

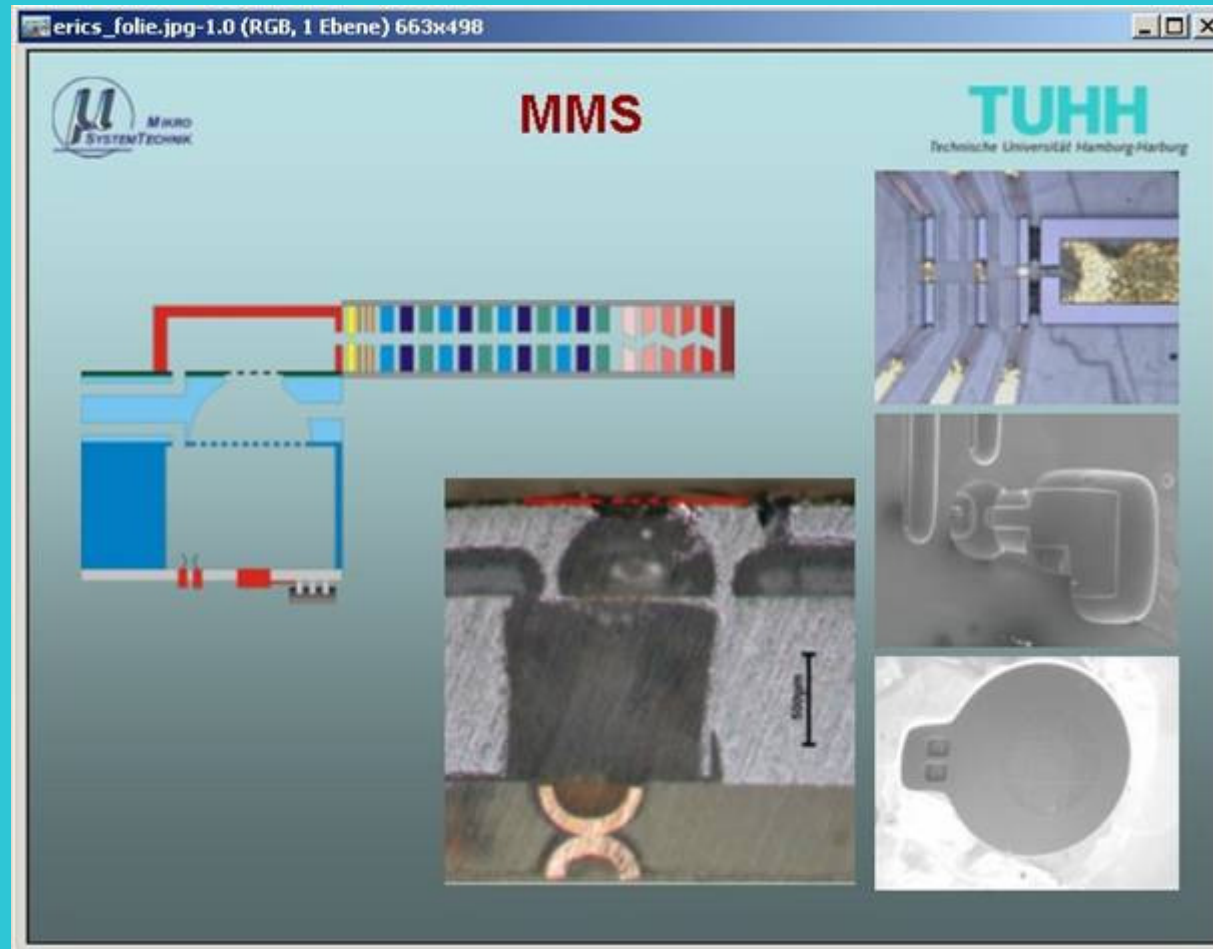
A Single Chip Mass Spectrometer in MEMS Technology



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Eric Wapelhorst
Jörg Müller

Hamburg University of Technology
Institute of Microsystems Technology
September 18th, 2007

HEMS 2005:



Eric Wapelhorst promised mass spectra ...

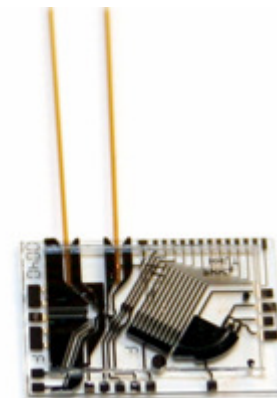
Overview

- Objectives
- Applications
- Function pinciple
 - TOF
 - Synchronous ion shield
- MEMS Fabrication
- Experiments: Mass spectra
- Conclusion
- Outlook

Objectives

Mass spectrometer on a chip:

- Cost effective mass production
- Small dimensions
- Relaxed vacuum requirements ($1\text{Pa} \approx 7.5\text{mTorr}$)
- Low power consumption



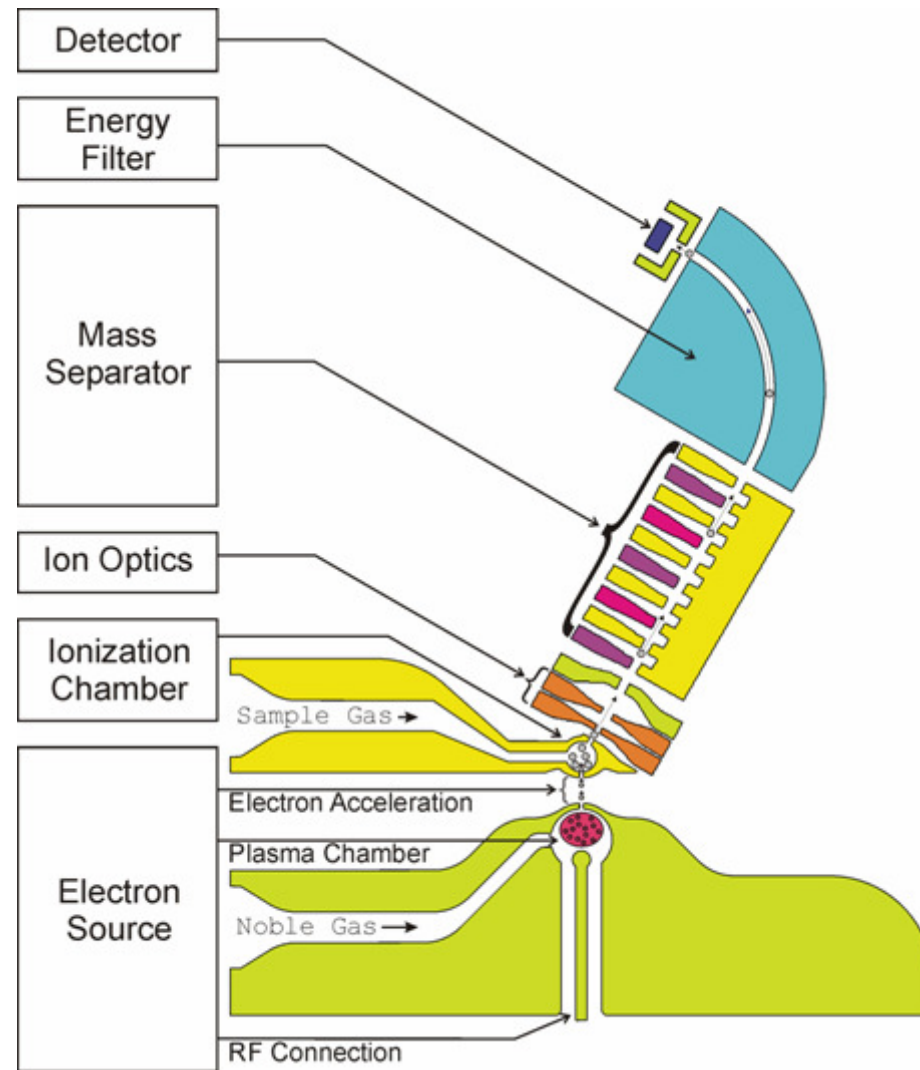
Applications

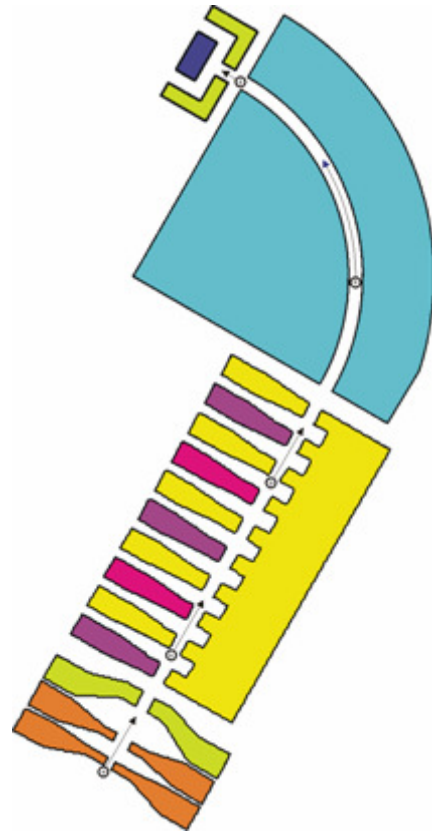
- Portable mass spectrometry:
 - Harsh Environment
 - Rescue service
 - Airport authority

- Online process control:
 - Chemical industry
 - Automotive applications
 - Air pollution monitoring

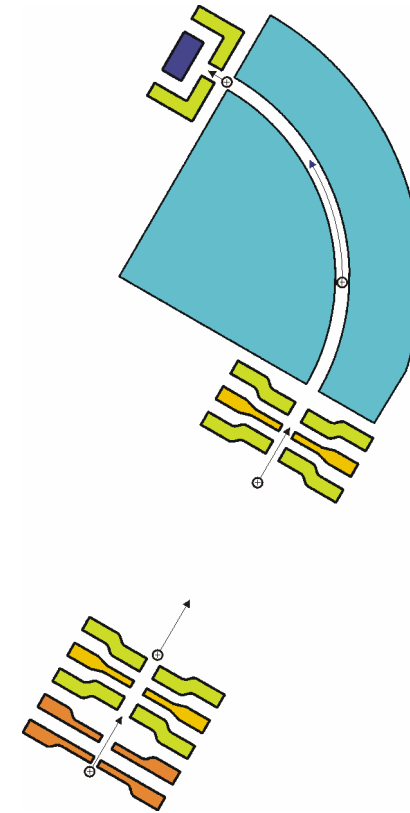


Function Principle



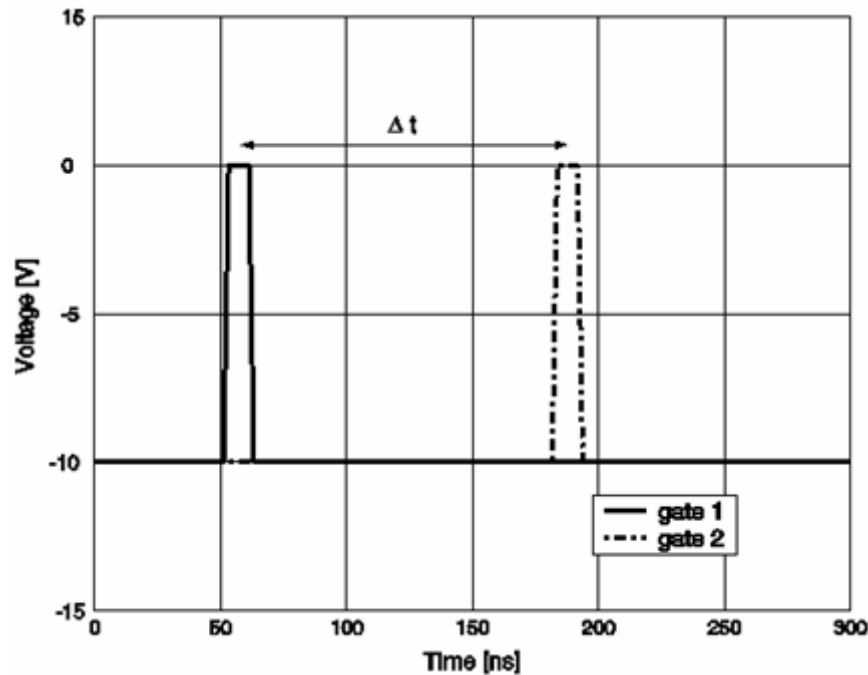


Synchronous Ion Shield (SIS)

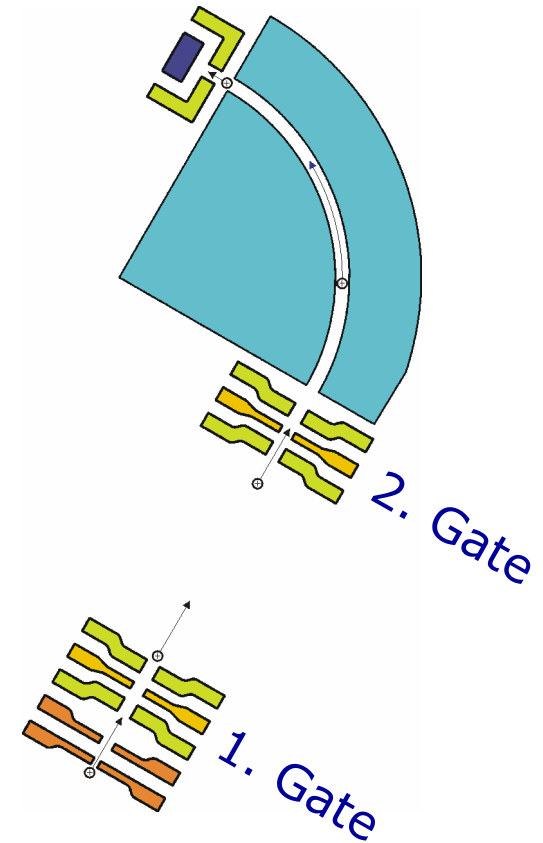


Time-of-Flight (TOF)

Time-of-Flight Mass Separator

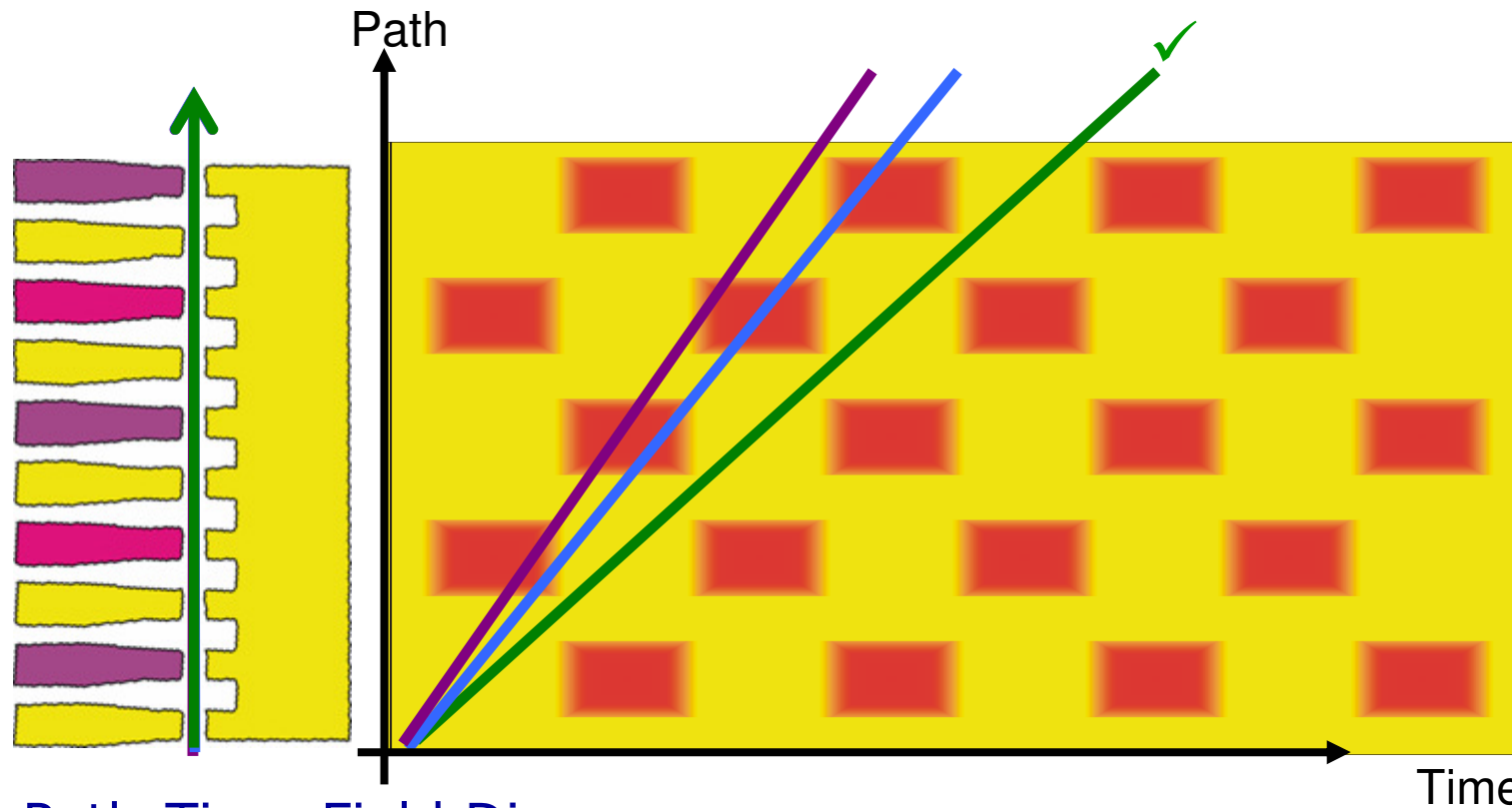


- Ion beam pulsed (1. Gate)
- Ion pulse diverges in drift zone
- Sampling (2. Gate)
- Mass interval chosen by phase shift



Synchronous Ion Shield Mass Separator

- 9 -

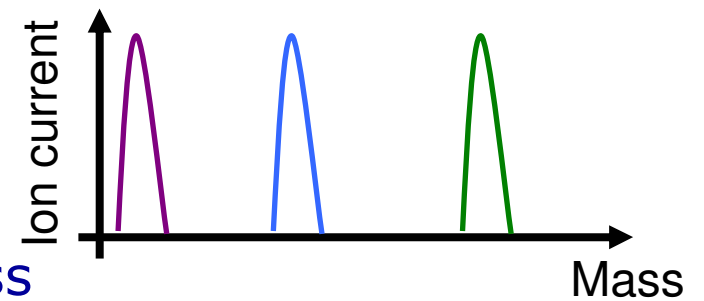


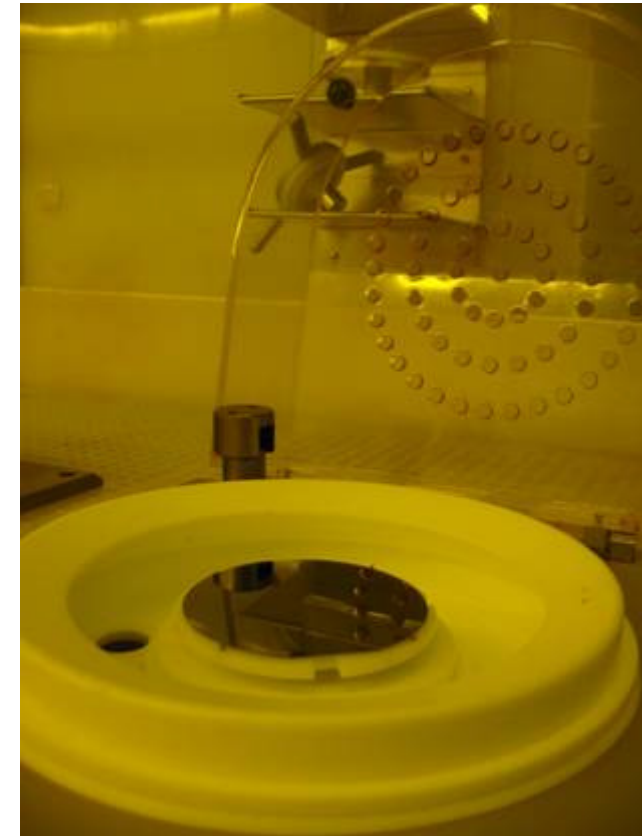
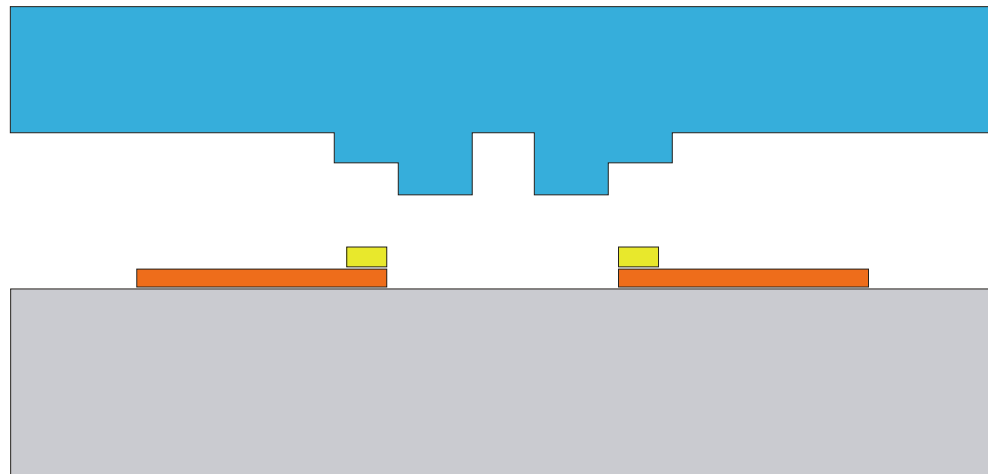
- Path-Time-Field Diagram
- Electric field perpendicular to ion path:

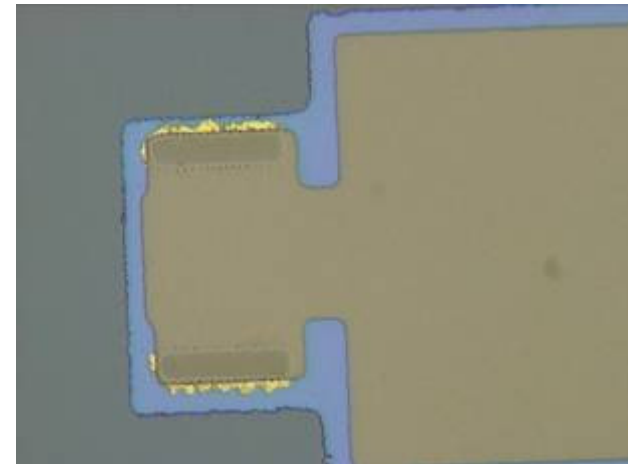
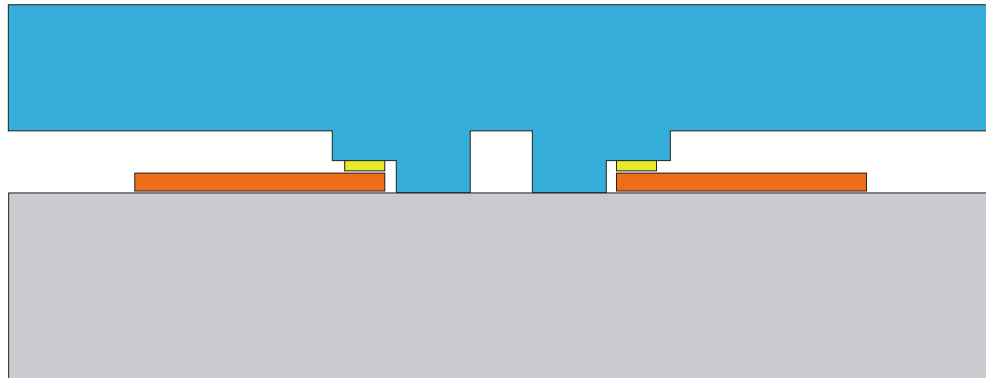
■ = zero

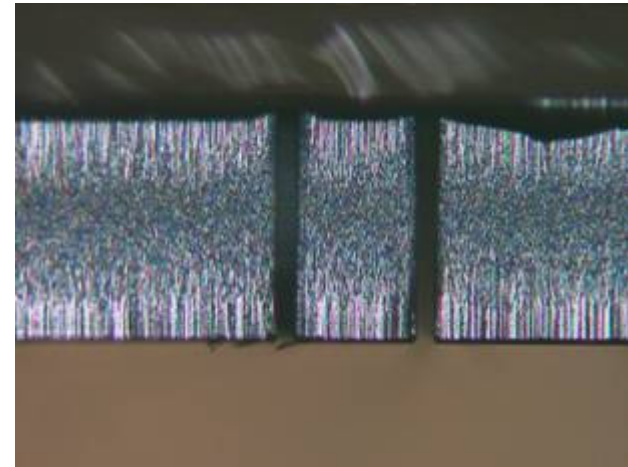
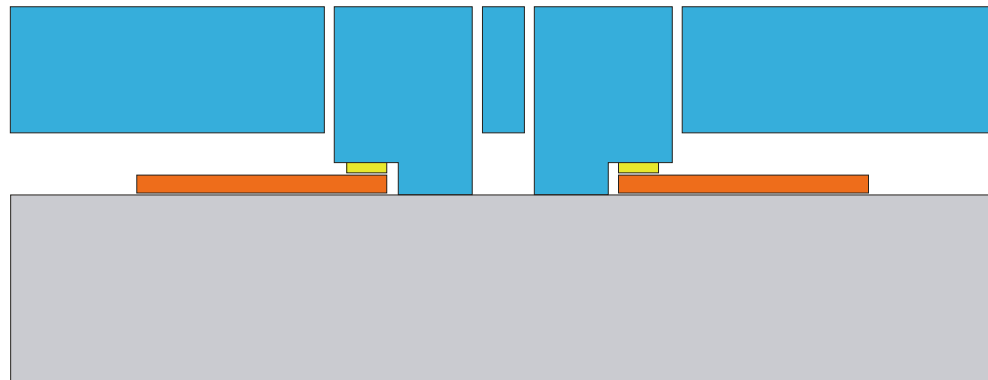
■ = strong

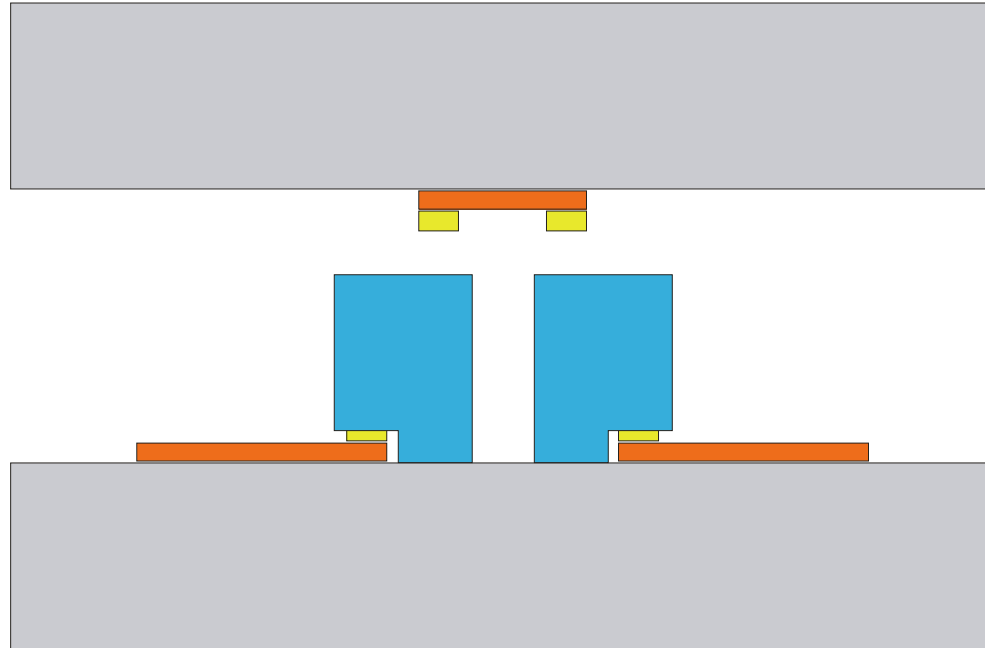
- Only ions traveling at zero field can pass

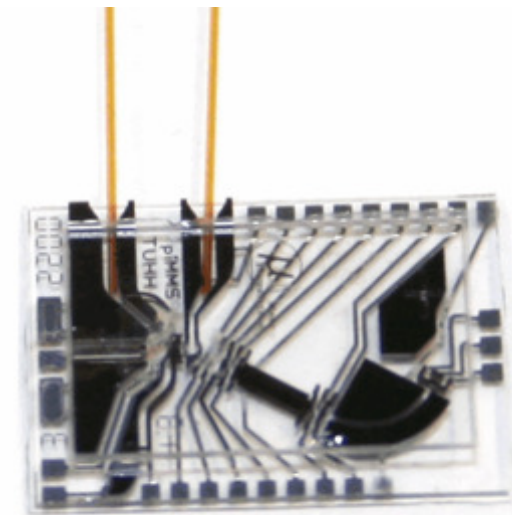
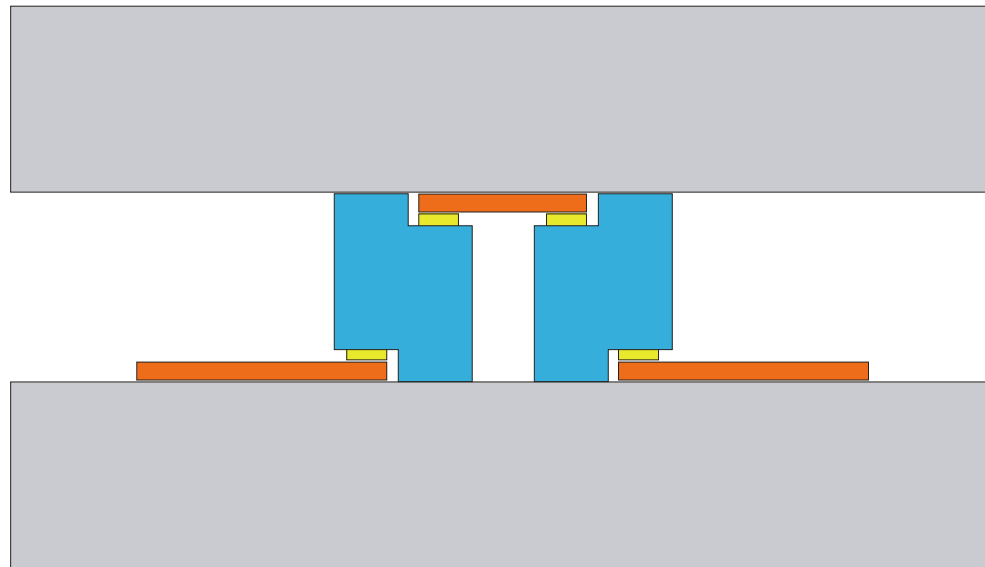










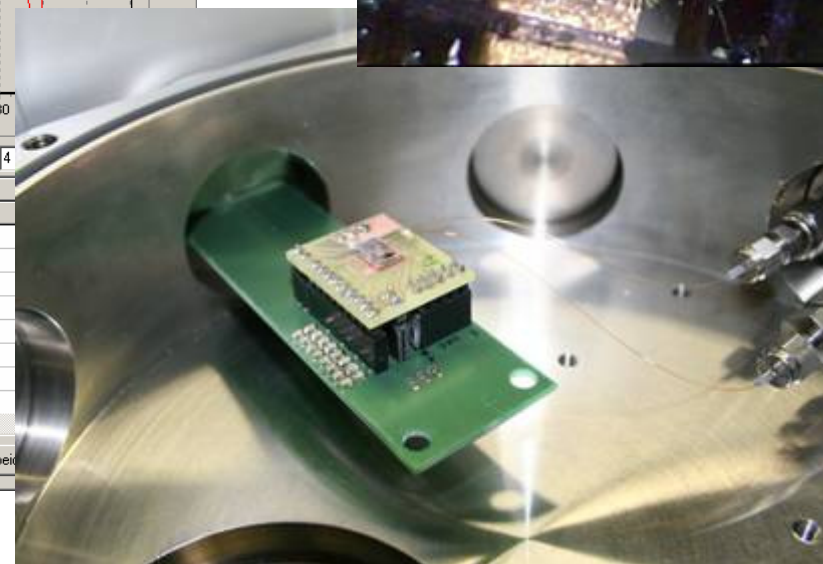
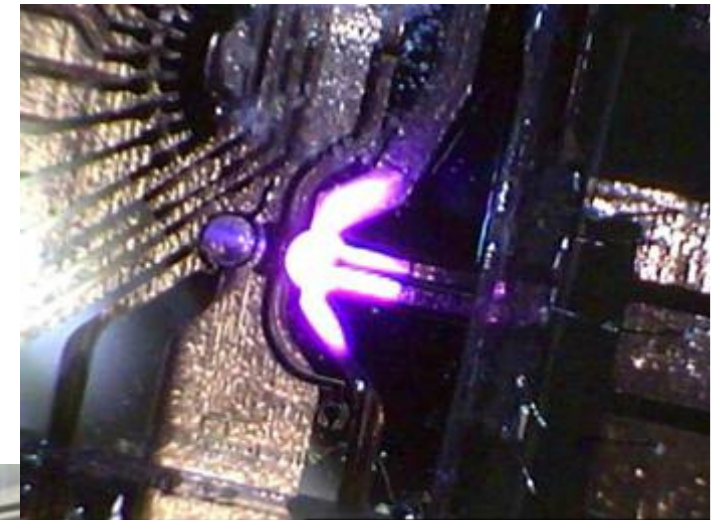
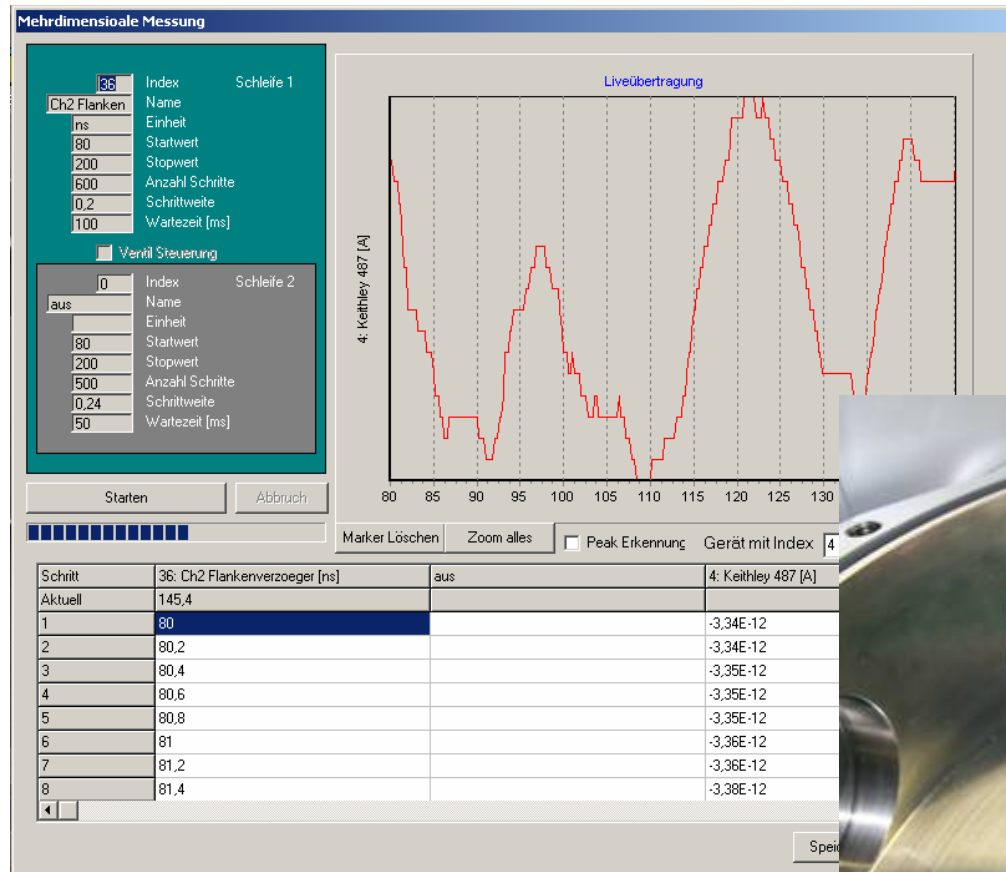




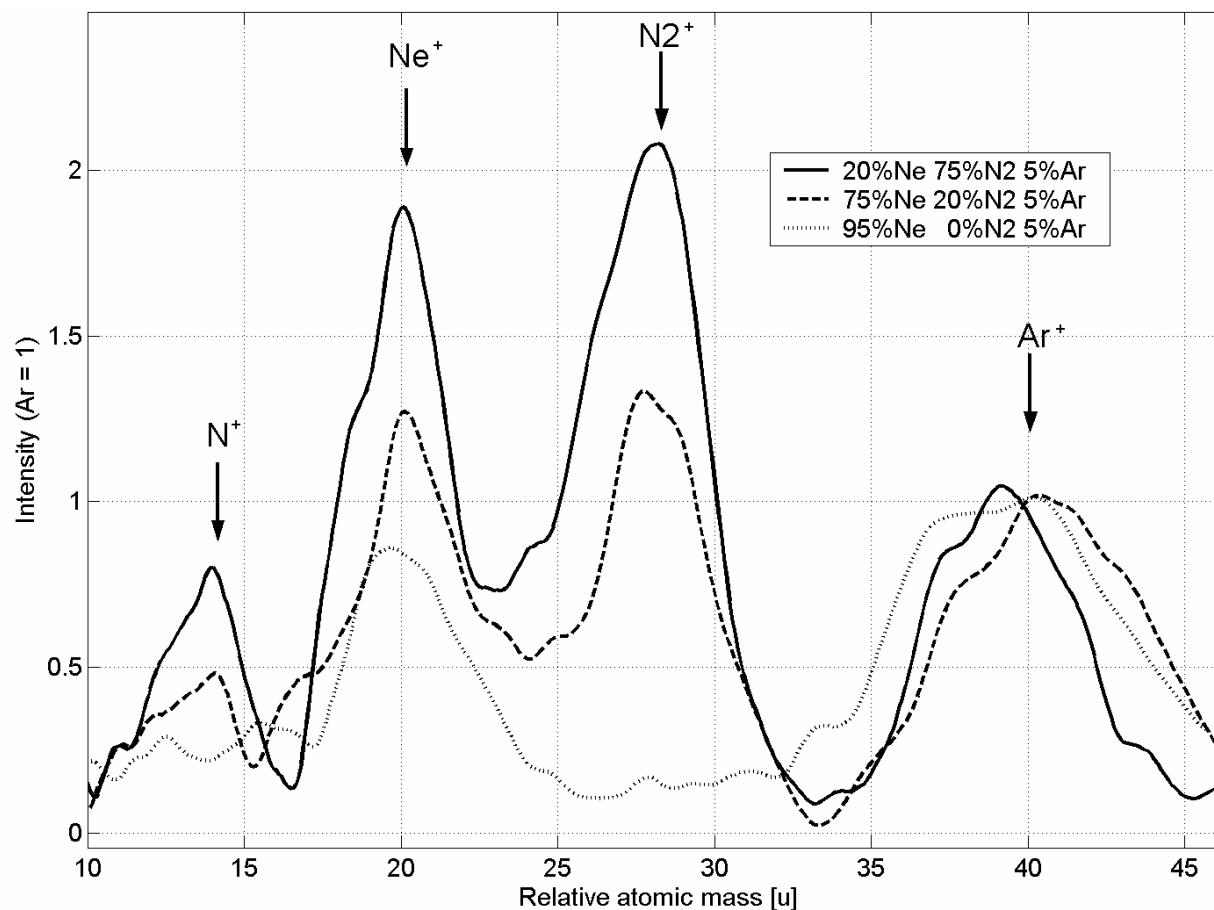
Synchronous ion shield



Time of flight



TOF mass spectrometer



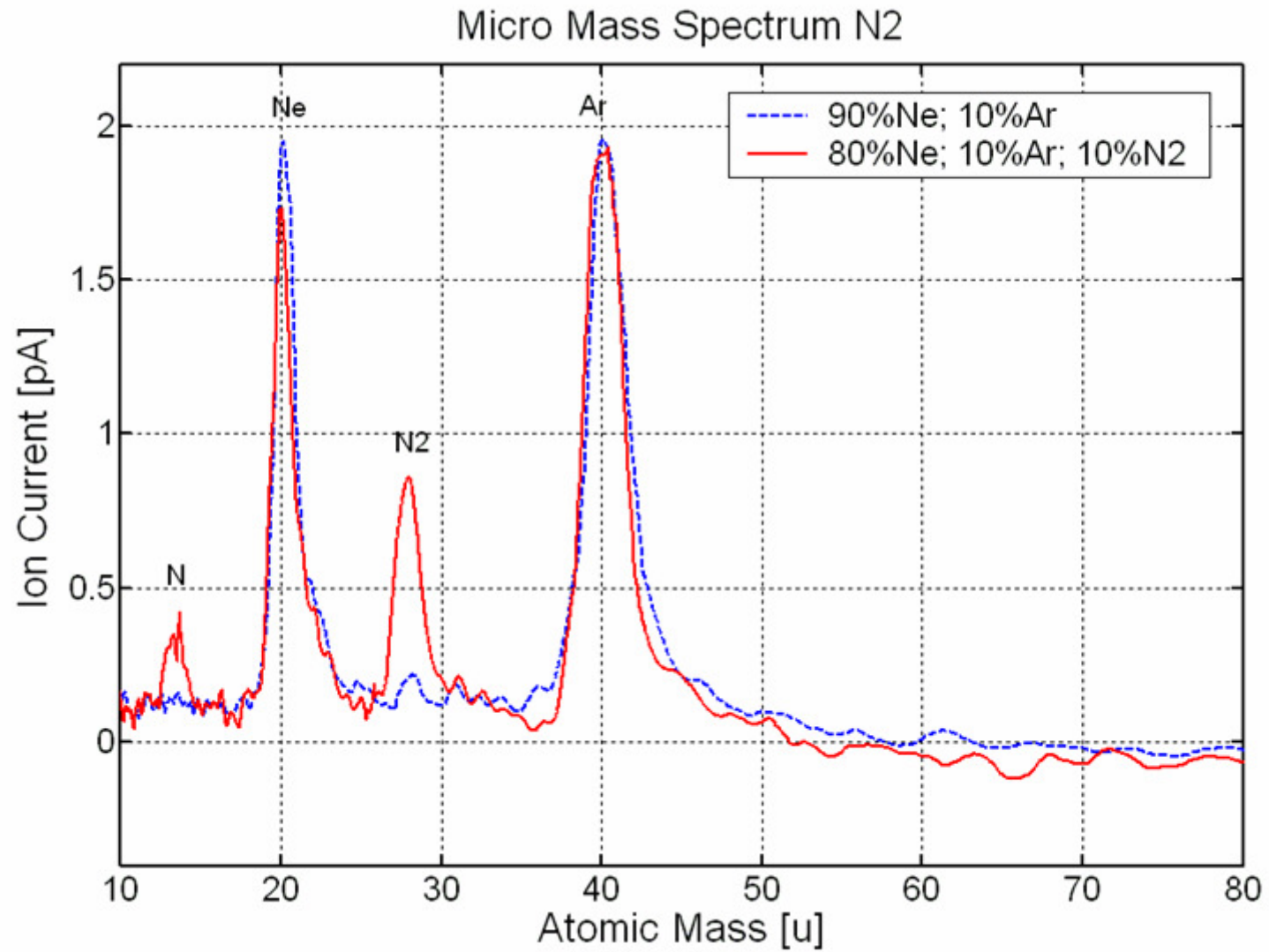
Results

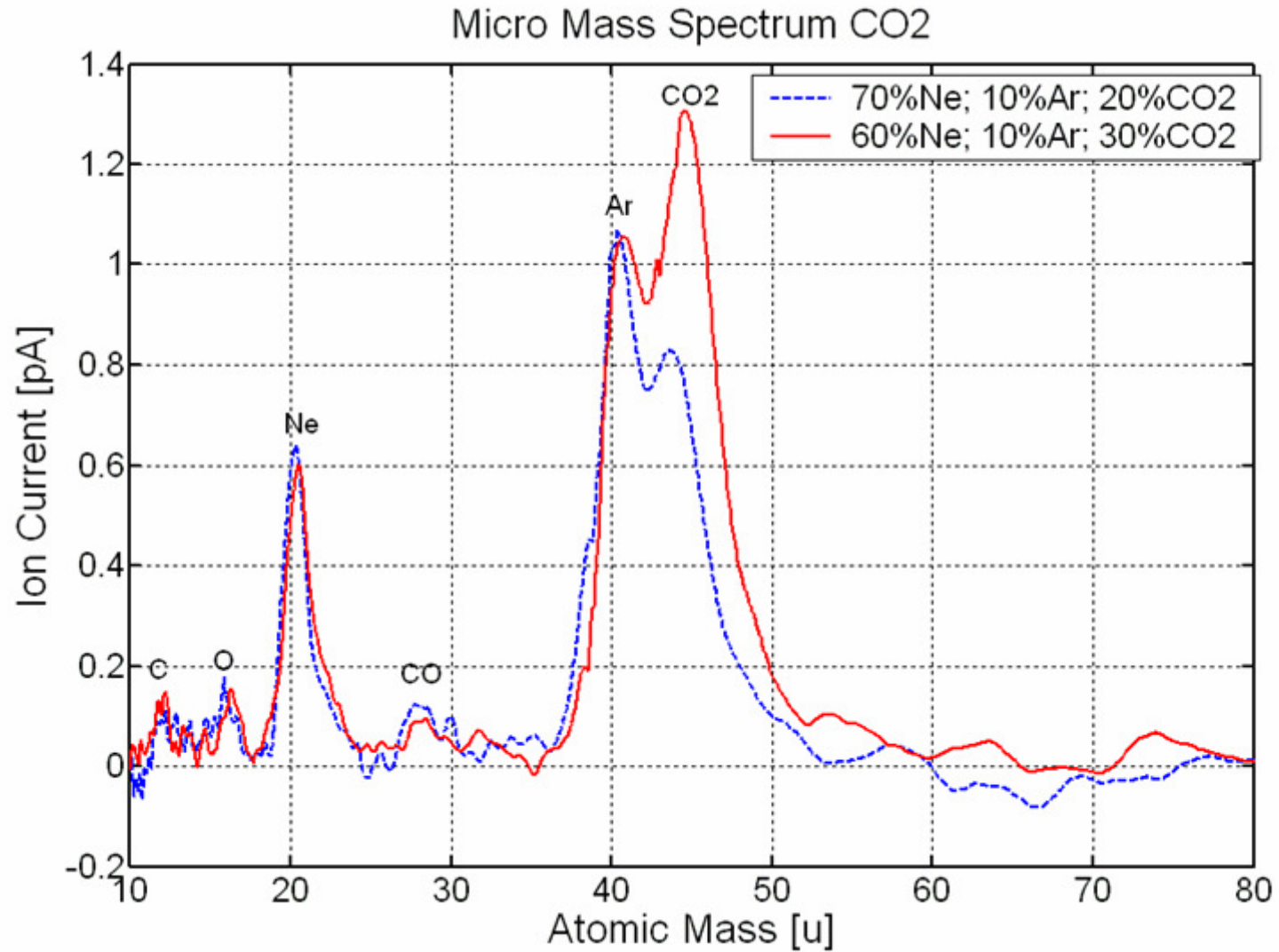
SIS

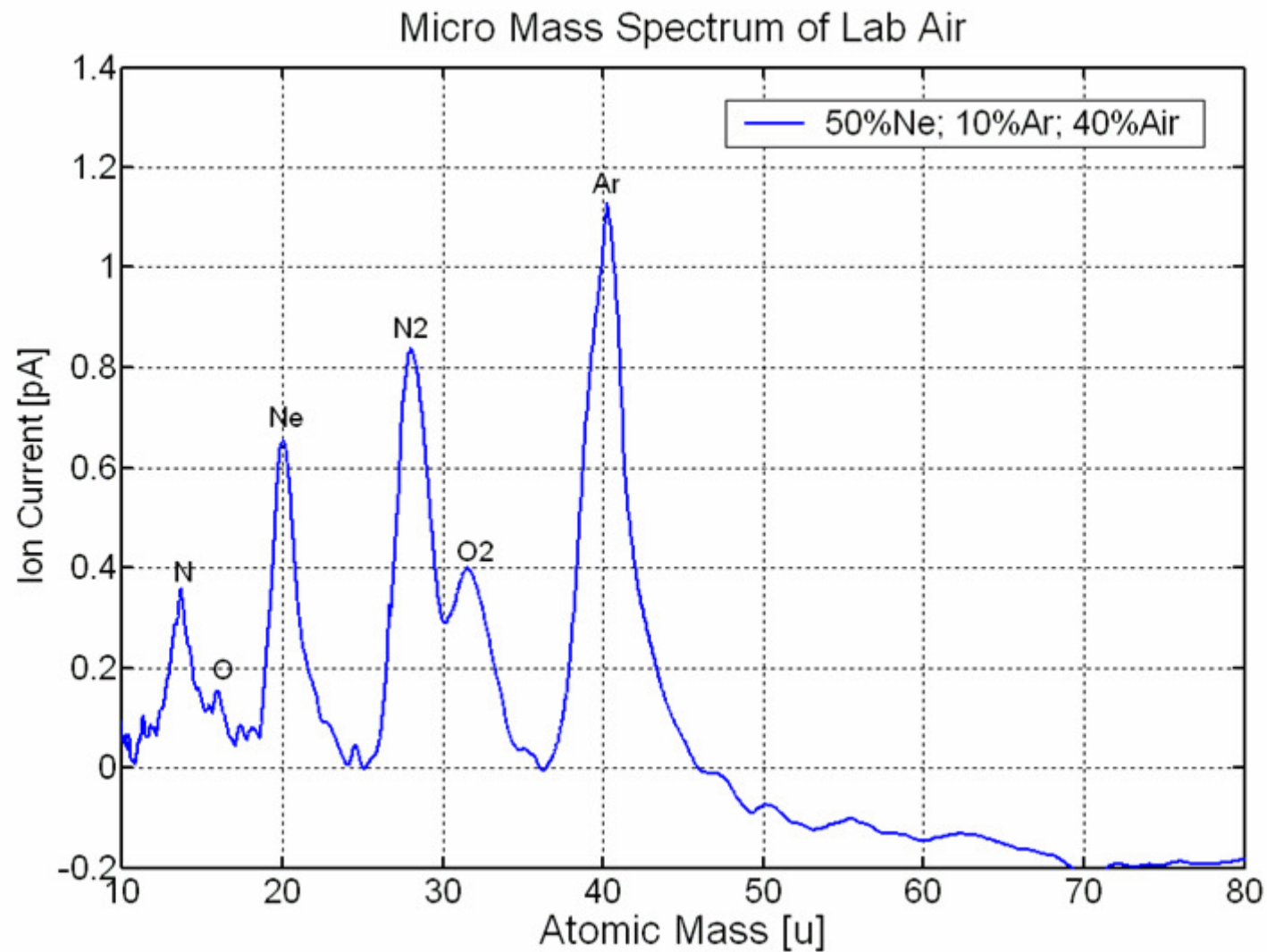
Micro Mass Spectrum



SIS





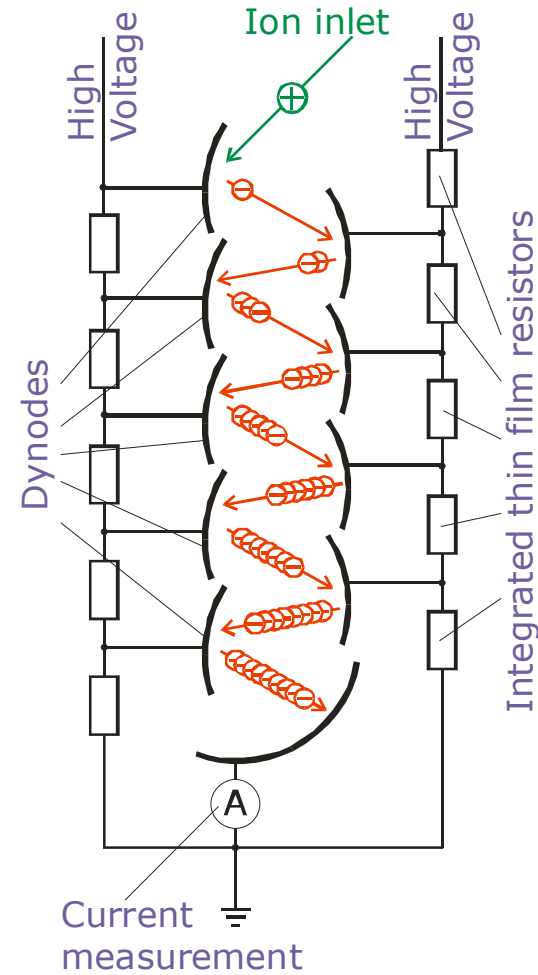
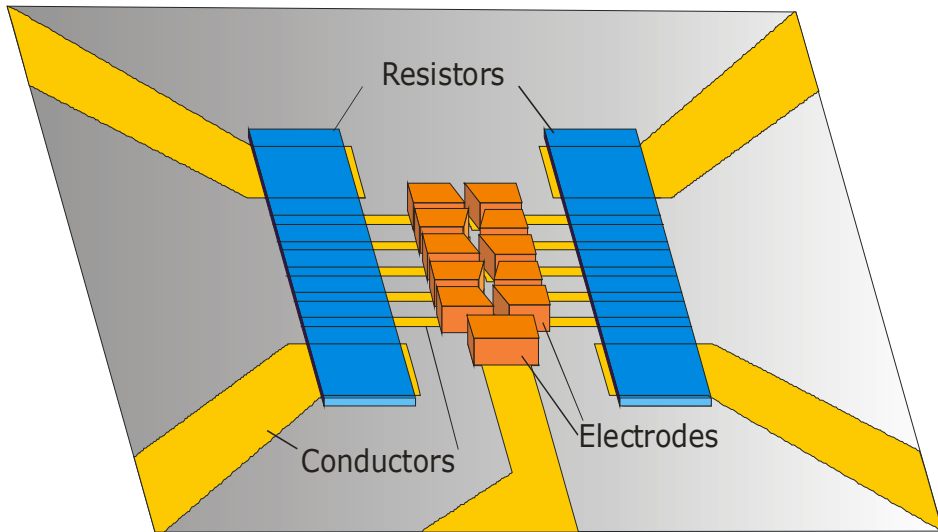


Conclusion

- Portable and stationary applications
- Function principle of the PIMMS
 - Time of flight
 - Synchronous ion shield
- Fabrication in MEMS technology
- Mass spectra
 - Air
 - N_2 , CO_2 (including fragments)

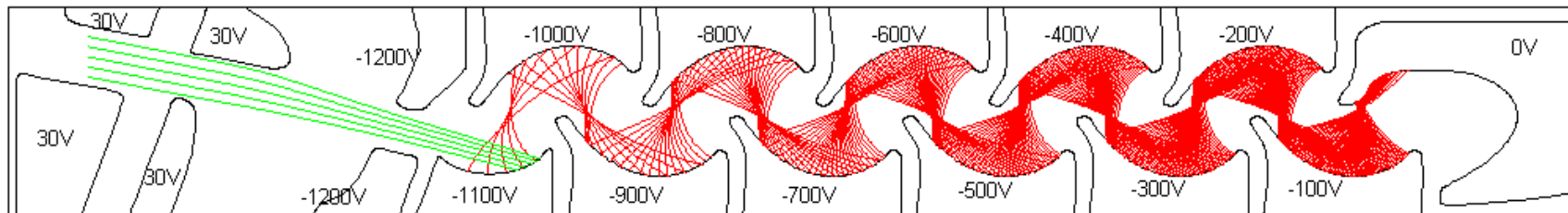


SEM Function principle

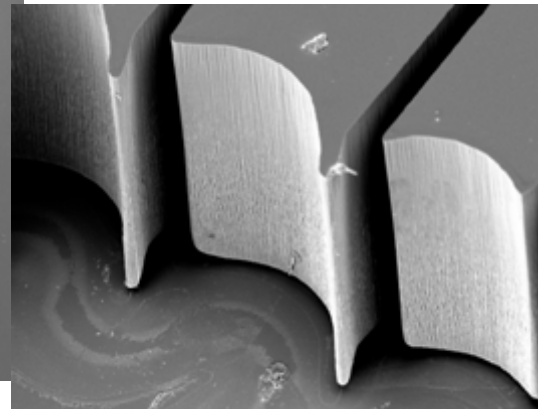
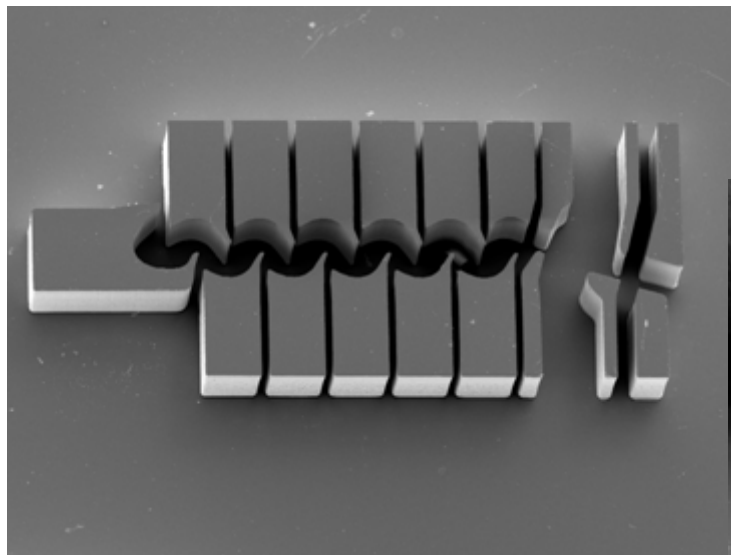


Outlook: Secondary Electron Multiplier - 24 -

SEM Simulations



Comsol Multiphysics®
and Matlab®

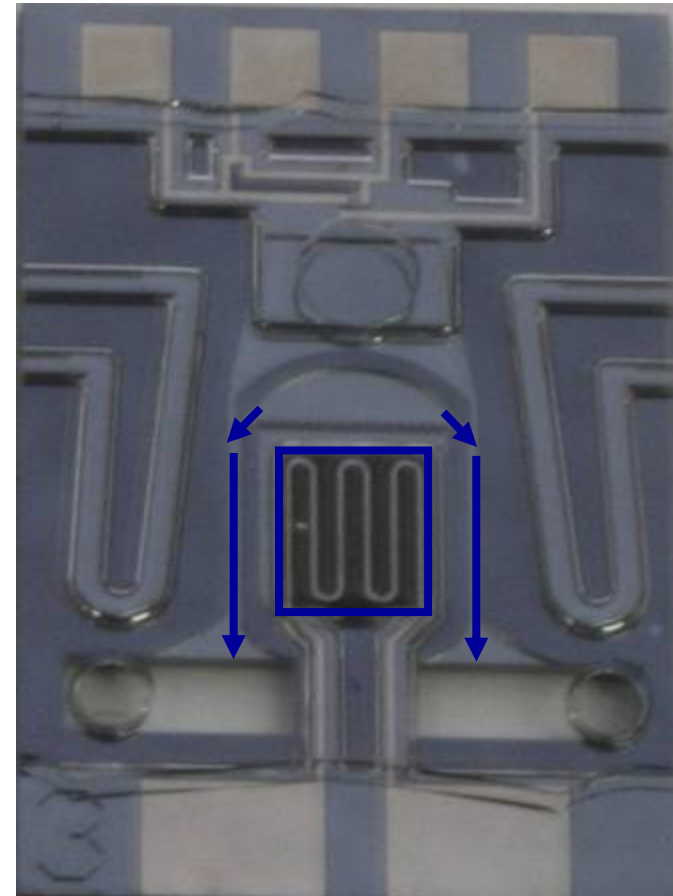
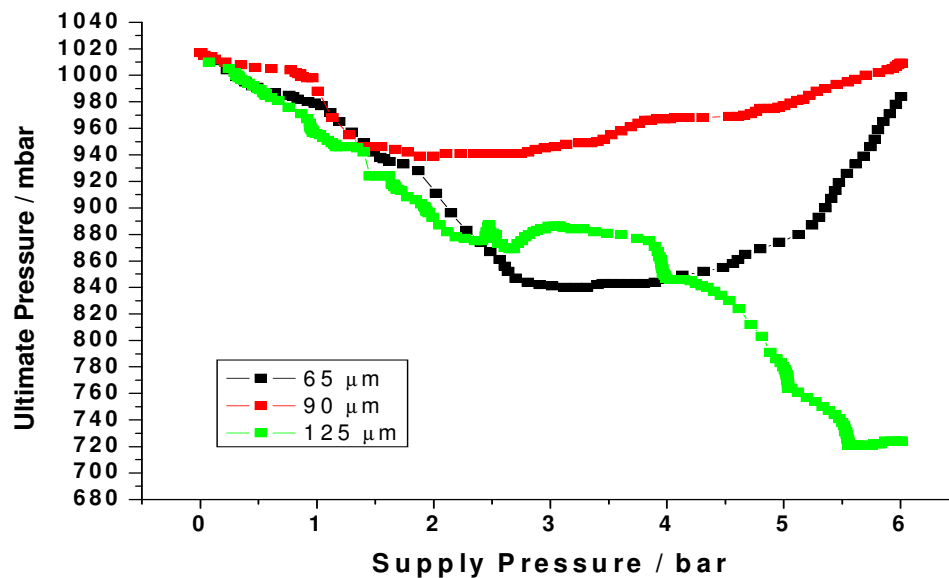


Images of test structures

Outlook: Micro pump from Marco Doms ^{- 25 -}

Diffusion pump principle (water vapor):

1. Vaporize driving liquid
2. Nozzles form steam stream
3. Impulse transfer on residual gas
4. Steam condensates
5. Fluid collection



- Secondary electron multiplier
- Geometry optimization
- Pressure measurements
- Integrated electronic
- Application oriented measurements
 - Needs for HEMS?



Acknowledgement
to
HEMS Student Awards Committee
for
HEMS 2007 Student Travel Award



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DFG