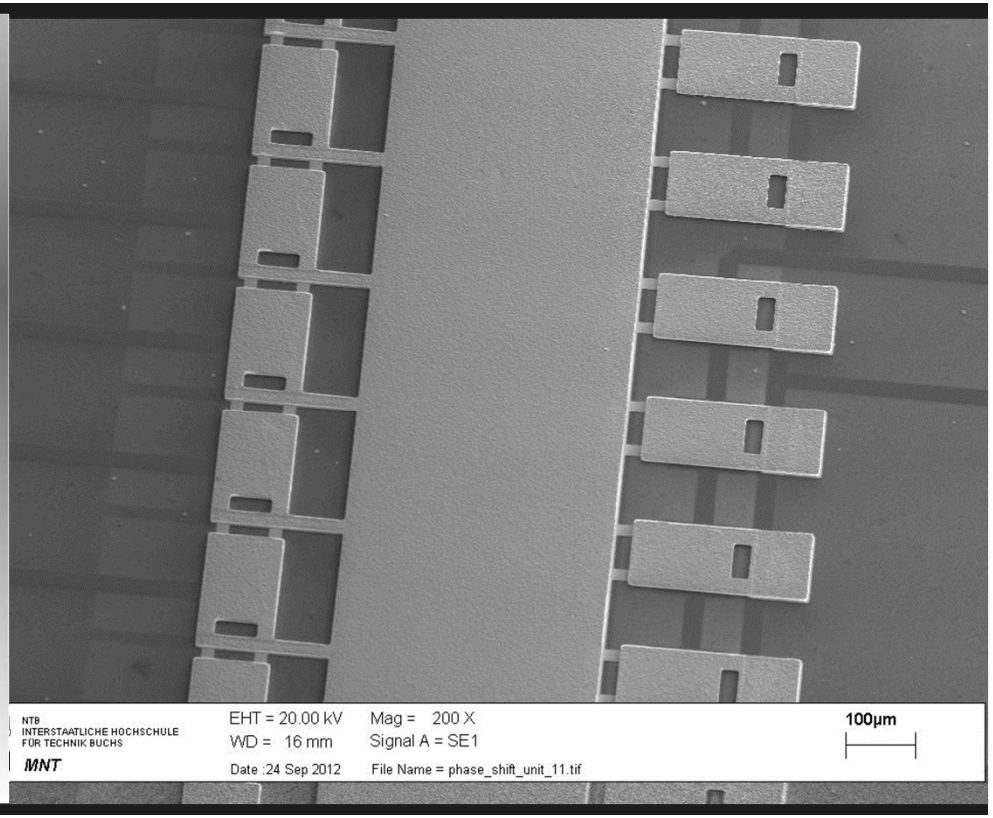
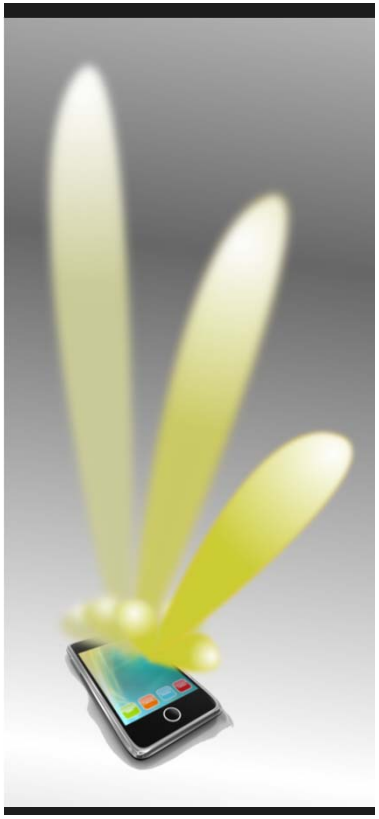
NTB
INTERSTAATLICHE HOCHSCHULE
FÜR TECHNIK BUCHS

Development and Industrialization of RF MEMS





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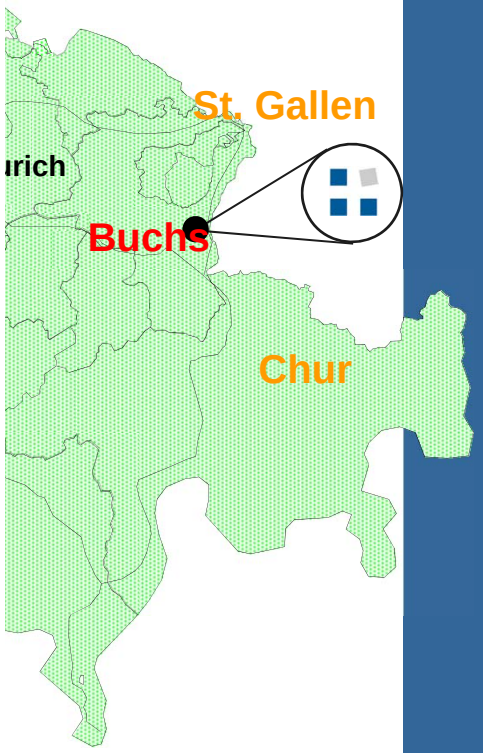
Näher dran
am System
der Technik
der Zukunft

Content

Introduction

Institute for Micro- and Nanotechnologies
Buchs, Switzerland



MEMS Group

- MEMS **modelling** and design
- MEMS **fabrication**
- **Analytics** and **testing**
- **Technology transfer** and **packaging**

Innovations and their Transfer to Industries

Innovation takes place everywhere!

- Always be one step ahead
- Advantages through technology may be the most sustainable.

What is a Company's Motivation for Collaboration?

- to be involved into R+D
- to extend its resources, which are limited
- to extend its competences in a particular filed
- to gain access to innovation

What is Technology Transfer?

- Together with industries, we **transfer** research results into efficient fabrication processes.
- Together with industries, we **implement** novel technology into existing or new products.

External Partners

Advantages of working with external partners

- External partners support a company with their individual competences.
- Can support the company with man power, while being willing to transfer/implement research results.
- Can help the company to develop a new product with given requirements and defined interfaces.
- Can provide the company with an independent expertise
- Can provide results from «field trials»

Example:
Development and Industrialization of a RF MEMS

Industrial Partner: Reinhardt-Microtech AG, Wangs, CH

- An experienced supplier in thin-film circuits on microwave substrates.
- Good customer relations
- Small R+D resources
- Limited competences in the field of application of their products.

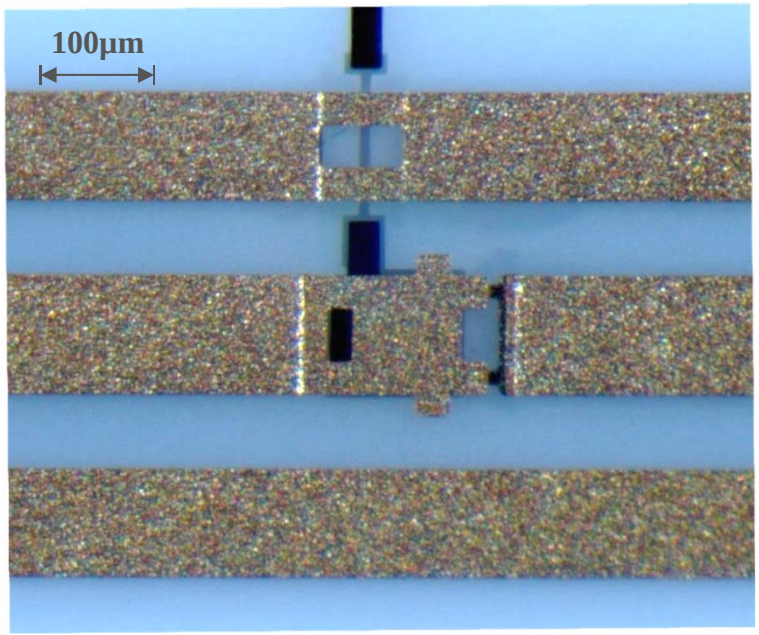
reinhardt
MICROTECH

Development and Industrialization of a RF MEMS

Innovation

- Make micro-electromechanical switches available in order to enable true time delay networks used in electronic scanning antennas.

- The same MEMS fabrication process can be used to realize programmable matching networks or programmable filter networks



Development and Industrialization of a RF MEMS

Founding

- European Project (EURIMUS) coordinated by THALES
- KTI/CTI Founding 381kCHF

External Partners:

- System integration, THALES
- Independent Expertise's, CNES
- «Field trials», ESA
- First demonstrators in lab, non-compatible with industrial purposes, XLIM
- Redesign, process development and material evaluation, technology transfer, process validation, measurement and analytics, NTB

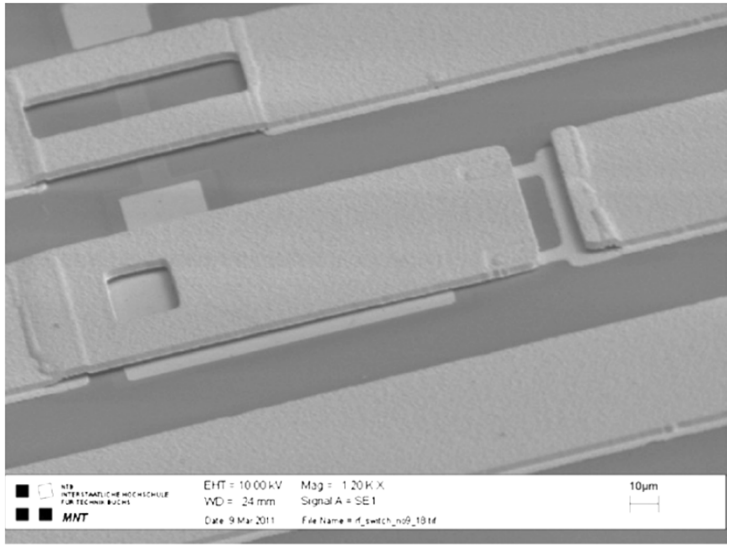
Development and Industrialization of a RF MEMS

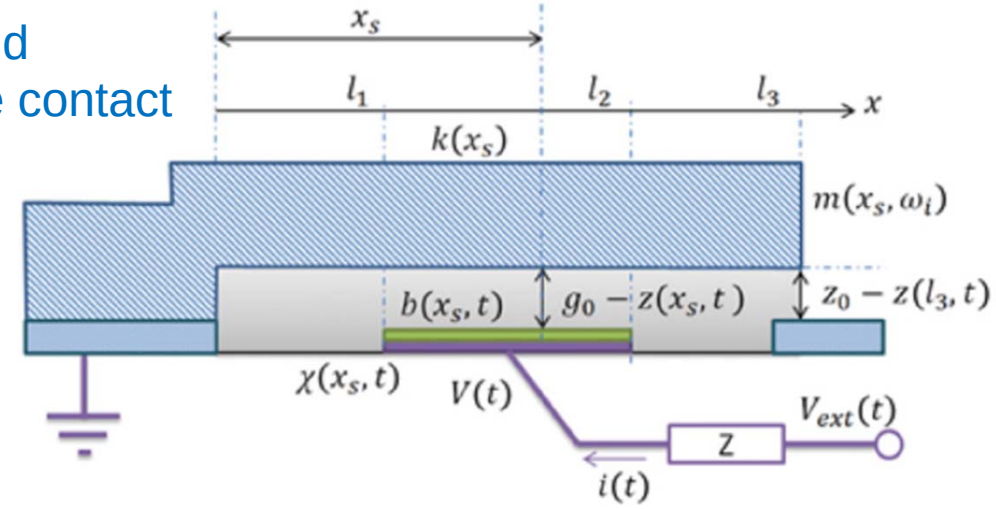
Modelling and Design

Which actuation voltage is required for a given RF isolation and contact pairing?

What are the influences of disturbances and process tolerances?

What are suitable dimensions and materials in order to increase the contact life-time?



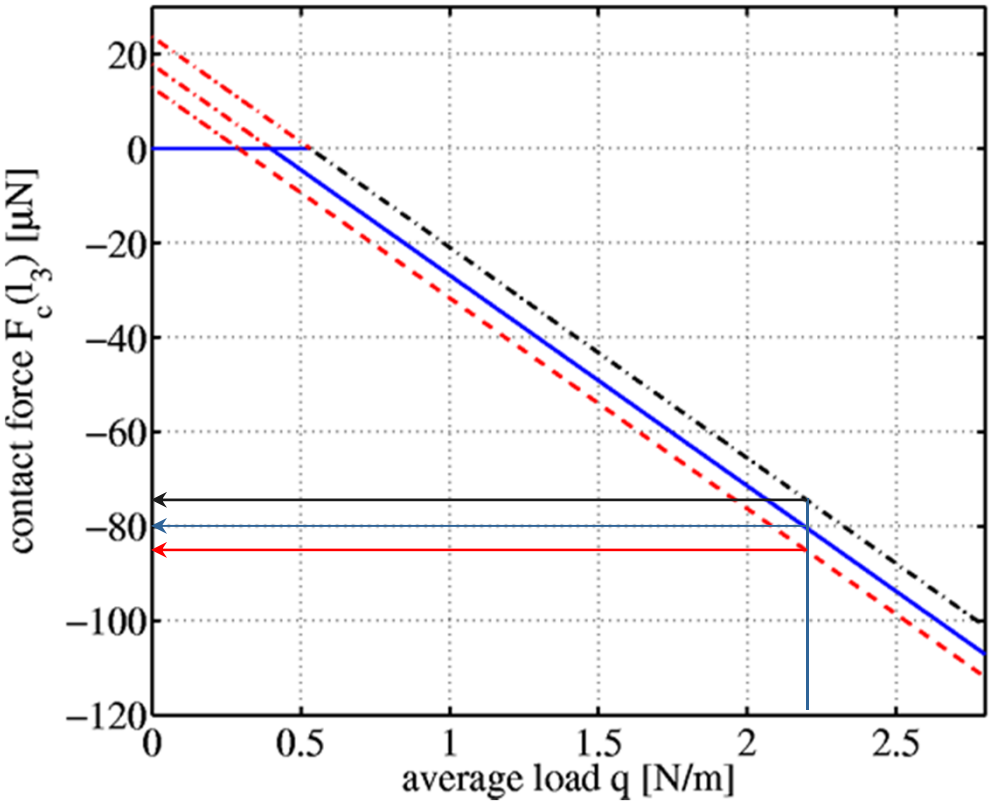


The influence of process tolerances

What is the influence of a cantilever thickness variation $t = (3150nm, 3500nm, 3850nm)$ on the static contact force?

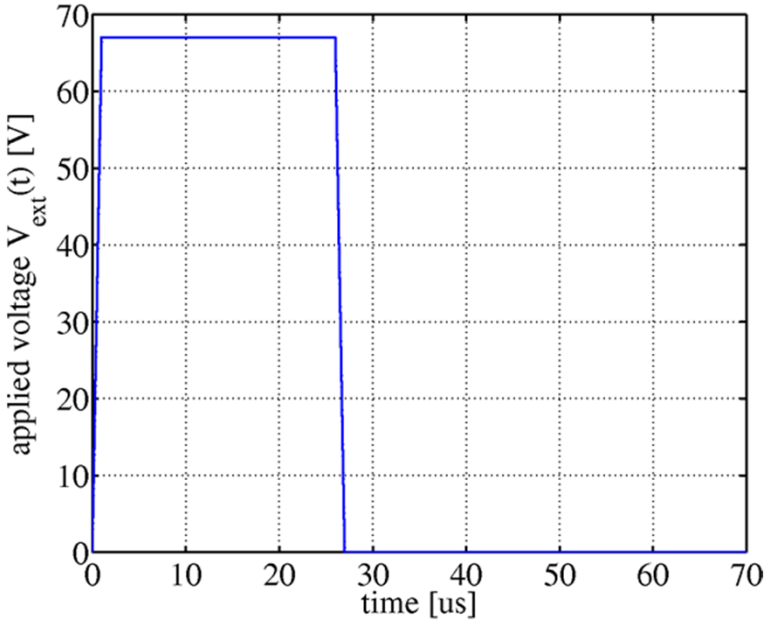
restoring force
13-24μN

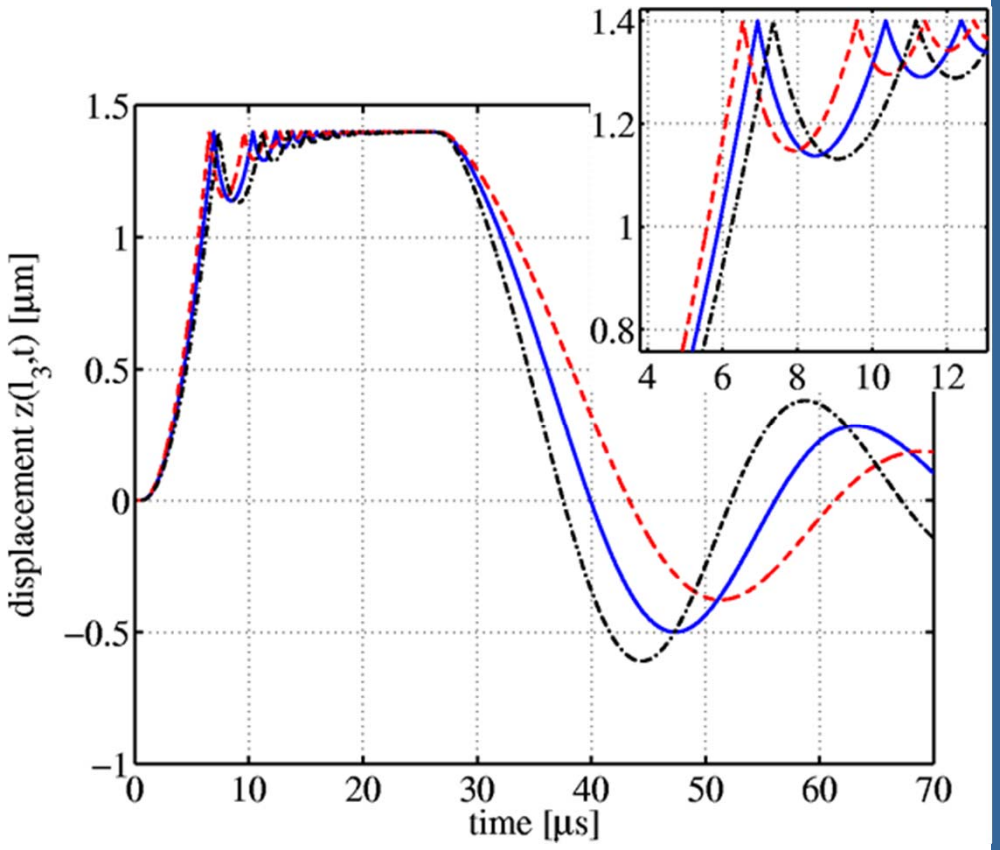
contact force
75-85μN



The influence of process tolerances

What is the influence of a cantilever thickness variation $t = (3150nm, 3500nm, 3850nm)$ on the switching dynamics?

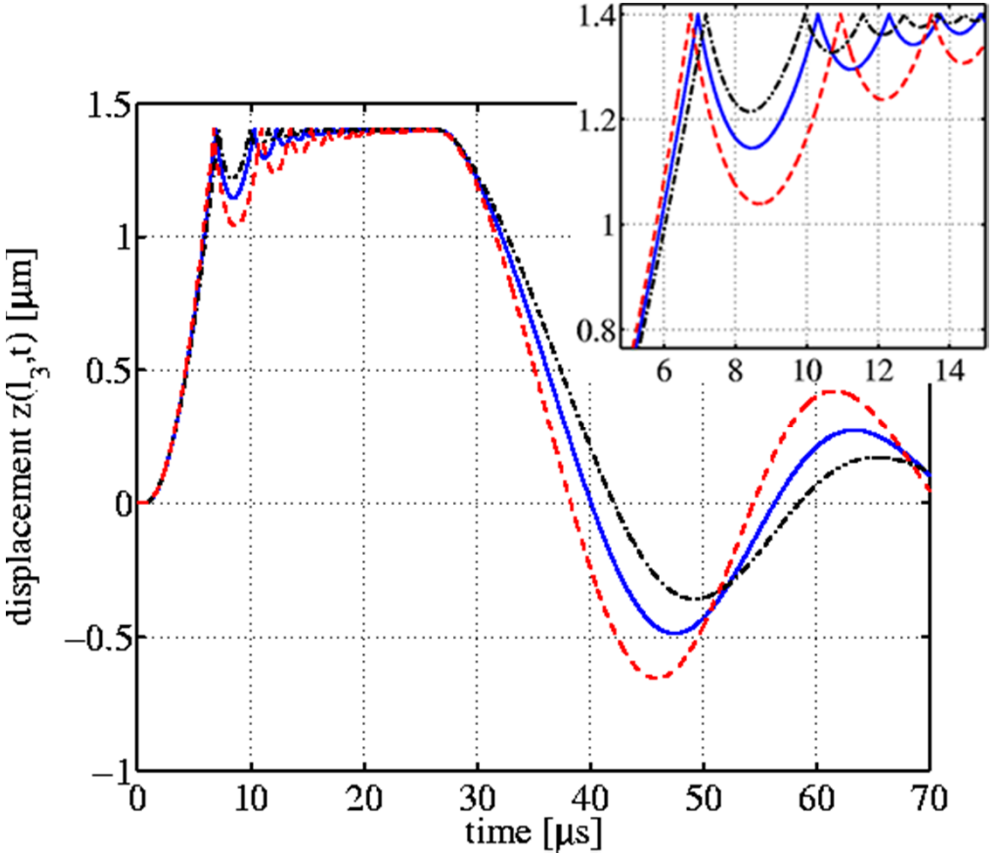




The influence of disturbances

What is the influence of a temperature variation
$T = (-73°C, 27°C, 127°C)$ on the switching dynamics?

Nitrogen at 1.0bar	
temperature T $[°C]$	viscosity $\eta(p,T)$ $[\mu Pas]$
-73	13.0
27	17.5
127	22.0

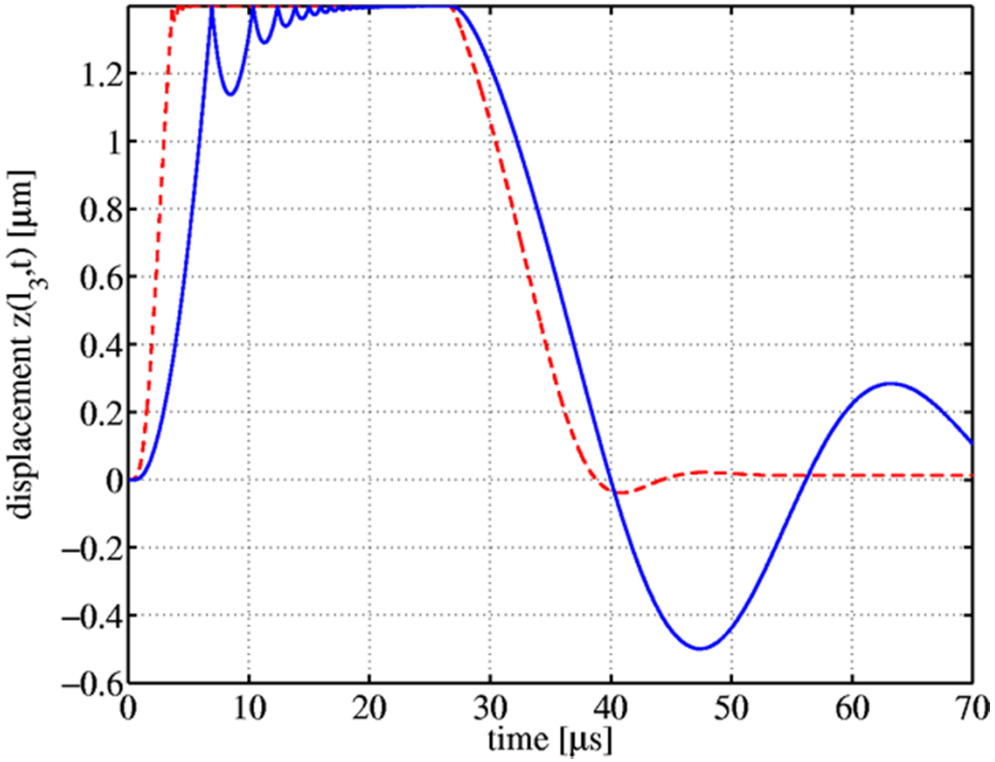


Tuning by the choice of the cantilever material density

What is the influence of the cantilever material density $\rho = \left(2700 kg/dm^3, 19300 kg/dm^3\right)$ on the switching dynamics?

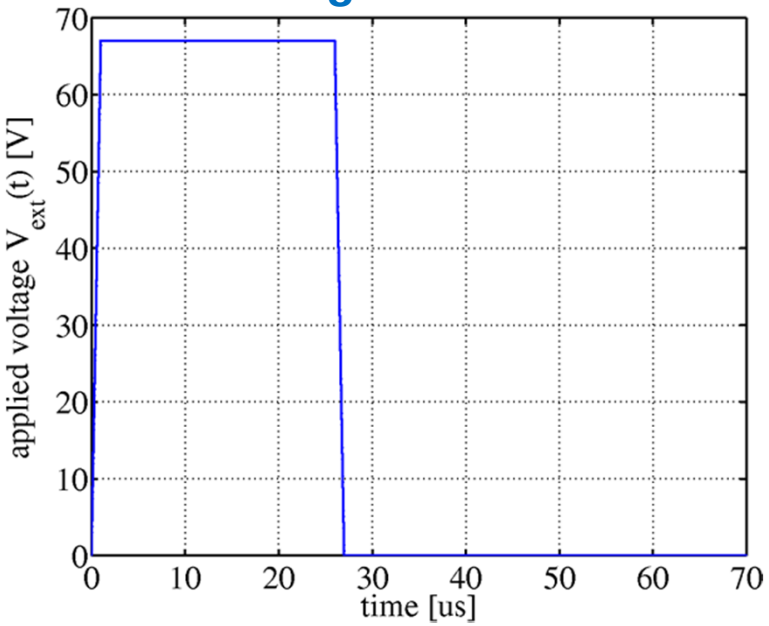
Since gold and aluminium have nearly the same plain-strain elasticity modulus, the static contact force is approximately the same.

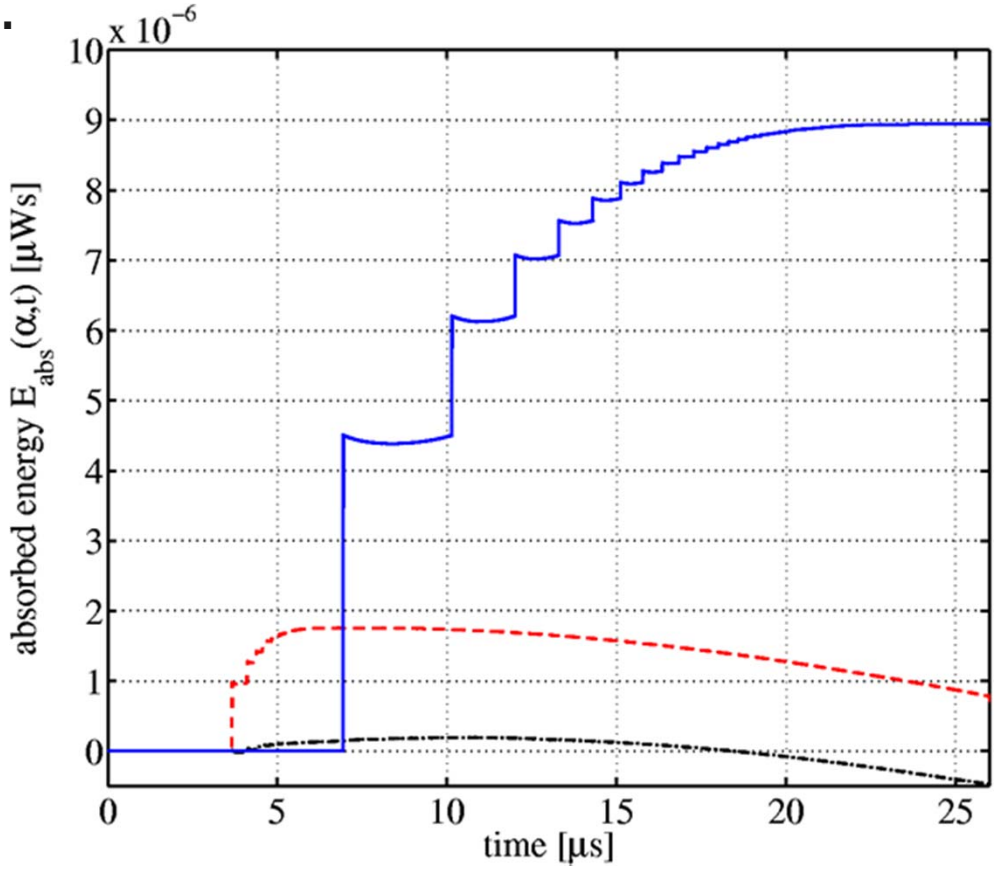
Faster switch on and switch off is achieved by using aluminium instead of gold.
In addition bouncing is reduced due to the lower resonant mass.



Tuning by the choice of the cantilever material density

Considering the energy absorbed by the contacts, assuming a momentum absorption coefficient of $\alpha = 0.05$ for a cantilever of gold and aluminum.



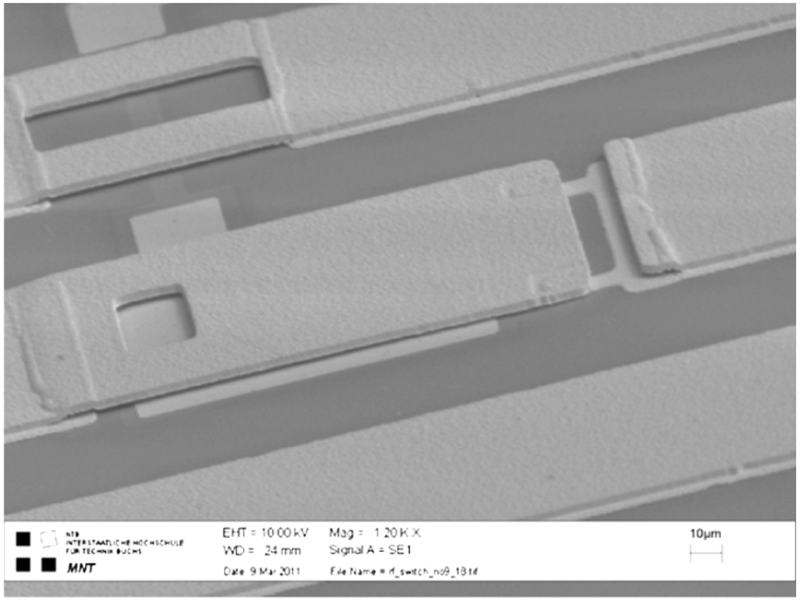


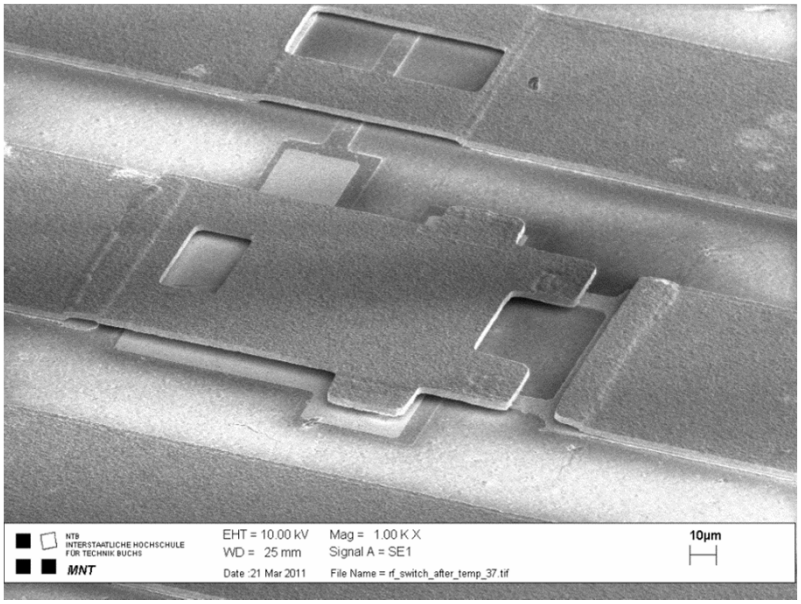
-. Simulation artefacts (error) due to changing boundary conditions

Development and Industrialization of RF MEMS

Fabrication

- This and many more switches have been fabricated in an industrial manner at RMT Reinhardt AG.





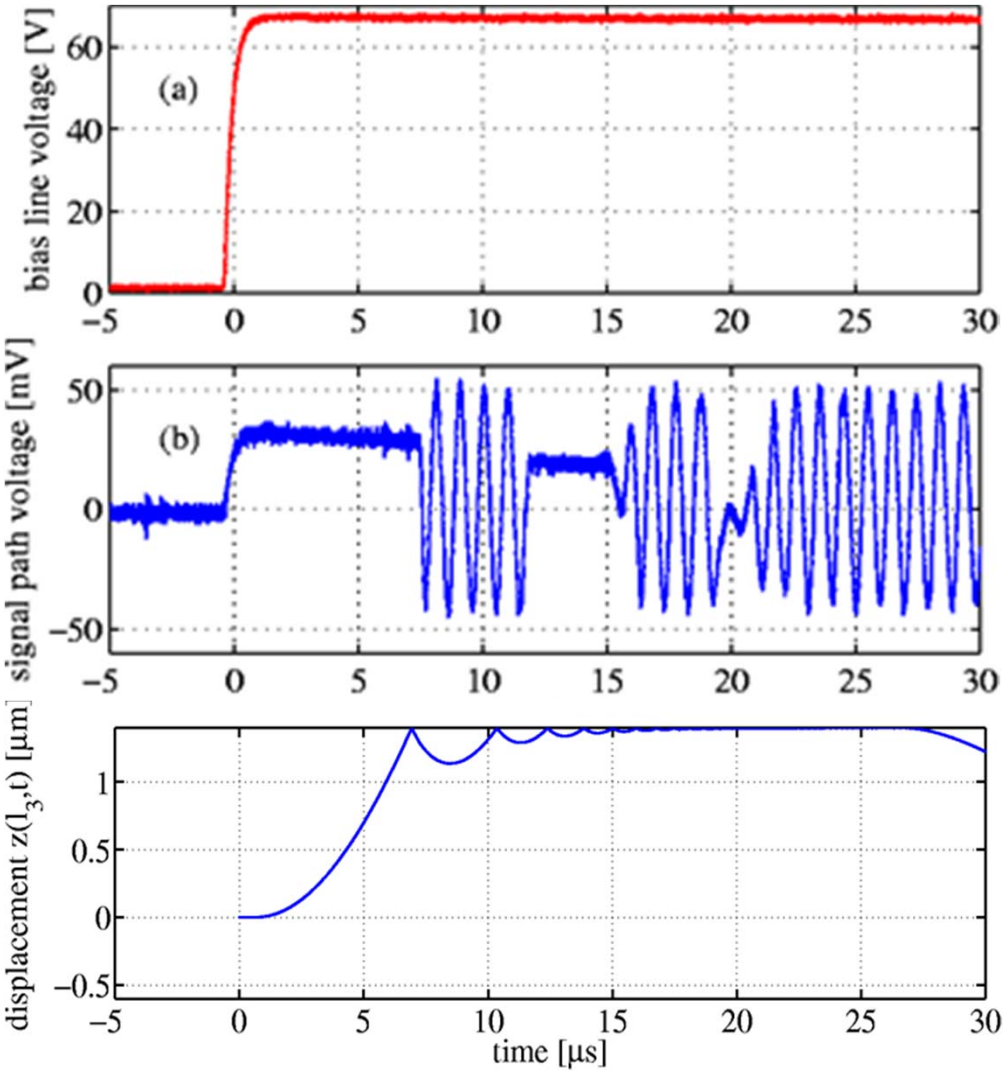
Experimental validation of the theoretical model

The meassured transition time of $7\mu s$ is in good agreement with the theoretical data.

The bouncing time of $3.5\mu s$ fits also with the theoretical model.

The contact time is around $5\mu s$, but not considered in the theoretical model.

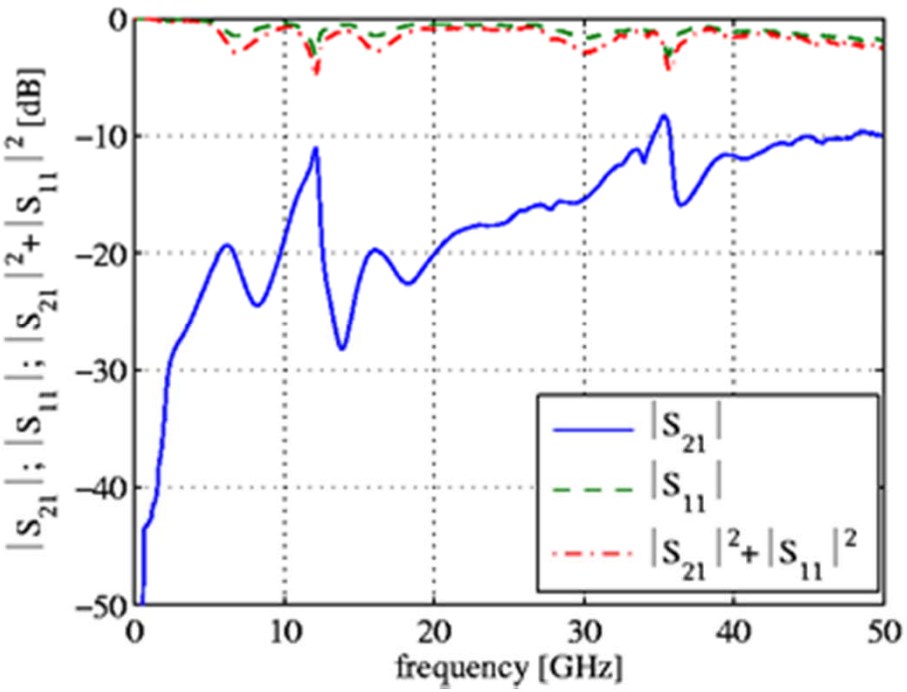
The signal switching takes $22\mu s$, and shows two bounces.

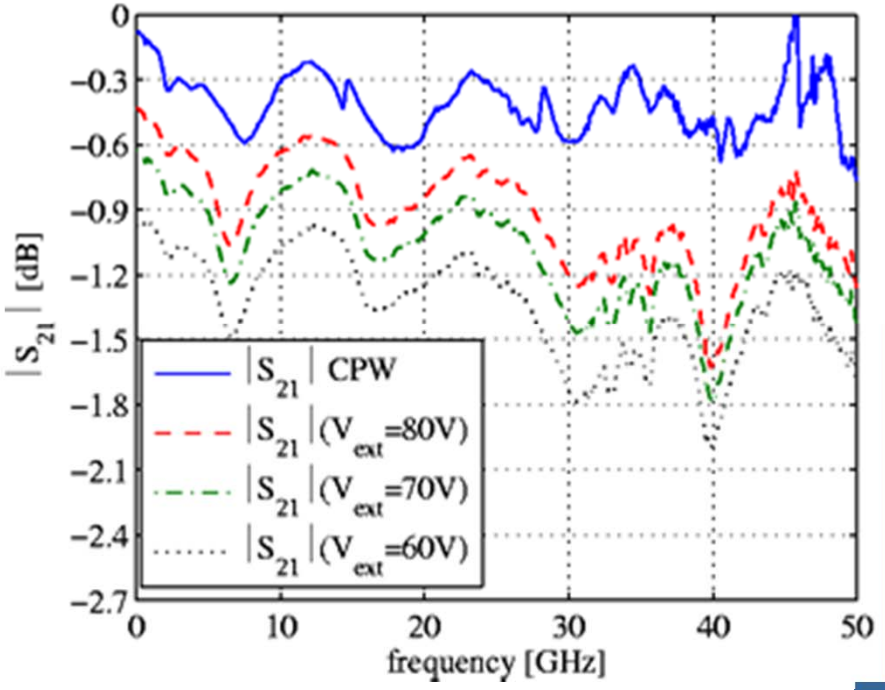


Development and Industrialization of RF MEMS

Characterization

- The fabricated switch show excellent isolation in the off-state. The insertion loss of the switch depends on the contact force.





**resonances stemming from the feed line length*

Summary

- Implementation of the research results or function demonstrators require technology transfer.
- Without technology adaptation, the idea will not result in a benefit.
- External partners can support small and medium sized companies with additional competences and can bring the product closer to a final application.
- **Based on the example of a RF-MEMS, Development and Industrialization can be achieved by collaboration with NTB.**

Please find further information regarding projects, technology analytic and process equipment on the web: www.ntb.ch/mnt

… thank you for your attention …