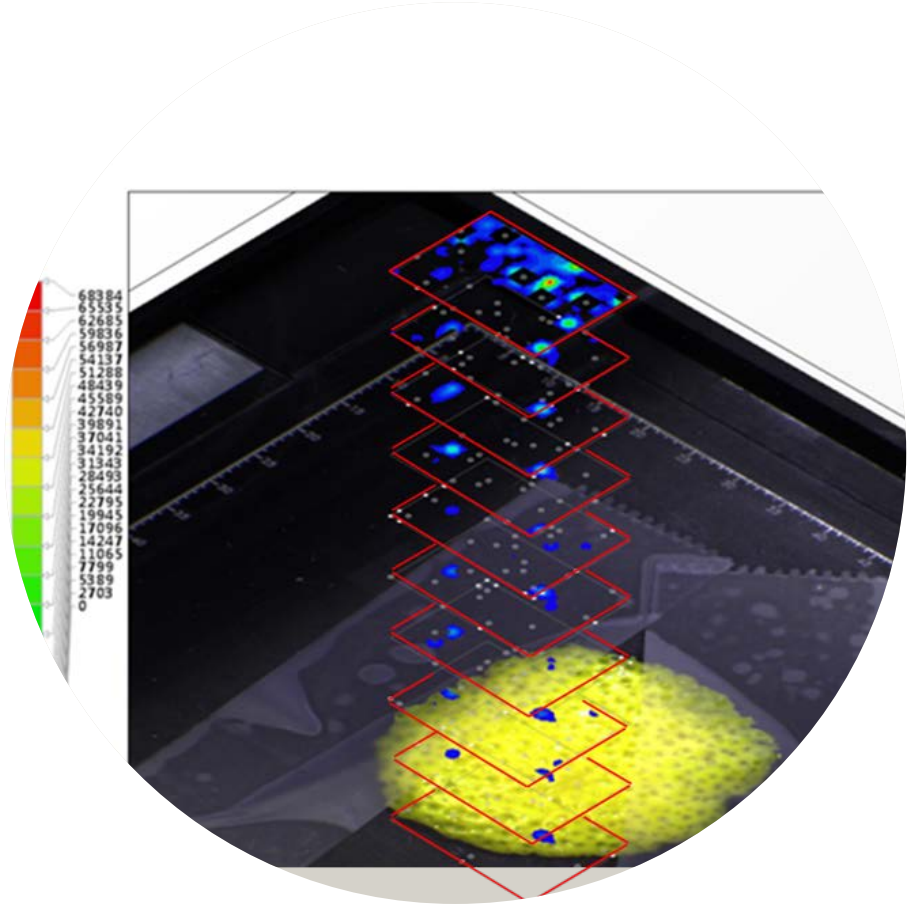
- Technologies:
  - DESI: (sub-)mm spatial resolution, experimentally tricky
  - DART: mm resolution, experimentally simple and robust
  - LAESI: > 150 µm spatial resolution, experimentally ok

- Applications:
  - Plant materials
  - Animal tissue
  - Surface chemistry
  - Food, feed products
  - Cell colonies
  - Hair and synthetic fibers

WAGENINGEN
UNIVERSITY & RESEARCH

Questions?

Success stories in the next presentations!



Program

- *Short introduction to Shared Research Facilities* ✓
- *Introduction to Ambient Mass Spectrometry Imaging* ✓
- *DART MSI of drugs of abuse in hair*
- *LAESI MSI characterization of high performance fibers*
- *LAESI MSI of foods and food ingredients*
- *LAESI MSI in plant metabolomics*
- *Wrap up and discussion*

WAGENINGEN
UNIVERSITY & RESEARCH