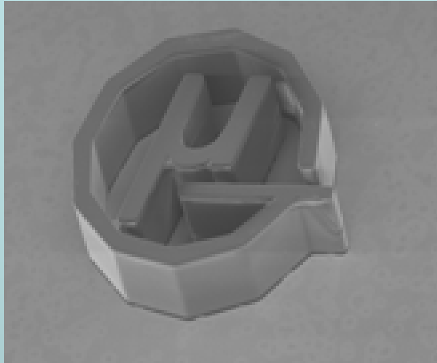
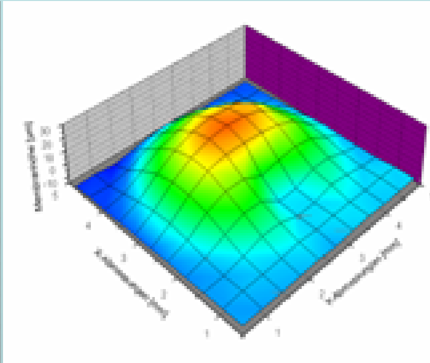
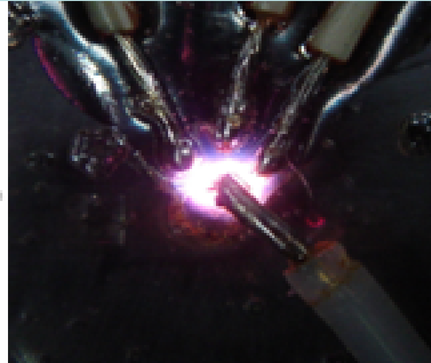
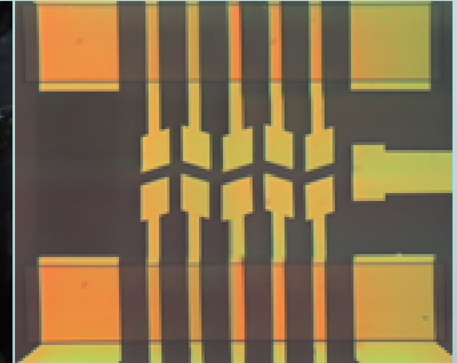

A Fully Integrated Micro Mass Spectrometer

Eric Wapelhorst

09/22/2005

Structure

- Motivation MS in MEMS Technology
- Function Principle of our MMS
- Fabrication
- Conclusion & Outlook

MEMS Products

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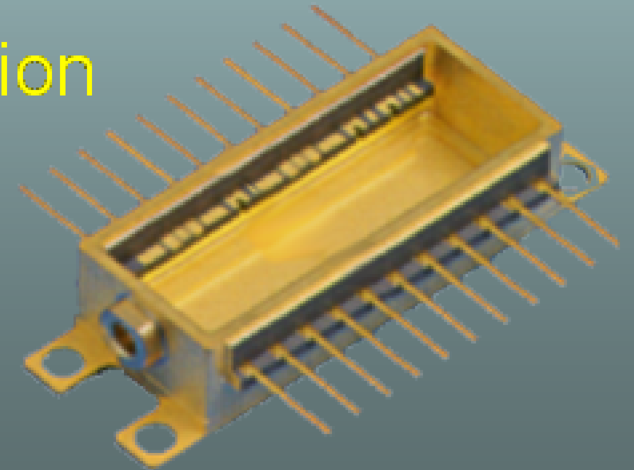
- Gyro Sensors
- Flow Sensors
- Pressure Sensors
- RF Switches
- Print Heads
- Micro Mirrors
- Micro Mass Spectrometers

Motivation MMS

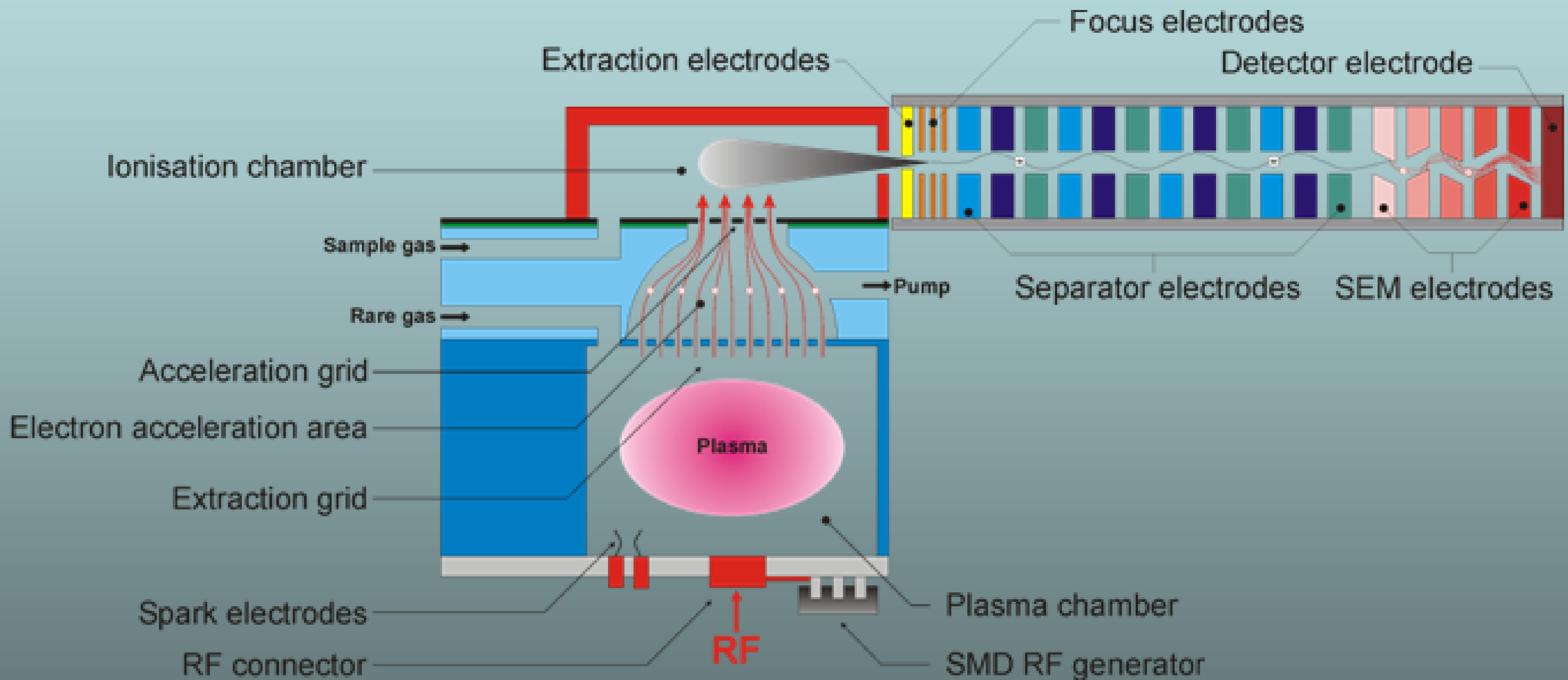
- Small in Size <5x3x2 mm³
- Low Power Consumption <500mW
- Low Gas Consumption <0.1sccm
- Uncritical Vacuum >1 Pa (>7.5mTorr)
- Wafer Based Standard Processes
  - Cheap in Mass Fabrication



Applications of the MMS

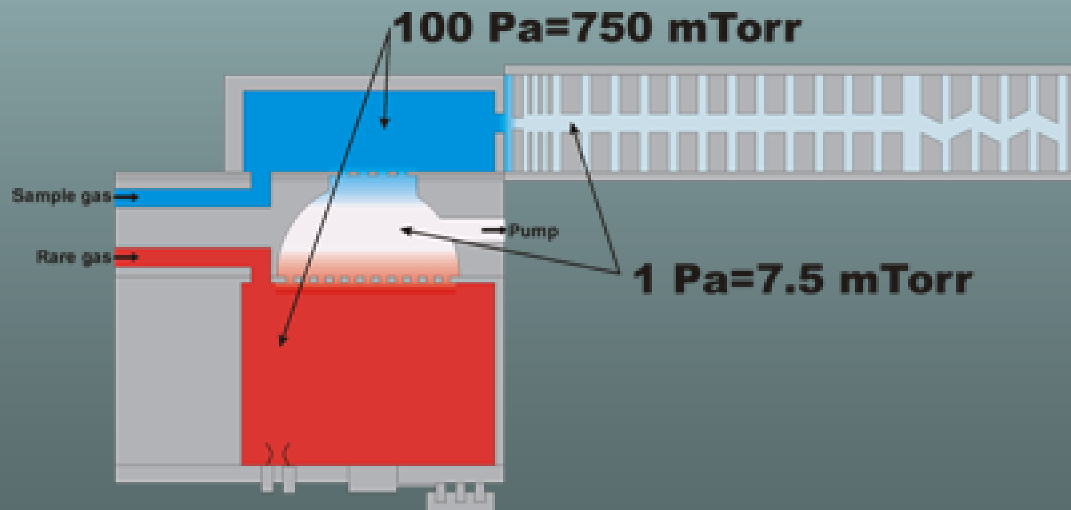
- Rescue Services
- Homeland Security
- Environmental Monitoring
- Process Control
- Automotive Industry

Function Principles



Pressure Regions

- Mean Free Path >3mm
- Low Pressure 1Pa=7.5mTorr
  - One-Stage Pumping System
  - Micro Diffusion Pump
- High Pressure Regions: 100Pa=750mTorr
- Pressure Apertures, Valves, Gas Flow Sensors

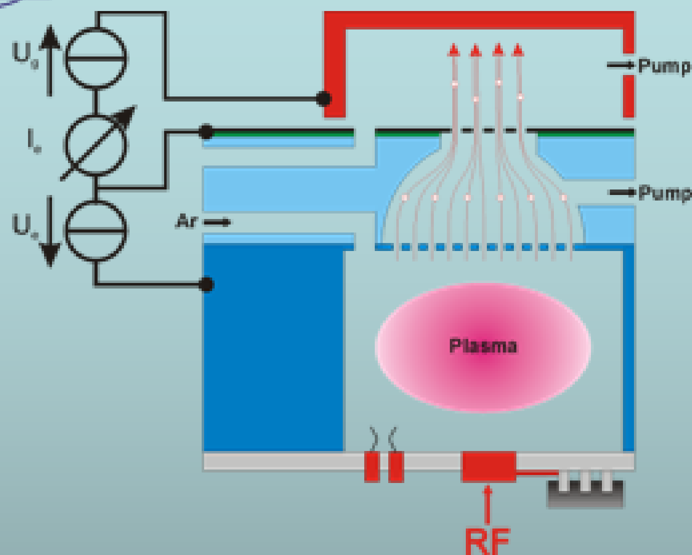


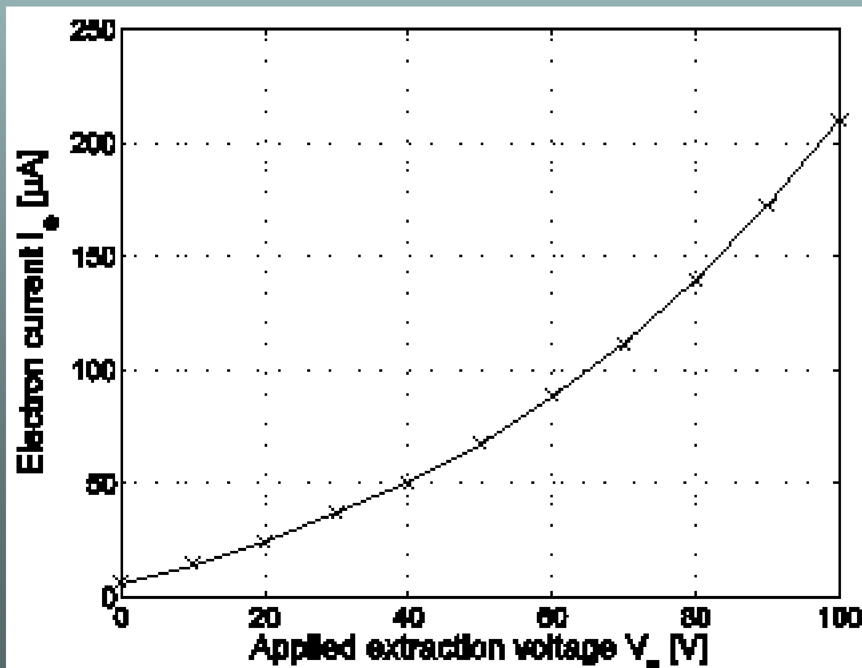
Function Details

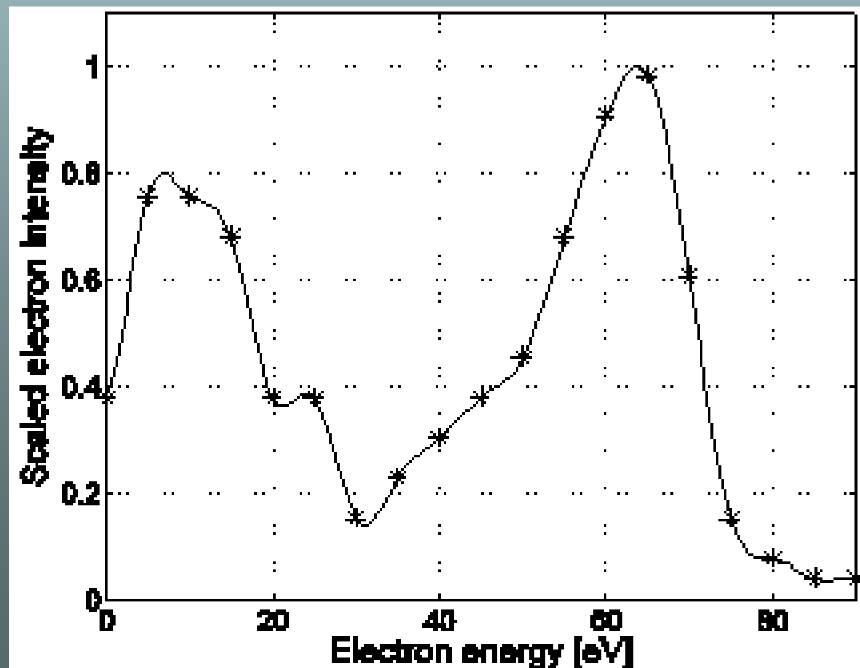
- Electron Source
- Ion Source
- Mass Separator
- SEM

Electron Source

- Stable RF Plasma
  - Constant RF-Power
  - Constant Pressure
- Electron Current Density 1A/cm²
- Constant U_e=70V

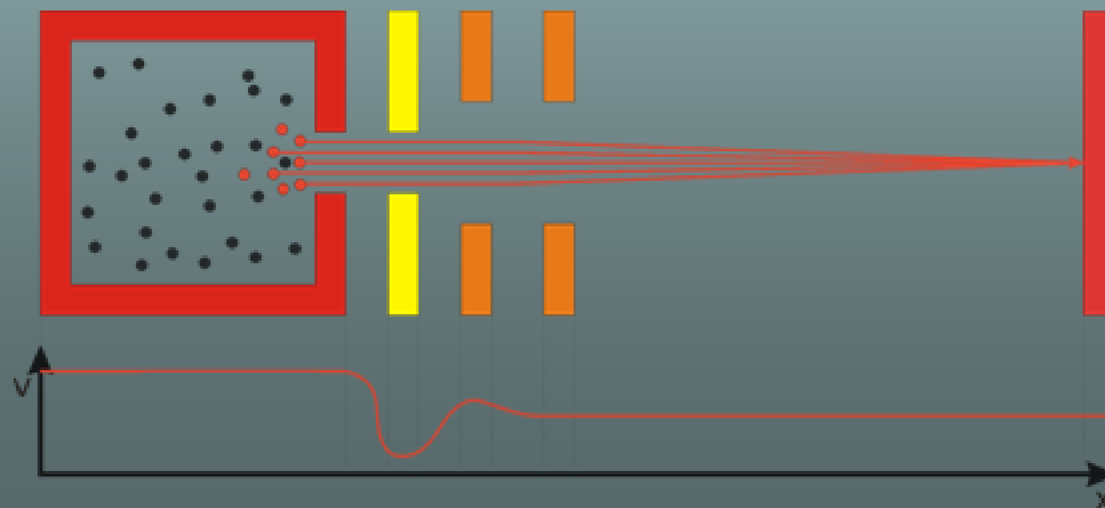






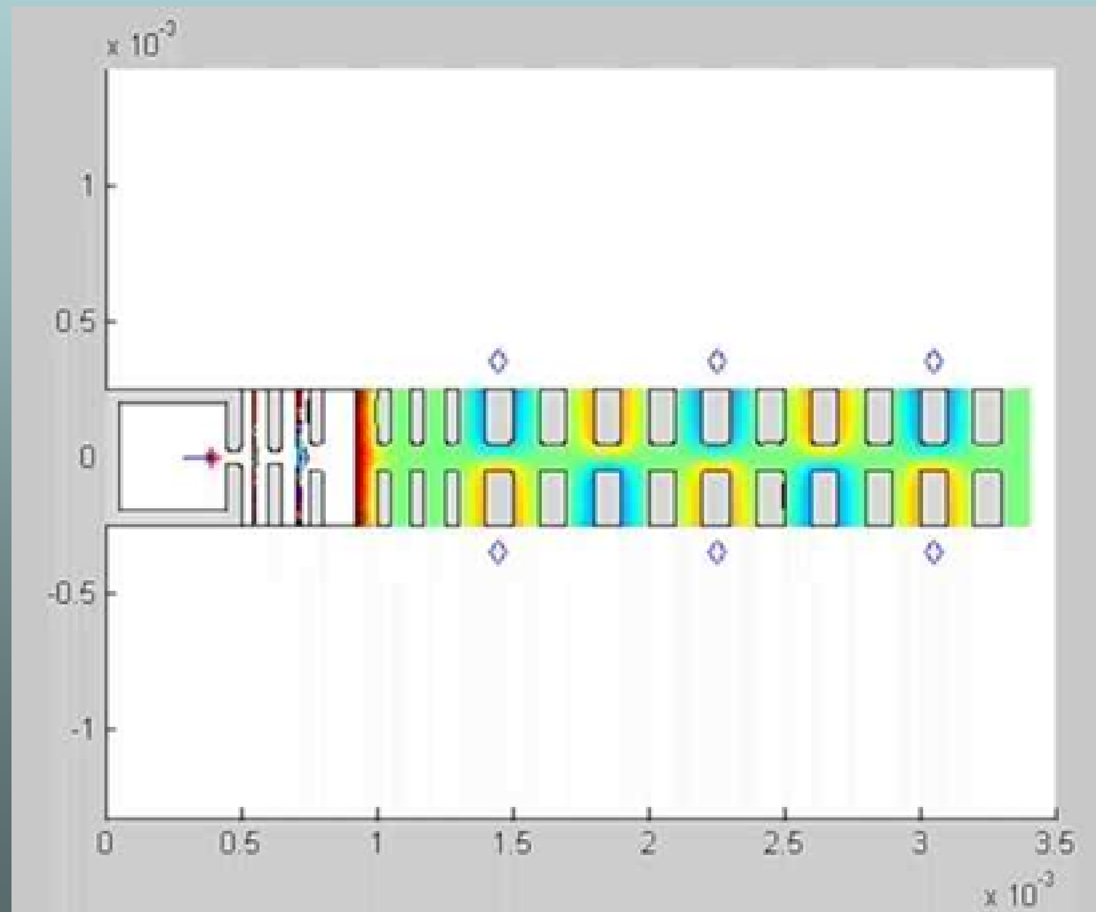
Ion Source

- Small Ionization Area
- Ion Outlet is Pressure Aperture
- Extraction Electrode (Acceleration)
- Focus Electrodes (Deceleration)
- Ion Energy Behind Focus Electrodes 50-100eV
  - Heavy Ions Slower than Light Ones
- Ion Current 5µA (Without Mass Separator)



Mass Separator

- Traveling Dipole Field (TDF)
- Finger Electrodes



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Electrical Field (Ion's Point of View)

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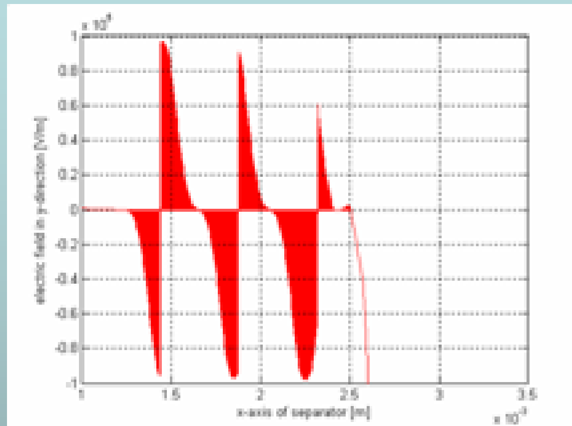
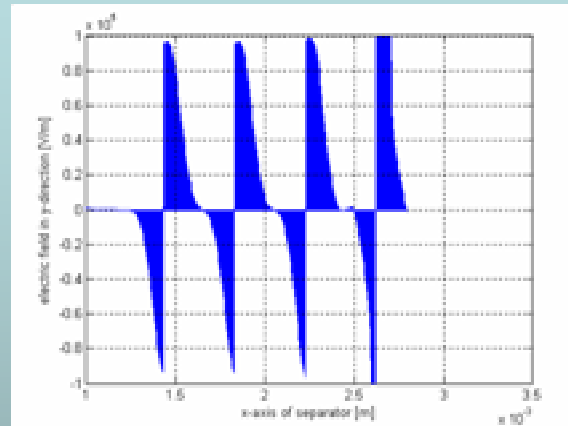
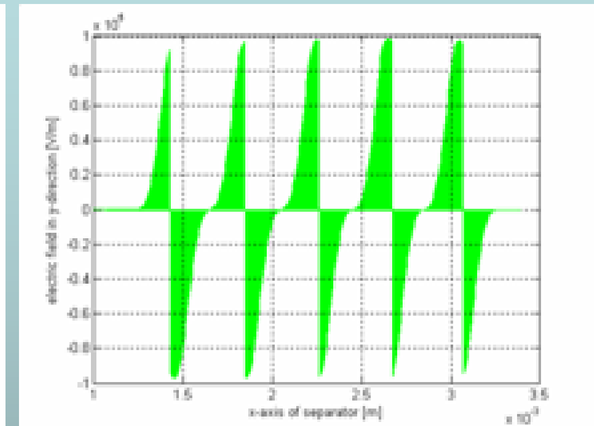


Ion Slower than TDF



Ion Faster than TDF



Ion Same Velocity as TDF

Mass Separator

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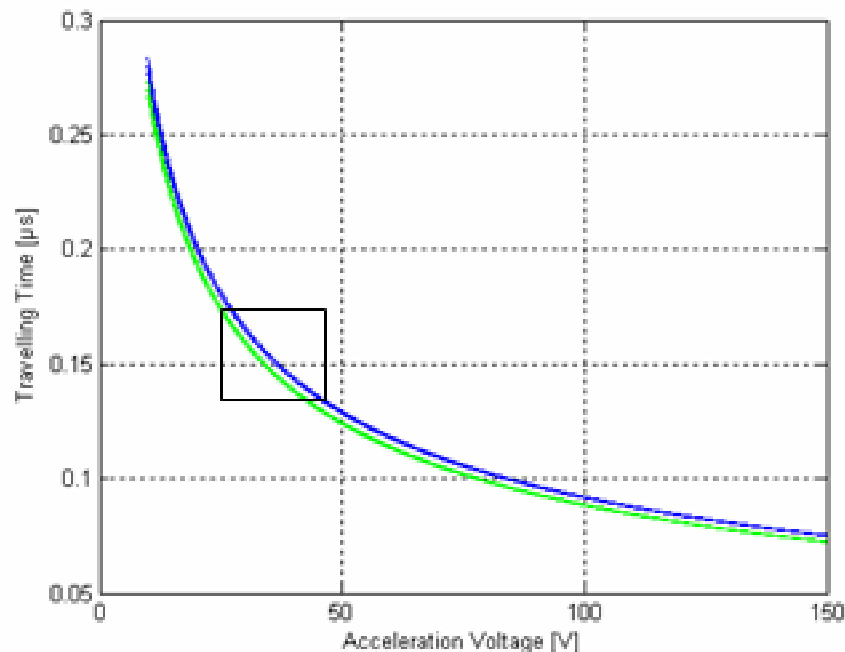
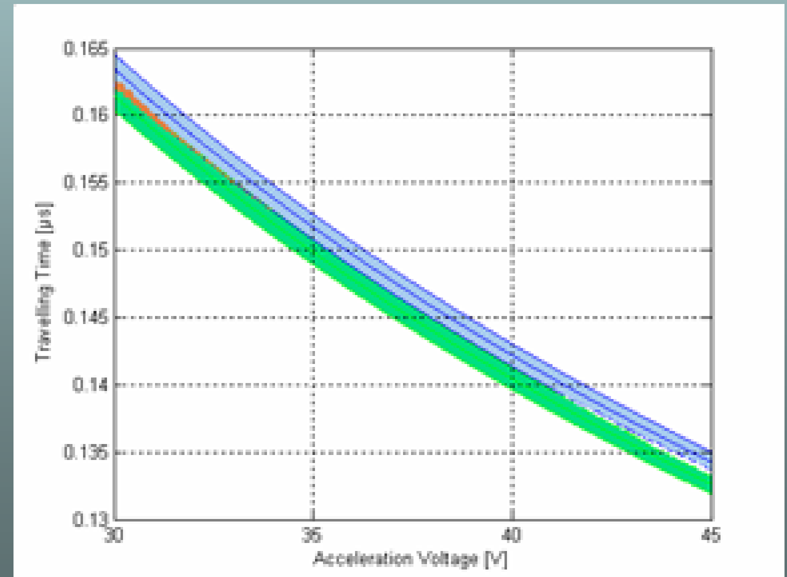
- Resolution is Limited by the Thermal Velocity

$$\overline{v_{ion}} = v_e + \overline{v_{th}} \qquad v_e = \sqrt{\frac{2e_0 U_e}{m}} \qquad \overline{v_{th}} = \sqrt{\frac{8k_B T}{m\pi}}$$

- Ar M=40 from M=41





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SEM

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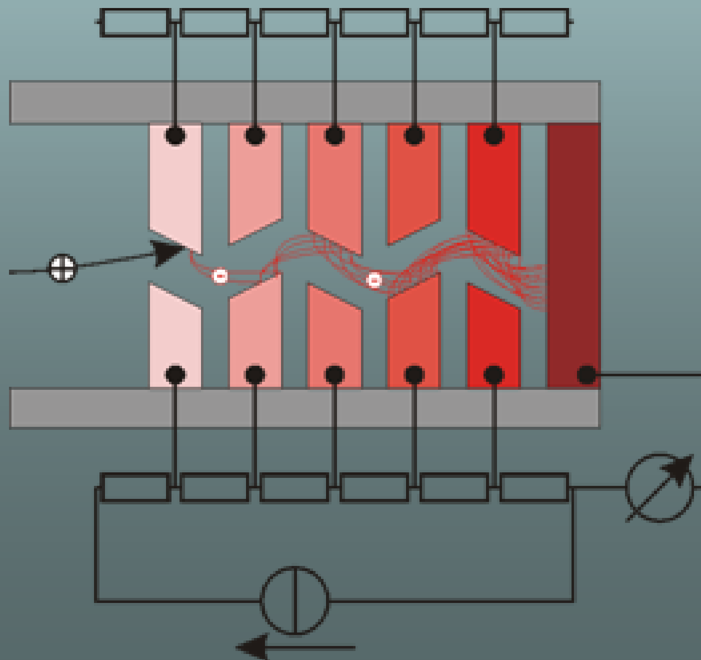
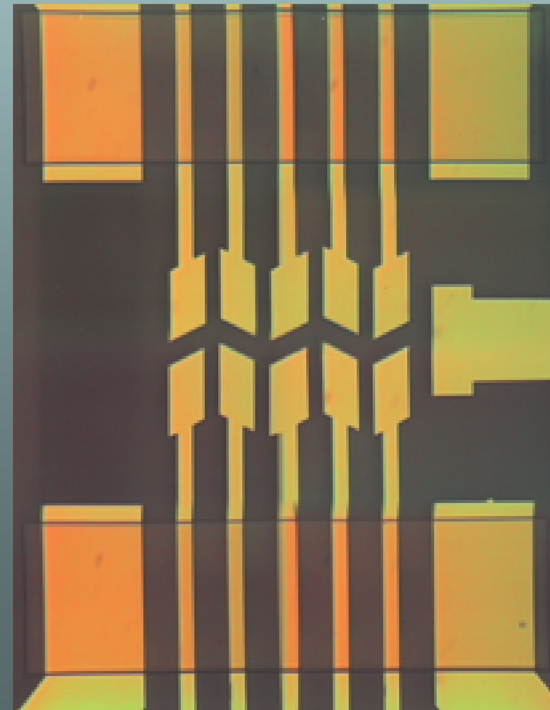
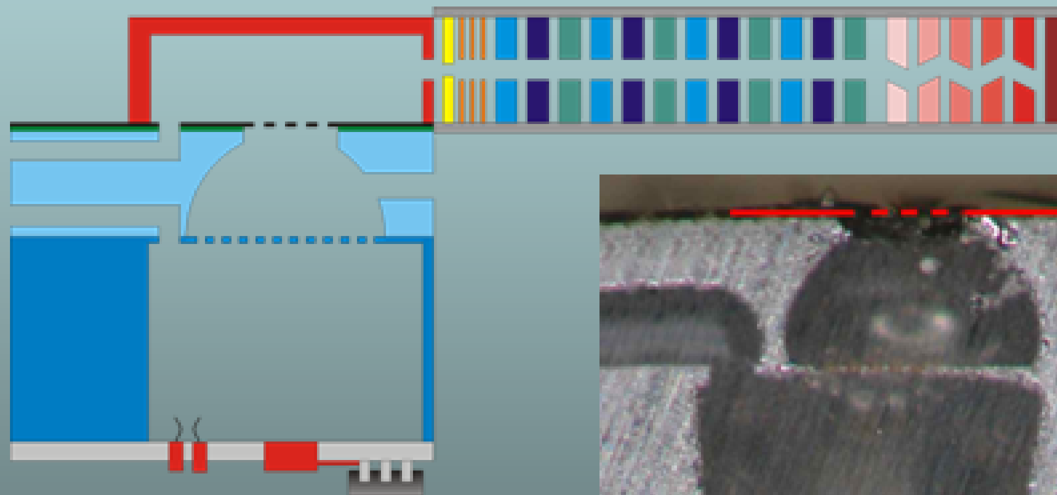
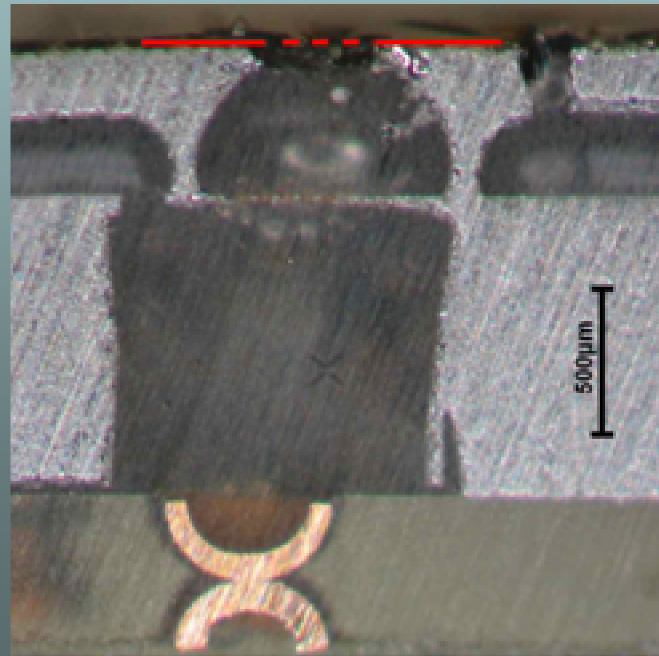
- High Voltage Cascade
- Integrated Thin Film Resistors (R>100MOhms)
- Surface Coating
- Ion Releases Electron Avalanche

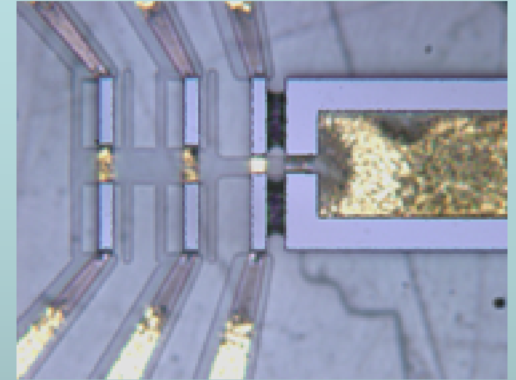


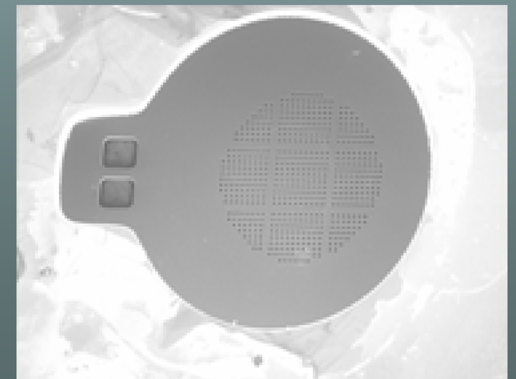


Fabrication MMS



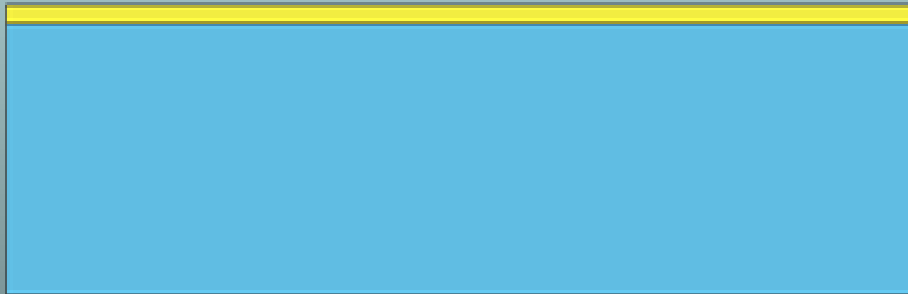


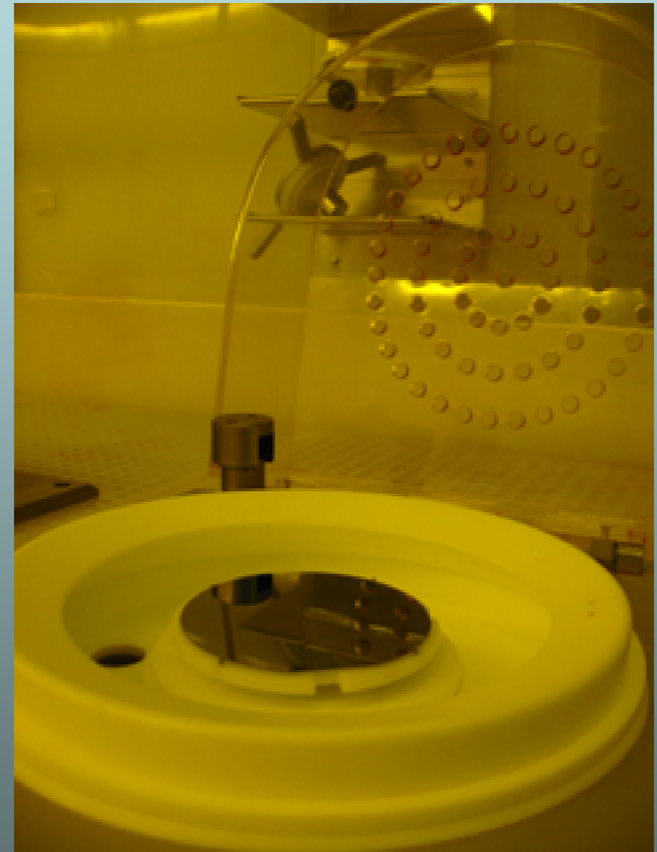




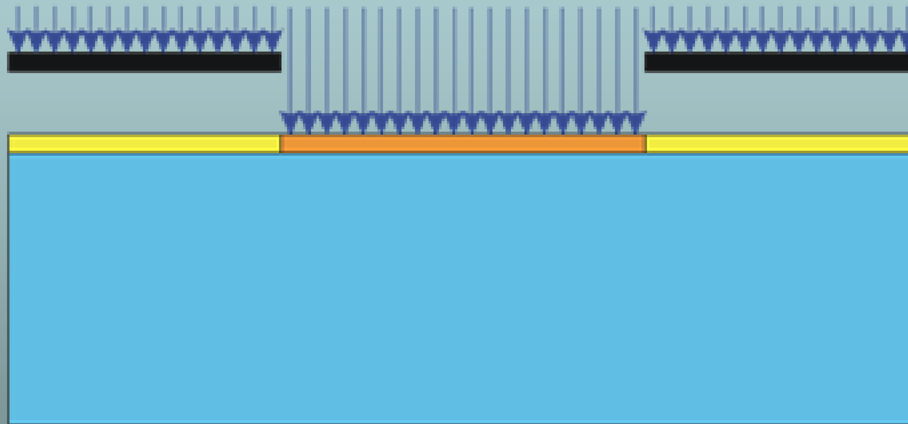
Fabrication Chamber

Fabrication Chamber





Fabrication Chamber



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Fabrication Chamber

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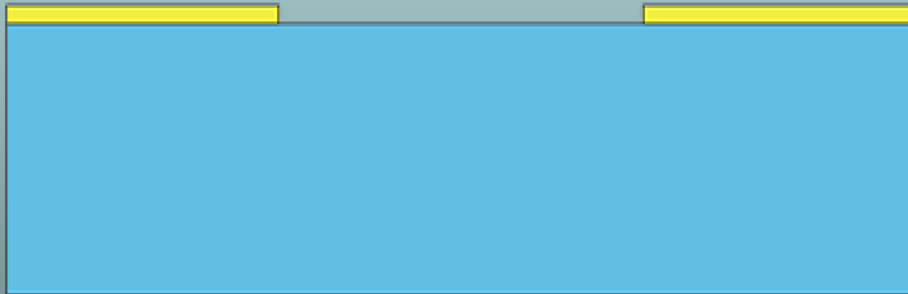

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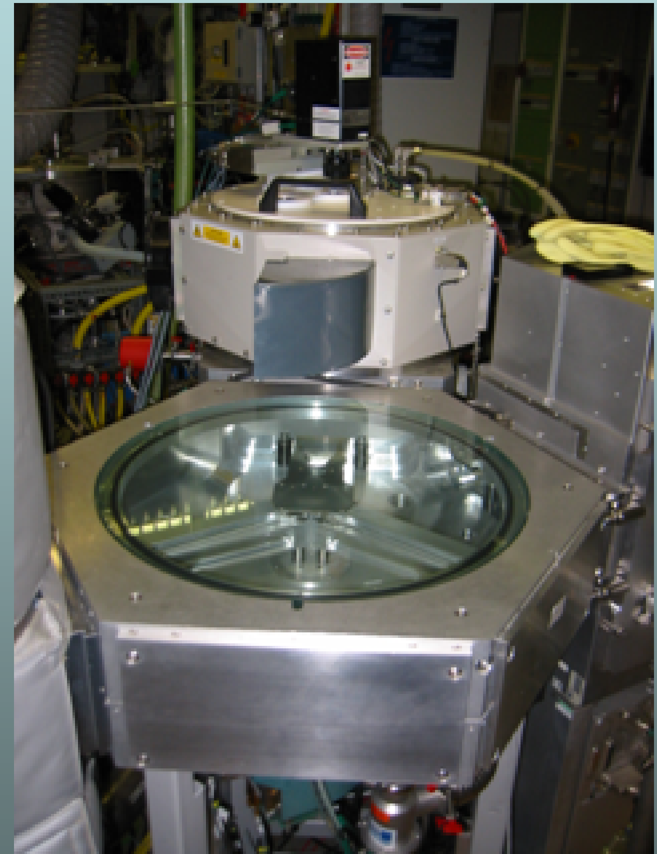

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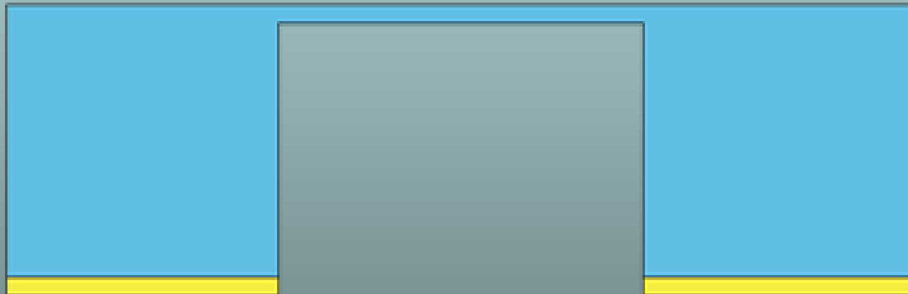

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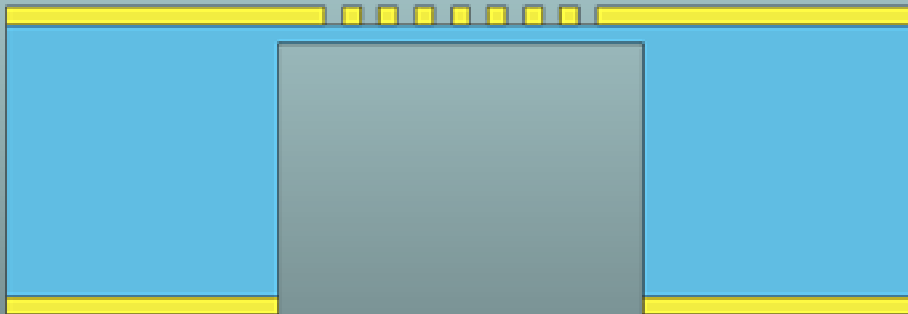
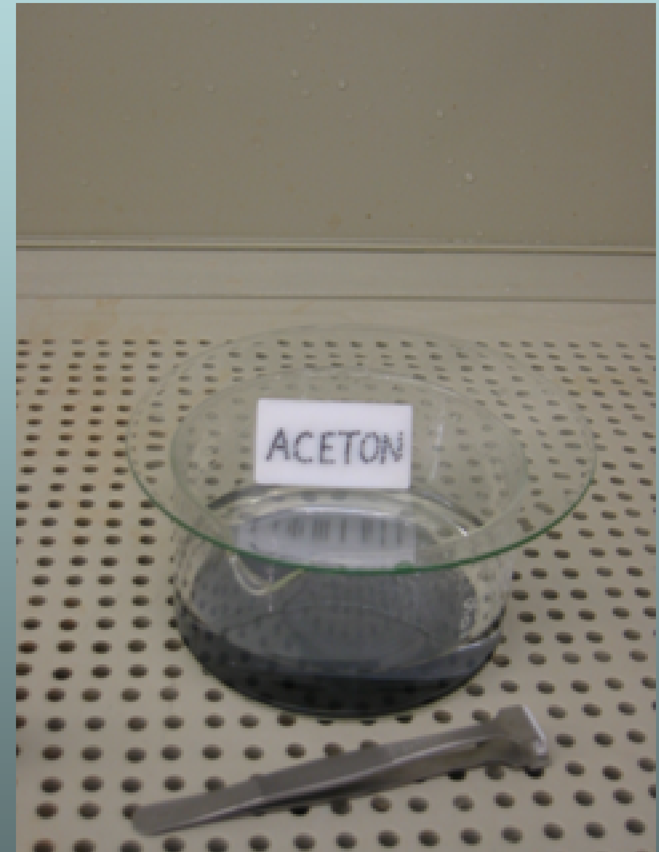


Fabrication Chamber

Fabrication Chamber



Conclusion & Outlook

- Small Mass Spectrometer
- Fabrication by Standard Processes
- New Separation Principle for MEMS Technology
- Electron Source
- Ion Source with Ion Optics

- Build up the Mass Separator
- Measure Spectrums

➤ **Fully Integrated Mass Spectrometer**

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Thanks for Your Attention

Acknowledgments: MMS - Team

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