Bundesministerium für Bildung und Forschung

Microsystems in Practice

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Education Partnership and Sharing of Precious Resources in MST:

the Network pro-mst

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Aus- und Weiterbildungsnetzwerk für Prozesstechnologien in der Mikrosystemtechnik

pro mst

pro mst

Motivation I: FH Zweibrücken

☺ Excellent technical infrastructure (300 m² MST cleanroom for complete process runs) dedicated to education.

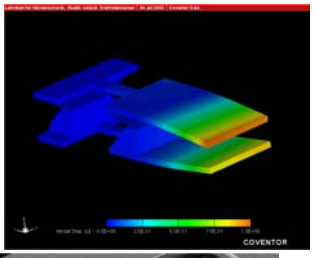
☹ Sustaining the cleanroom requires a minimum size, i.e. a critical mass of personnel and funding:

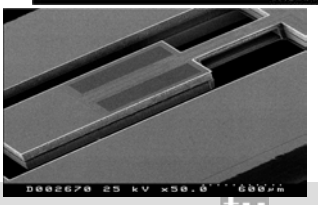
- **Too much for only education**

  Generally financed by research, which then often prevents proper education

Motivation II: Saarland University

- Dept. of Mechatronics with research focus on MST
  - Measurement tech., esp. microsensors
  - Micromechanics, microactuators/-fluidics
  - Materials for MST
  - Medical microtechnology
- ☺ Excellent theoretical education
- ☺ International research projects
- ☹ Limited technology (only for specific process steps)
- ☹ Limited practical experience for students





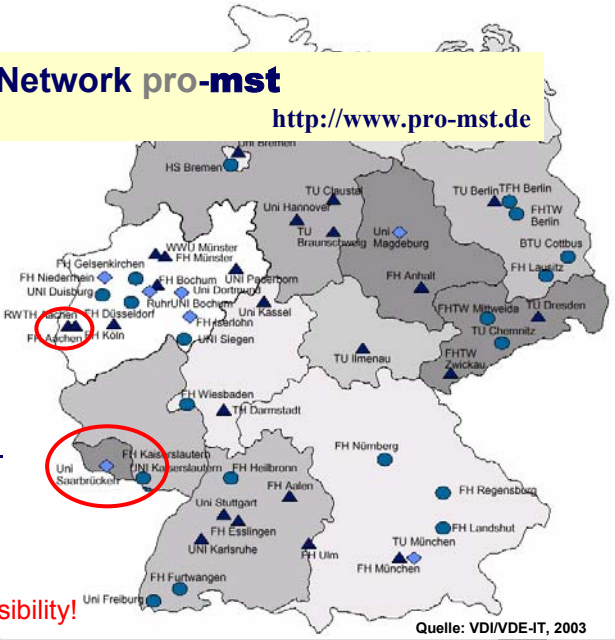
Motivation III

- HTW Saarbrücken, FH Aachen
  - Similar to Saarland University
- Research institutes (FhG-IBMT, IMM Mainz)
  - Training of new technicians and research personnel
  - Avoiding costly errors with downtime of critical equipment
- Companies (HYDAC, thinXXS)
  - Training of personnel
  - Cooperation in development with new processes

! **All** need more students, technicians and researchers

The Network pro-mst

http://www.pro-mst.de



Quelle: VDI/VDE-IT, 2003

Partners:

- 4 Universities
- 2 R&D-institutes
- 2 Companies
- 4 Pilot-schools

From 3 federal states:

- Rheinland-Pfalz
- Saarland
- Nordrhein-Westfalen

Education is state reponsibility!

pro-mst goals and activities

- Cooperation in education and research
  - joint effort in developing courses and training materials
  - joint definition of research projects
- Cooperation in financing the clean room used by all
- Joint PR activities in schools to increase interest in MST and technical disciplines in general
- Ultimately: Strengthening the economic competitiveness of the region Westpfalz/Saarland (still depending on coal and steel)

Examples for cooperation with schools

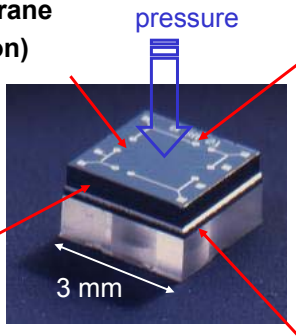
- MST introductory courses for teachers
  - Introduction to MST technologies, components and applications
  - MST-examples and experiments for use in classes (physics, tech)
- MST workshops in the cleanroom
  - Photolithography
  - Microstructure characterization
- Support of school projects
  - Sensors for a wind tunnel
  - Go-kart with micro-sensors

Examples for cooperation in education

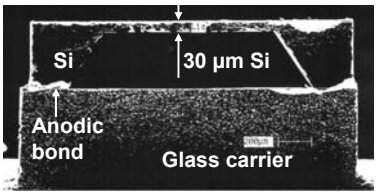
- Hands-on courses in the cleanroom in Zweibrücken for students from Saarland University
  - **Prerequisite**: courses in MST supplied by home university
  - **Preparation:** 3-day block course using the Virtual Cleanroom tools developed in the project ing-media (presented by A. Picard)
  - **Five day hands-on course** in Zweibrücken: complete process run for a simple pressure sensor (4 mask layers) from wafer preparation to sensor characterization
  - **Staffed from both** Zweibrücken and Saarland University

Pressure sensor prepared in lab project

4 piezo-resistive strain gauges in Si-membrane (bridge configuration)



Al leads and bondpads ("sputtered thin film")



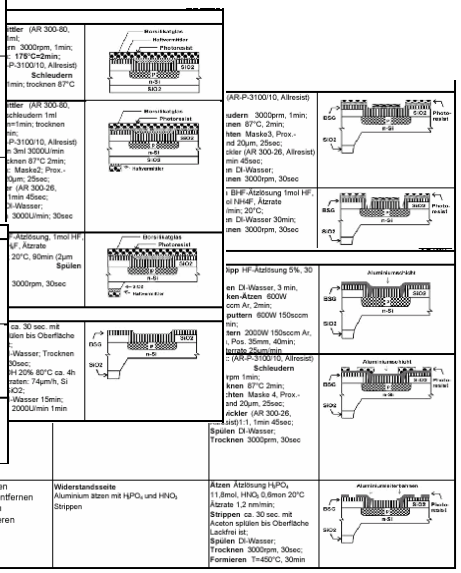
Si-chip with micromachined membrane (back-side etch)

Packaging: Si-chip bonded to glass carrier („Anodic bonding")

n-type Wafer, 4", 400µm Gesamtdicke,beidseitig poliert, <100> Orientierung

Nr.	Prozess	SiO2 -Maske für Dotierschritt	Paramerter	Schnittschema
	Piezoresistive Widerstände			
1	Thermisches SiO_2 Feuchtoxidation	beidseitig Feucht-Oxidation erzeugen einer Isolationsschicht und Ätzmaskengrundlage	**Oxidationsstufe:** 1000°C, Bub.+Heizb.95°C; **Tempverierung** 2slm N2, Oxid.=0,9slm O2-feucht 12h; **Abkühlung** 2slm, N2	
2	Haftvermittler Softbake	beidseitig **Haftvermittler** auftragen, für eine bessere Haftung des Fotolackes während des Ätzprozesses	**Haftvermittler** (AR 300-80, Allresist) 1ml; **Schleudern** 3000rpm, 1 min; **Trocknen:** 175°C=2min	
3	Belacken Softbake Belichten Entwickeln	**Widerstandsseite** **Halbmaske M1** auf Widerstandsseite: M2 abdecken, Proximity-Belichtung der Waferhalfte W1 mit M1; Maske horizotal drehen und Belichtung für W2 wiederholen	**Lack** (AR-P-3100/10, Allresist) 1:1 3ml, **Schleudern** 3000U/min=1min, **Trocknen** 87°C=2min; **Belichten** Maske1, Prox.-Abstand 20µm, 17sec; **Entwickler** (AR300-26, Allresist), 1min 45sec; **Spülen**, DI-Wasser; **Trocknen** 3000rpm, 30sec	
4	SiO_2-Ätzen	**Widerstandsseite** **HF-ätzen**, erzeugen einer Diffusionsmaske (Widerstandsstrukturen) in der SiO_2 Oberfläche, anschließend Spülen+Trocknen	**Ätzen** BHF-Ätzlösung 1mol HF, 2,8 mol NH_4F, Ätzrate 25nm/min, 20°C, 90min (2µm SiO_2) **Spülen** DI-Wasser 30min; **Trocknen** 3000rpm, 30sec	
	Bor- Dotieren und BSG-Isolation			
5	Lack entfernen Spin-on-Dopand aufschleudern	**beidseitig** **Strippen** Lack und Haftvermittler entfernen, spülen, trocknen, **Widerstandsseite** **Spin-on Dopand** auf die strukturierte SiO_2 Seite auftragen	**Strippen** ca. 30 sec. mit Aceton spülen bis Oberfläche lackfrei ist; **Spülen** DI-Wasser; **Trocknen** 3000rpm, 30sec; **B-76X Dopand** =1,5ml; aufschleudern 3000rpm, 20sec; **Trocknen** 150°C=60sec.	
6	Diffusion	**P-dotieren:** Widerstandsbereiche (an den geöffneten SiO_2-Stellen) erzeugen; Diffusionsstufe wird vortemperiert, Wafer werden einfahren und derDiffusionsprozess gestarten.	**Diffusionsstufe** vortemperieren 870°C, 2slm N2; **Diffundieren:** 1000°C, 4slm N2, 100sccm O2, 15min;	
7	Verglasen Abkühlung	**Verglasen:** Spin-on-Dopand wandelt sich unter Wasserdampfzugabe zu Borsilikatglas;	**Diffusionsstufe verglasen** 1000°C, 4slm N2, 200sccm O2-Bubbler, 15min; **Abkühlen:** 45min, 2slm N2, auf ca. 650°C	

"Simple" pressure sensor: more than 100 process steps



The Future I: Cooperation with other Universities

- Courses offered to Higher Education Institutions
  - Nationally and internationally
  - Course program developed cooperatively adapted to education requirements of home university
  - Cost participation based on clean room and personnel costs necessary: 15 k€ for 5-day course for 12 participants
- R&D project support to realize own designs
  - Multi-project wafers with standardized process for education
  - Lower cost than foundry process for use in project groups
- Extension of cooperation to other technology fields?

The Future II: Commercial hands-on courses

- Course program making use of
  - Technical infrastructure (i.e. cleanroom, test equipment etc.)
  - Know-how available through the partners

  Aim: supplementing University funding for the cleanroom
- Advantage for companies and R&D institutes
  - Training of new staff without interrupting production
  - Preventing operating errors resulting in equipment downtime
- Standard courses
- User defined courses for specific requirements, i.e. regular training of new staff for companies

Commercial courses: example I

Cleanroom techn. and correct cleanroom behavior

- 2-day course
  - **Lectures**
    - Cleanroom technology, equipment and clothing
    - Cleanroom behavior
    - Measurement technology for cleanroom characterization
  - **Hands-on modules**
    - Correct clothing and behavior in the cleanroom
    - Use of cleanroom equipment
- Maximum 12 participants
- Cost: approx. 700 € per participant

Commercial courses: example II

MST technologies, components and applications

- 3-day course with hands-on modules
  - **Lectures** giving an introduction
    - Microtechnologies (lithography, thin-film technology) and equipment, characterisation and testing
    - Microcomponents, -sensors, -actuators and systems
    - MST applications
  - **Hands-on modules**
    - Lithography
    - Thin-film deposition
    - Sensor characterization
- Max. 9 participants, approx. 1200 € per participant

Conclusions

- New approach for sharing of precious ressources: Partnership in education and research
- Example for public private partnership
- Applicable not only to MST
- Solutions for financing across state borders required
- Please contact us for course requests/requirements

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