

Outline

- Part I - MEMS at Bosch and Foundry History
- Part II - Why Foundry Business?
- Part III - Product Development using Foundry Services
- Part IV - Factors Creating Customer Satisfaction
- Part V - The German Europractice Manufacturing Cluster



Outline

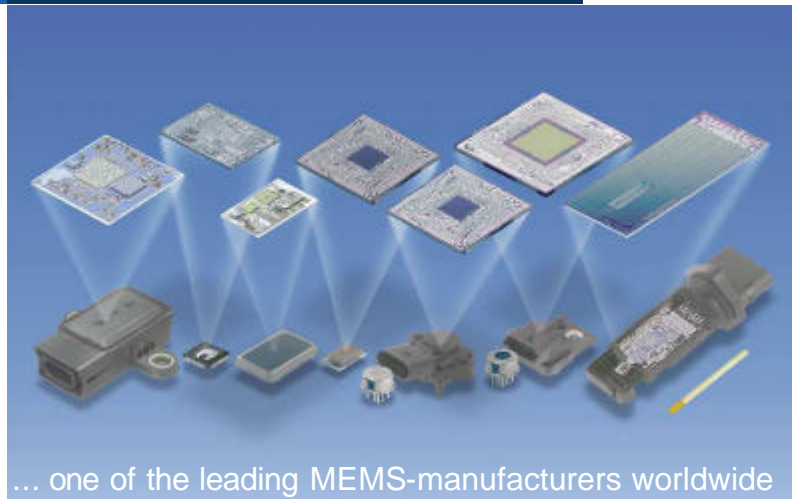
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Milestones MEMS at Bosch

- ⚡ 1987 Start of MEMS research activities
- ⚡ 1989 Development section for MEMS
- ⚡ 1992 Deep trench process developed (the "Bosch Process")
- ⚡ 1993 First volume MEMS-product: Pressure sensor
- ⚡ 1995 SOP micromachined mass flow sensor
- ⚡ 1997 SOP micromachined accelerometer
- ⚡ 1997 Start of component sales to external customers
- ⚡ 1998 Silicon gyro in mass production
- ⚡ 1999 Research Center Palo Alto founded
- ⚡ 2002 Market introduction of 2nd generation accelerometers
- ⚡ 2002 More than 70 Mio MEMS-based sensors per year
- ⚡ coming: Hydrogen sensor, gas sensor, new applications ...



Bosch Foundry Highlights

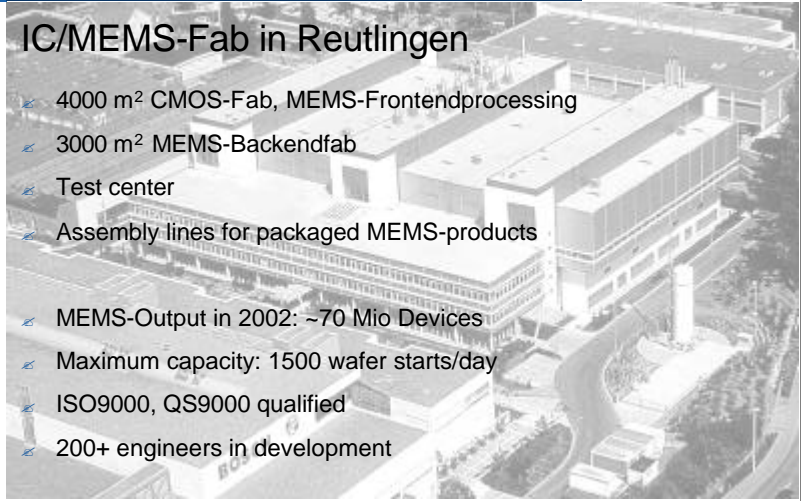
- ⚡ 1995 Release of Si surface micromachining design rules
- ⚡ 1996 1st MPW run with 10 customers
- ⚡ 2000 1st low volume production
- ⚡ 2001 1st single customer wafers
- ⚡ 2002 Start of bulk micromachining foundry activities targeting at life science applications;
Release of bulk micromachining process catalog
- ⚡ 2003 1st bulk micromachined biotech chips



IC/MEMS-Fab in Reutlingen

- 4000 m² CMOS-Fab, MEMS-Frontendprocessing
- 3000 m² MEMS-Backendfab
- Test center
- Assembly lines for packaged MEMS-products

- MEMS-Output in 2002: ~70 Mio Devices
- Maximum capacity: 1500 wafer starts/day
- ISO9000, QS9000 qualified
- 200+ engineers in development



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Why Foundry Business?

- Initially AE purely captive MEMS supplier
- Foundry service
 - helped to make known Bosch MEMS activities
 - provided confidence in Bosch microsystem technology
 - raised interest in the traditional Bosch market (automotive) as well as in non-automotive markets (consumer electronics, industrial goods, bio-/medical market)
 - broadened the customer base and lead to new product developments for the external market

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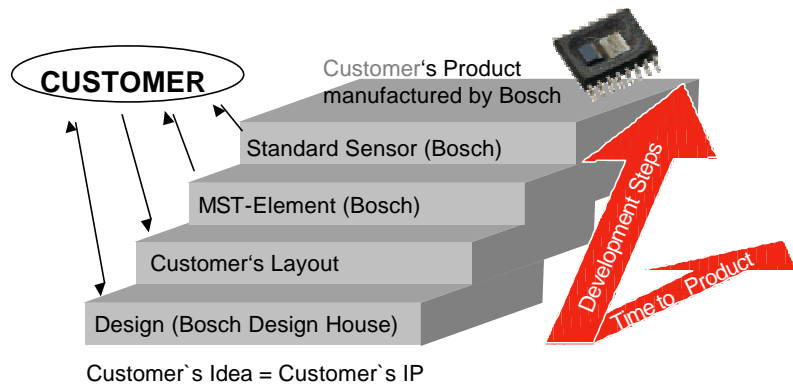
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Product Development



Development time and costs depending on starting level

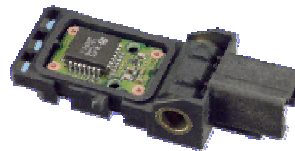


Product Overview Inertial Sensors

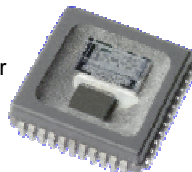
Airbag accelerometer



Peripheral acceleration sensor

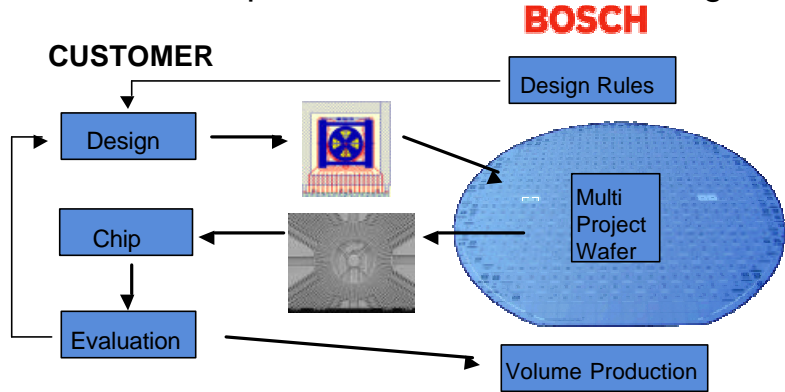


Angular rate sensor:
navigation and roll over





MPW Concept for Surface Micromachining



Shared costs during development, prototyping and low volume production

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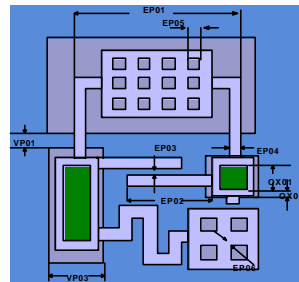
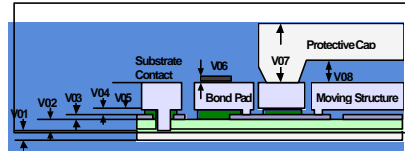
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Design Rules

Rule	Description	Dimension
V01	Wafer	675 ? 1.5
V02	Pad Oxide	2.5 ? 0.15
V03	Buried Polysilicon Layer	0.45 ? 0.05
V04	Sacrificial Oxide	1.6 ? 0.2
V05	Epitaxially grown Polysilicon	10.3 ? 1.0
V06	Metallization	1.3 ? 0.2
V07	Cap Wafer	380 ? 1.5

Rule	Description	Layout
EP01	Free Structure (fixed on both sides)	< 1000
EP02	Free Structure (fixed on one side)	< 400
EP03	Spacing between EP structures	> 2.0
EP04	Width	> 3.0
EP05	Etch hole	> 4.0
EP06	Width for structures that are to be	< 5.8



Detailed design-rules available free of charge upon signature of NDA

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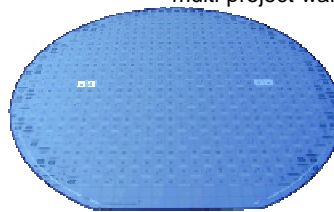
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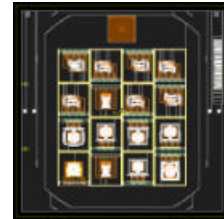
MPW-Runs

- Up to 16 customers share one wafer
- 3 runs per year
- Run 22 underway
- Turnaround time ~14 weeks
- so far more than 80 projects and 200 designs
- Start next run: December 2003
- Contact:

Dr. Wilhelm Frey/Dr. Christoph Gahn
europpractice_foundry@de.bosch.com
www.europpractice.bosch.com



multi project wafer



reticle

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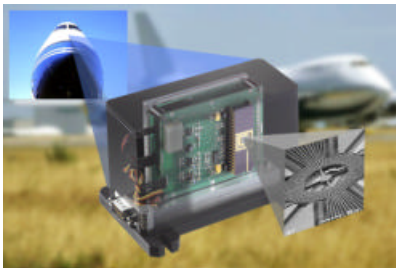
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Department

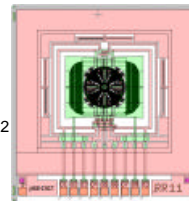


Case Study: Gyro DAVED-RR by HSG-IMIT



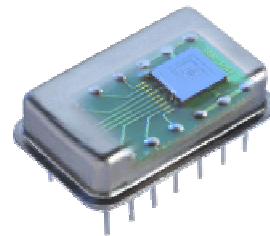
Properties

- Resolution 0.01°/s
- Range ±200°/s
- Dimension 2.3*2.6 mm²



Applications

- Navigation systems
- Camera stabilisation
- Robotics



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The Product DAVED-RR®



- **Product development focused to the field of automated guided vehicle system (driverless vehicles) in low and mid-range volume**
- **Sensor is used to assist or replace the fibre optic gyroscopes (low performance class)**
- **etp - electronics trading & production (Freiburg)**
 - **Assembly, Packaging and Final Test of the Sensor**
 - **Sales and Marketing**



Hahn-Schickard-Gesellschaft
Institut für Mikro- und Informationstechnik – www.hsg-imit.de

Inertial Sensors Systems



Product Development using FoundryServices



Approach to Bulk Micromachining Foundry

- Extend foundry service to Silicon-bulk-micromachining technology
- Target applications: Life Sciences
- Bosch USP: - experience with high volume production of MEMS
- large technology portfolio
- Feasibility studies concerning high volume production of devices
- Prototyping for selected projects
- Definition of a standard foundry MPW process for life science applications

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Current Status

- Standard process modules are defined (e.g. etching, lithography, bonding, porous silicon, CMP, ...)
- Process module catalog available upon signature of NDA
- Discussions with potential customers (on-going)
- Feasibility studies for 10 projects
- Prototyping for 4 customers

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Possible Devices

- Pumps
- Valves
- Microchannels
- Mixers
- Dispensers
- DNA arrays

Wet chemical etching	Anodic water bonding
<p>Isotropic etching in an acid etching bath (imprecise shapes)</p> <p>Etching mask Silicon</p> <p>Anisotropic etching in an alkaline etching bath (precise shapes)</p>	<p>Pyrex glass Silicon Hot plate Pyrex glass wafer Silicon wafer</p>
<p>DRIE</p>	<p>Porous Silicon</p>

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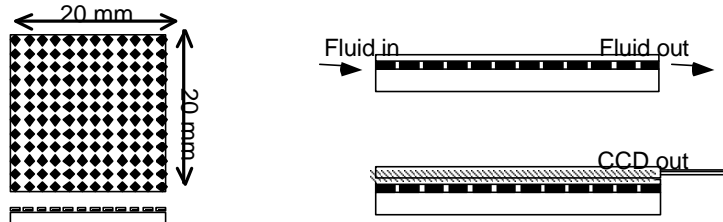
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Customer Project: Axaron, Heidelberg

“Three-dimensional DNA-Array“ BBC

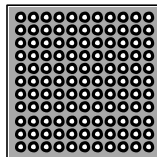
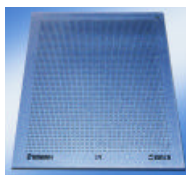


- ⚡ Low fluorescence signal from Si-substrate
- ⚡ Advanced fluidic functionality by using capillary effects
- ⚡ Opportunity for convenient CCD readout

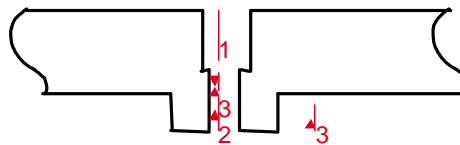


Customer Project: Axaron, Heidelberg

Parallel Dispensing Head matching the BBC



Cross section of a single nozzle:
Through hole in wafer is fabricated using three high rate ASE steps





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Factors Creating Customer Satisfaction

- Reliable Stable Process
 - MPW uses same process as >100M Bosch MEMS since 1996
 - Bulk foundry relies on well-proven process steps:
 - >150M pressure and air-flow sensors since 1993
- Comprehensive Design Support
 - Dedicated Tools by MEMSCAP and IntelliSense
 - Design house service by AML and FhG-ISIT
 - DRC, chip templates, individual support
- Punctuality and Regularly Scheduled Runs
 - Three MPW runs per year since 1996
- Information: process details, packaging know-how, reliability ...
- Special Services: packaging, better vacuum, wafer mapping ...

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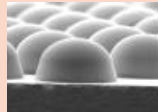
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Fraunhofer Institute for Si Technology



- Greytone-lithography
- Metal surface micromachining
- Design house service

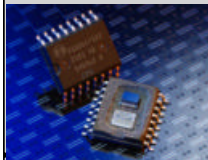


- Micromirrors
- Microlenses
- Diffractive optical elements
- Microswitches

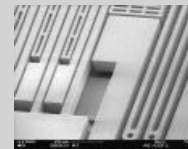


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- Si surface micromachining foundry
- Si bulk micromachining foundry



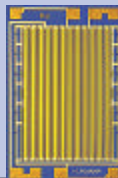
- Accelerometers
- Tilt sensors
- Gyroscopes
- Microfluidic chips, BioMEMS



HL-Planartechnik GmbH



- Thin film technology
- Silicon membrane technology



- Thermopiles
- Temperature sensors
- Magnetoresistive sensors

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