Transfer Efficiency and Timing Performance Measurements of Multipole Ion Guides and Ion Wave Guides Constructed with Planar Technologies

Albrecht Glasmachers, Alexander Laue, Albrecht Brockhaus; University of Wuppertal, Germany
Michel Aliman; Carl Zeiss NTS GmbH, Oberkochen, Germany

University of Wuppertal, Germany
Institute for Pure and Applied Mass Spectrometry

Introduction

Overview:

For the transfer of ions between different stages within a mass spectrometer, structures with radial storage fields (ion funnels or 2-D multipoles) superimposed with axial transport fields (DC gradients for ion guides or traveling potential wells for ion wave guides) are investigated.

Challenge:

Design and realization of precise mechanical components combined with electrical parts and wiring without high manufacturing and assembly cost

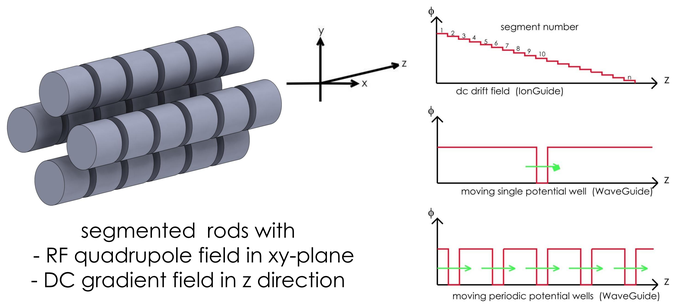
Approach:

Development of special solutions which can be fabricated with standard high precision technologies for printed circuit boards. Metrological characterization of transfer performance.

Methods

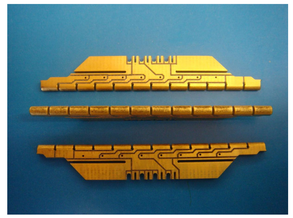
Waveguide	12 stage quadrupole structure with radius of 1 mm and segment length of 4mm. Designed with gold-plated PC-boards
RF supply	Self-made 5W push-pull amplifier driving a transformer with 4 tapped secondary coils
Ionization source	UV laser 266 nm, 200 µJ pulse energy
Shift pattern generator	Self-made, µC-based with programmable parameters
Ion detector	Self-made Faraday Cup with low noise charge amplifier (1pF, 680 meg)
Buffer gases	Nitrogen, (Helium)
Gas phase sample	Toluene

Principle of Operation

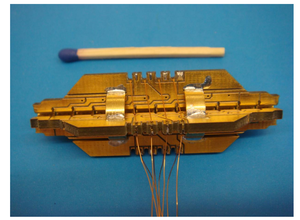


segmented rods with
- RF quadrupole field in xy-plane
- DC gradient field in z direction

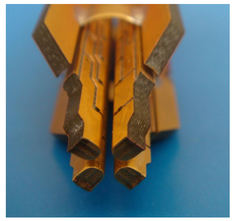
Realization of Ion Wave Guide



- PC-Boards (FR4 or Rogers 4000)
- 2.2 mm thick, gold plated
- 12 segments , each 4mm long



- precise assembly by gold plated rings
- simple connection by copper wires

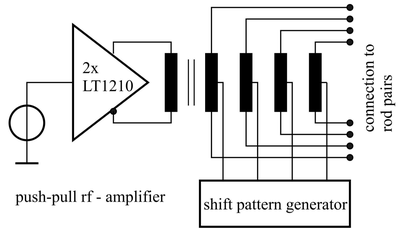


- quadrupole radius: 1 mm
- interface radius: 4 mm
- max. radius: 20 mm

Sample

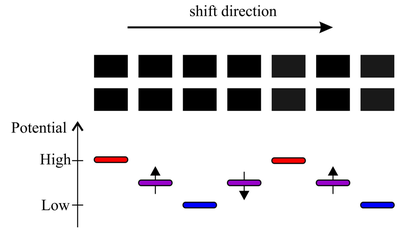
Experimental Setup

Circuit Diagram



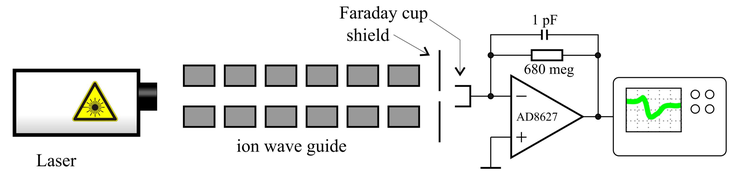
- frequency: 2 MHz to 5 MHz
- amplitude: up to 150 Vpp

Shift Pattern



- periodic pattern with 4 phases
- phase periods: adjustable 50 µs to 500 µs
- potential wells: adjustable 1V to 5V

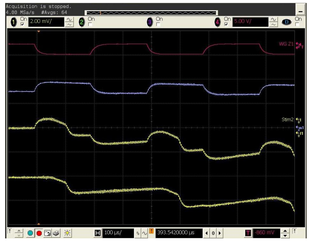
Measurement Setup



- UV laser, wavelength 266 nm, pulse-energy 200 µJ
- sample: toluene
- cooling gas: nitrogen, pressure 10^{-1} to 10^{-3} mbar

Measuring Results

Crosstalk Correction

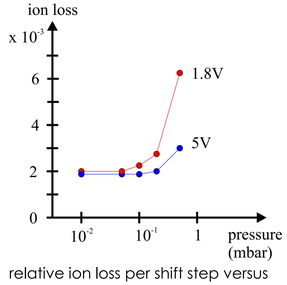


from top to bottom:
- shift signal at the last segment
- output signal, laser off, (crosstalk only)
- output signal, laser on (ion signal + crosstalk)
- after crosstalk subtraction (ion signal only)

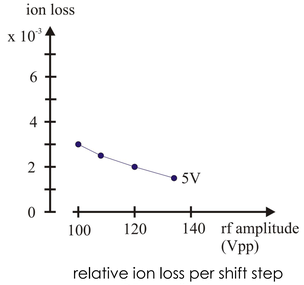
Shift Performance

- top: shift signal at the last segment
- bottom: output signal, (crosstalk subtracted)
- left: „smooth" shift
- right: „abrupt" shift

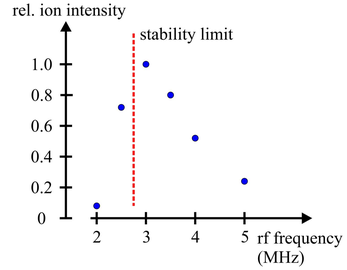
Transfer Efficiency



relative ion loss per shift step versus cooling gas pressure with potential well depth of
- red: 1.8V
- blue: 5.0V



relative ion loss per shift step versus RF amplitude with potential well depth of 5V



Conclusions

Technology

→ precise planar structures
→ standard PCB technology
→ easily customizable design
→ cost efficient
→ bake-out up to 180° Celsius

Measurement results

→ high transfer efficiency
99.8 % per shift step
→ mass range adaptable by
RF frequency and amplitude
→ smooth segment to segment transfer with variable shift speed
→ precise timing for fast ion ejection

Future aspects:

→ investigations of designs with minimal outgassing
→ design of gas-tight solutions for pressure stages

Acknowledgement

Financial support of this work by Carl Zeiss NTS, Oberkochen, Germany.