MEMS Development at Infineon Technologies SensoNor

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Never stop thinking

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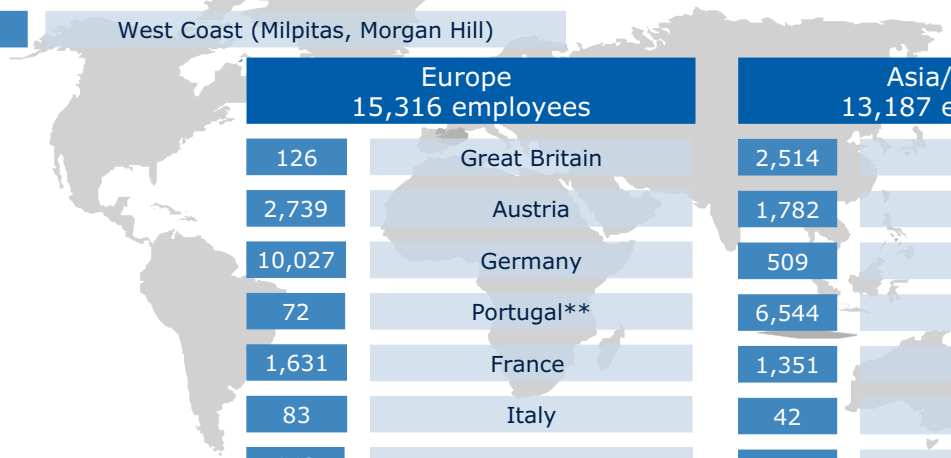
Infineon Technologies SensoNor

- A fully owned subsidiary of **Infineon Technologies AG** since 2003.

Infineon Technologies

- Revenues of 1.03 billion EUR in the third quarter of FY 2008.
- Approx. 30,000 employees as of June 30, 2008.
- Strong technology portfolio with about 22,900 patents and applications; more than 30 major R&D locations worldwide.
- Focus on Energy Efficiency, Communications and Security.
- Majority holding of Qimonda.
- Infineon back in the Top 10 in CY 2007
  (*Source*: iSuppli, Annual CLT 2008).

Infineon: 29,356 Employees Worldwide*



USA 853 employees	
451	East Coast (Allentown, Fishkill, ...)
402	West Coast (Milpitas, Morgan Hill)

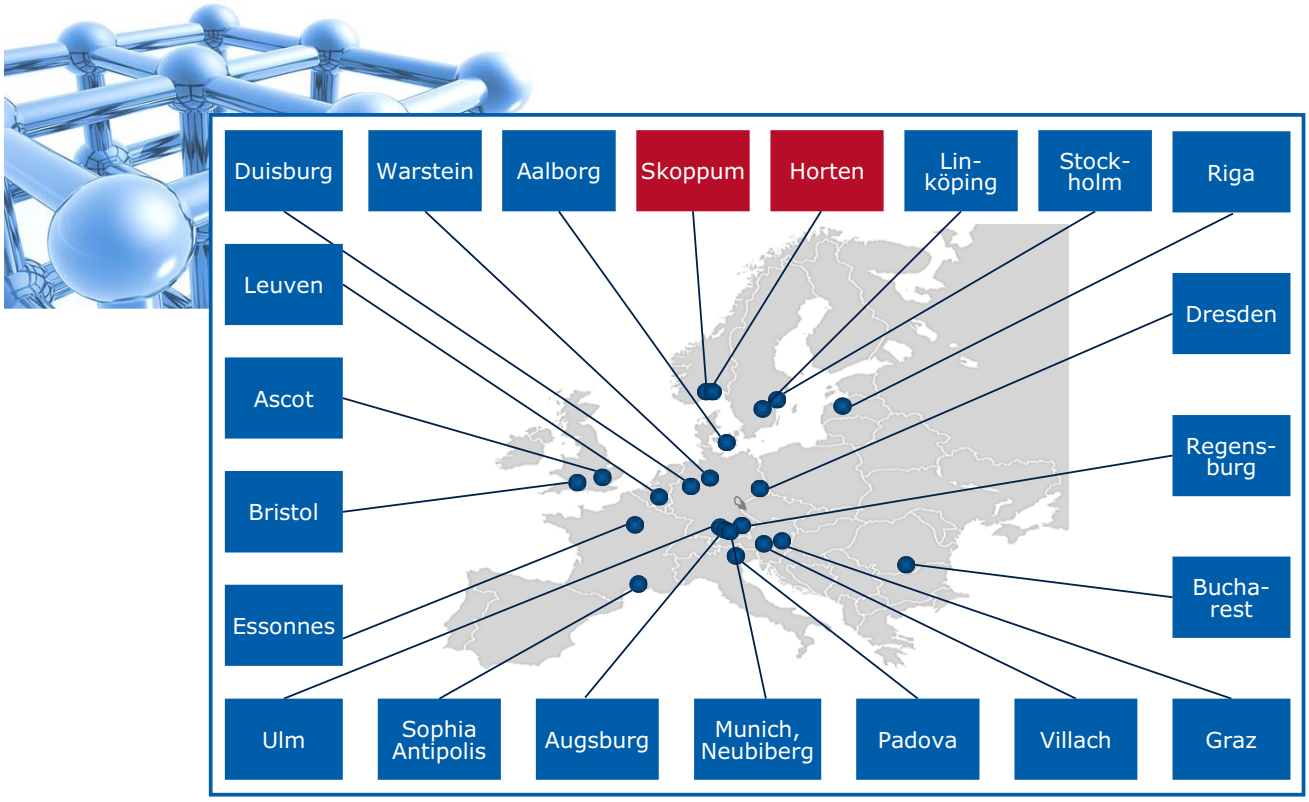
Europe 15,316 employees	
126	Great Britain
2,739	Austria
10,027	Germany
72	Portugal**
1,631	France
83	Italy
142	Romania
234	Sweden, Norway
245	Hungary
17	Other Europe

Asia/Pacific 13,187 employees	
2,514	Singapore
1,782	Indonesia
509	India
6,544	Malaysia
1,351	China
42	Hongkong
163	Japan
149	Korea
122	Taiwan
11	Australia

* as of Jun 30, 2008; data w/o Qimonda

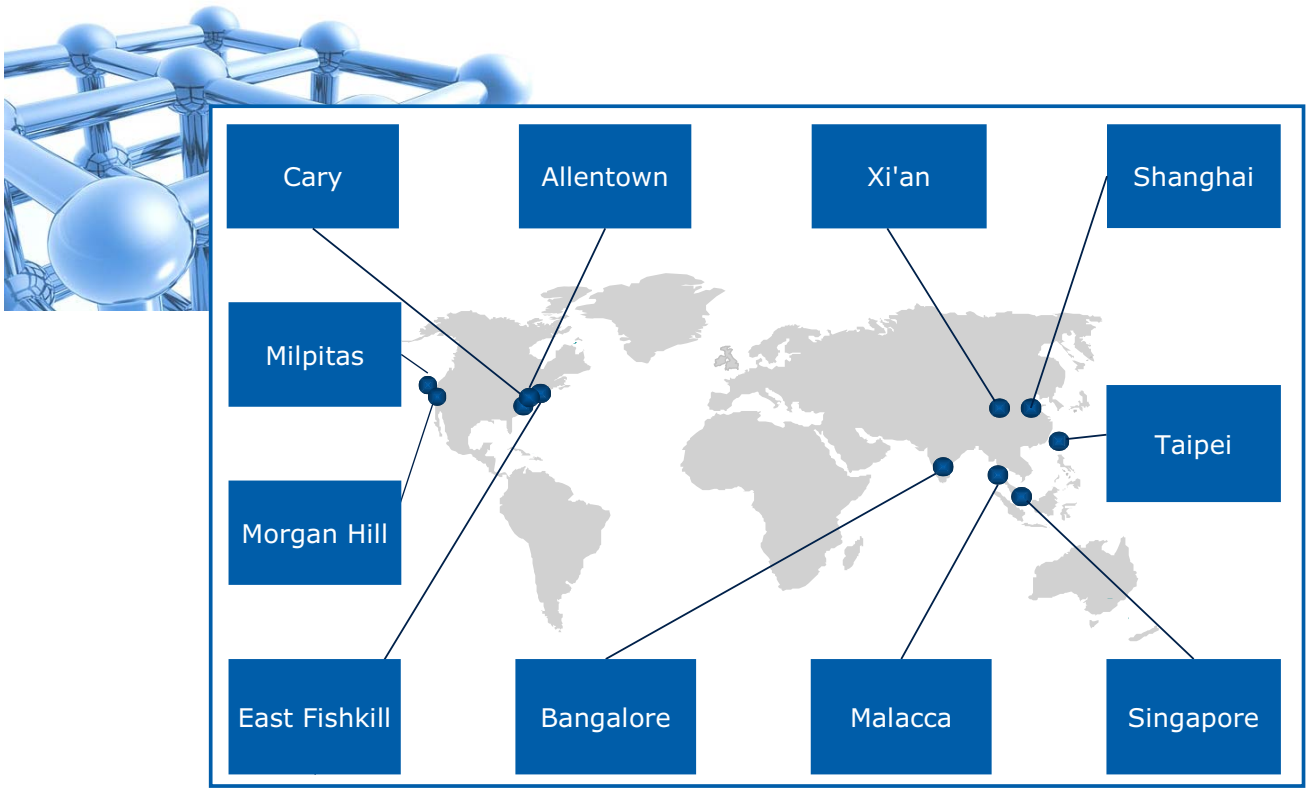
** incl. ESAS HC

Infineon – R&D Network in Europe

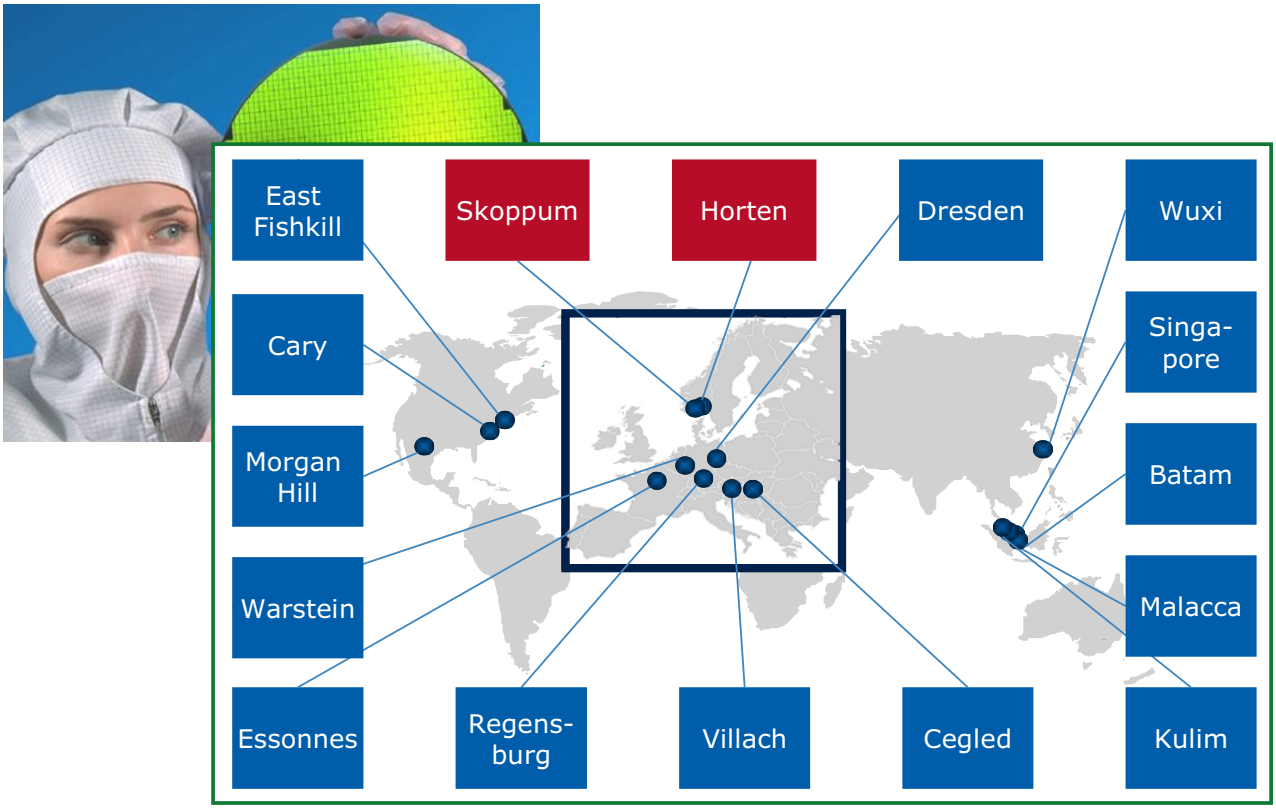


Infineon – Worldwide R&D Network

(Excluding Europe)



Infineon Production Sites



Ranking in our Global Target Markets – CY 2007

Power*	Industrial	Chipcard*	Auto-motive	Wireline Access*	Wireless ASSP
#1	#1	#1	#2	#1	#3
Market share 8.5%	Market share 7.5%	Market share 29%	Market share 9.4%	Market share 20.4%	Market share 6.1%
IMS, Aug. 2007	Semicast, May 2008	Frost & Sullivan, Aug. 2007	Strategy Analytics, April 2008	Gartner, July 2007	iSuppli, 2Q 2008

*CY 2006

Infineon - Business Structure

Business Groups

Applications

AIM

Automotive, Industrial & Multimarket

Car Electronics (power train, safety management*, body & convenience, multimedia/telematics),

Power control (distributed power generation, automation/motor control, transportation, power supplies, medical, building control),

Chip Card & Security (communications, payment, identification, entertainment)

COM

Commu-nication Solutions

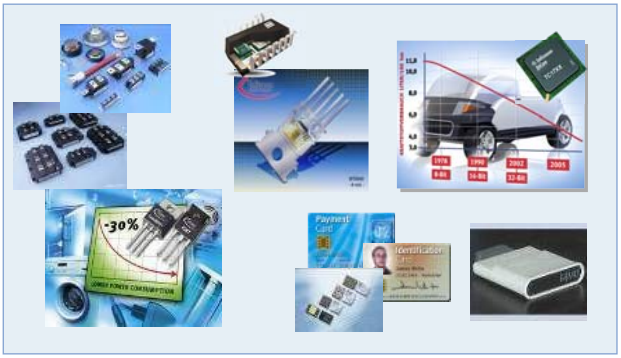
Wireless communications (mobile phones, cellular base stations, cordless telephones, RF technology for short, medium and long-range distances, TV receivers, navigation),

Wireline communications (voice commu-nication, broadband data communication, integrated voice and data communications, wireless infrastructure, home networks)

Customers

* Infineon Technologies SensoNor

AIM - Overview



Product Range

- Power -discretes, -modules, -ICs;
- **Pressure***, **roll-over***, temperature, magnetic sensors, RF ICs;
- 8-bit, 16-bit, 32-bit microcontrollers TriCore® & XC product ranges;
- AF/RF diodes and transistors, SSICs;
- Security ICs;
- **ASIC Design Solutions***.

Core competencies

- High quality products and services;
- Leading edge technology and IP portfolio;
- System expertise with broad application competence;
- Strong worldwide presence with local sales and application support;
- Dedicated account teams and distributors.

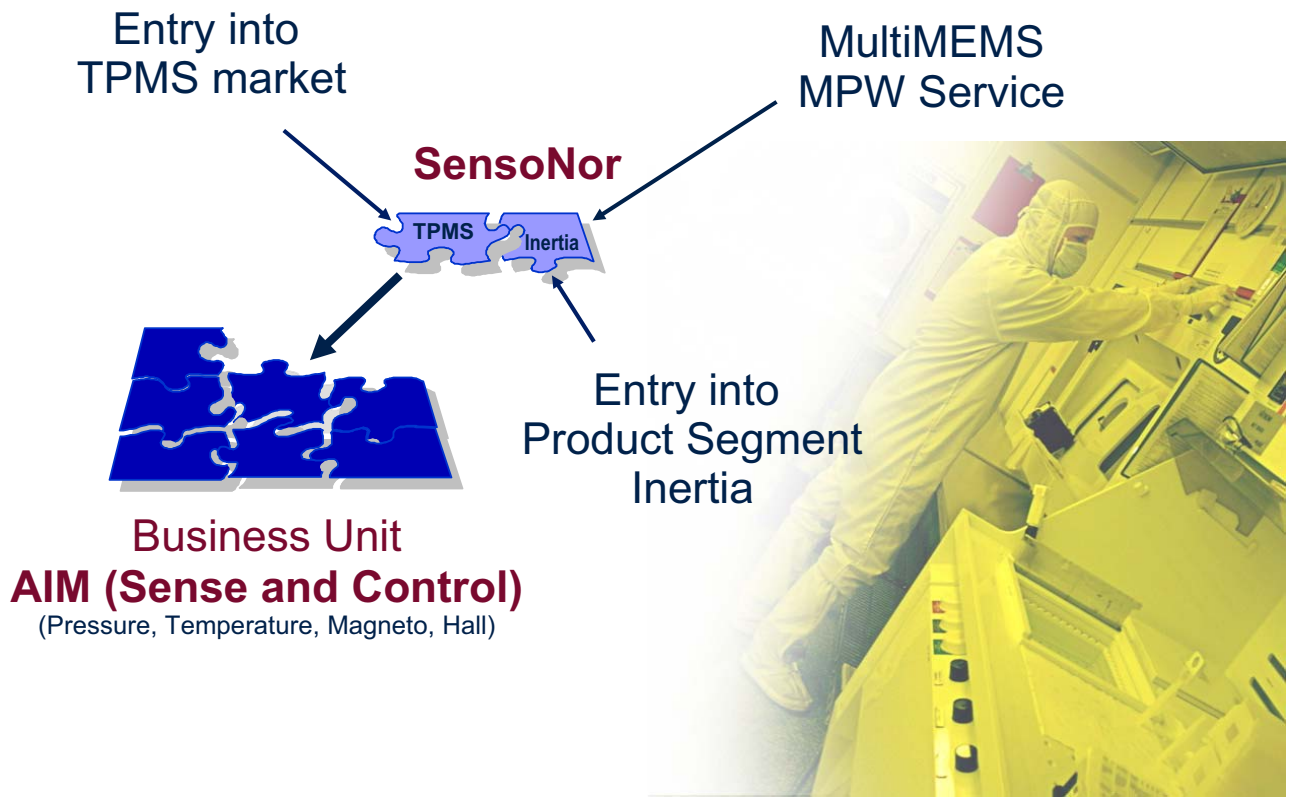
Market Positions

- No. 1 in Power Semiconductors;
- No. 2 in Industrial applications;
- **No. 2 in Automotive ww, no. 1 in EU**;
- No. 1 in Chip Card Ics.

Sources:
IMS Research (2007), Semicast (2007)
Strategy Analytics (2007), Frost & Sullivan (2007)

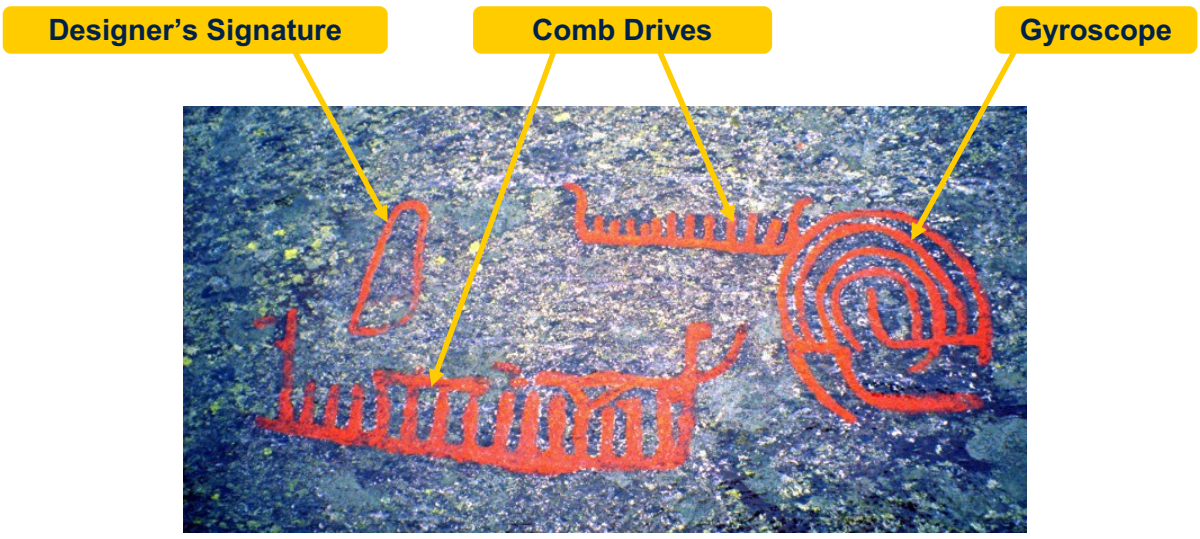
* Infineon Technologies SensoNor

SensoNor within Infineon Technologies



Infineon's MEMS Design Centre

- MEMS experience since 1985...



Sketches by Neolithic Norsemen on Austre Åmøy island, near Stavanger.

Infineon Technologies SensoNor at a Glance

- A fully owned subsidiary of Infineon Technologies AG since 2003.
- More than 900 000 MEMS sensors shipped per week (world class supplier of sensors for the automotive market).
- 185 employees, of which 100 engineers.
- 12,000 m^2 floor space facilities, of which
  - 1,500 m^2 clean-rooms.
- In house MEMS and ASIC design competence.

Production Sites

- Front-end / MEMS line (Horten).
- Back-end Assembly & Test line (Skoppum).

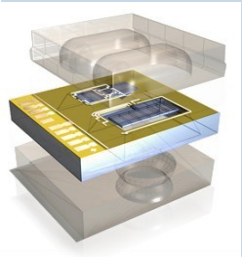
FE / MEMS line, Horten

BE Assembly & Test line, Skoppum

SensoNor Benefits

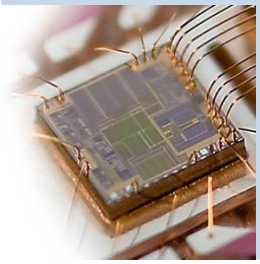
Tripple-stack Dice

- Excellent media compatibility
- High reliability (buried piezoresistors and conductors)
- Sealed cavities



ASICs

- Low power consumption
- High flexibility (on-chip micro-controller)
- High programma-bility (flash memory)

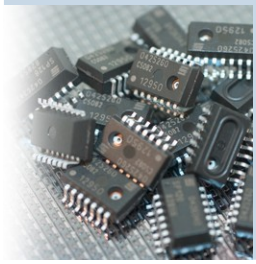


Packaging

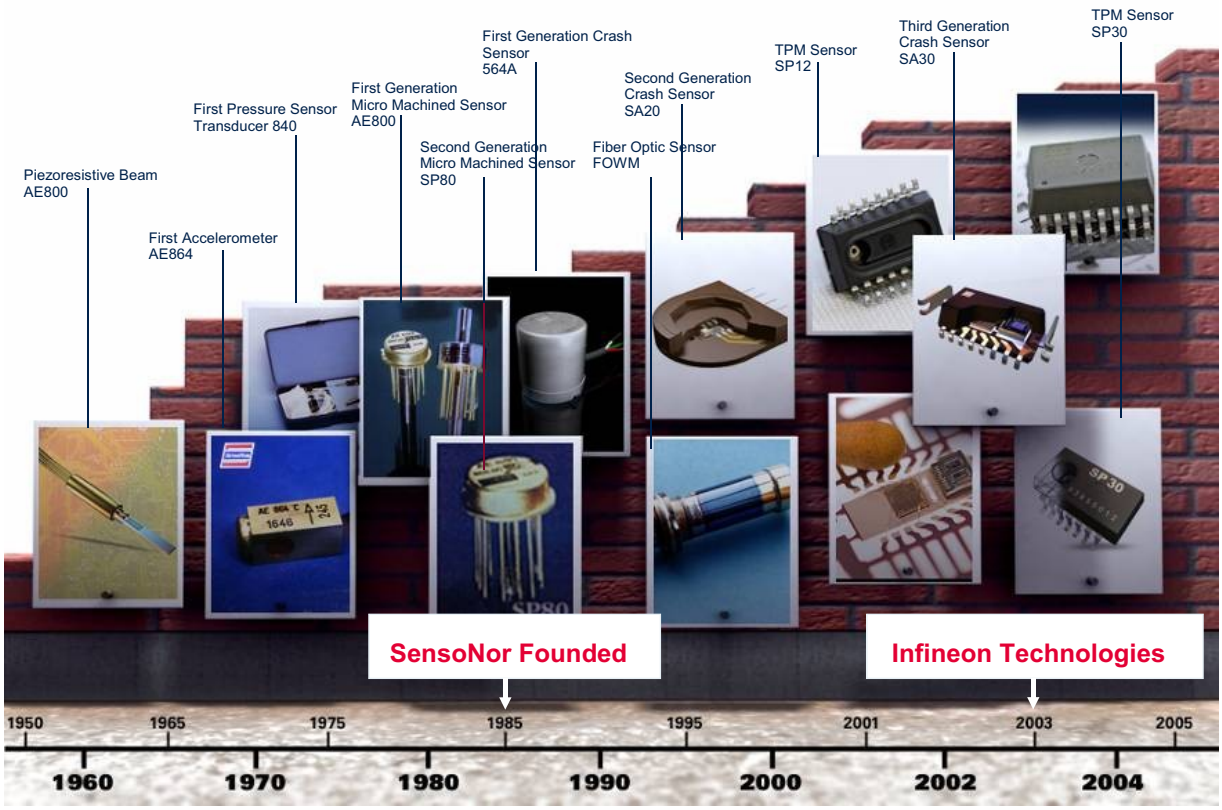
- 14 pin small outline package
- Low cost process (transfer moulded)

Volume Production

- Complete in-house production, assembly and test capabilities
- Highly automated processes



SensoNor Product Development History



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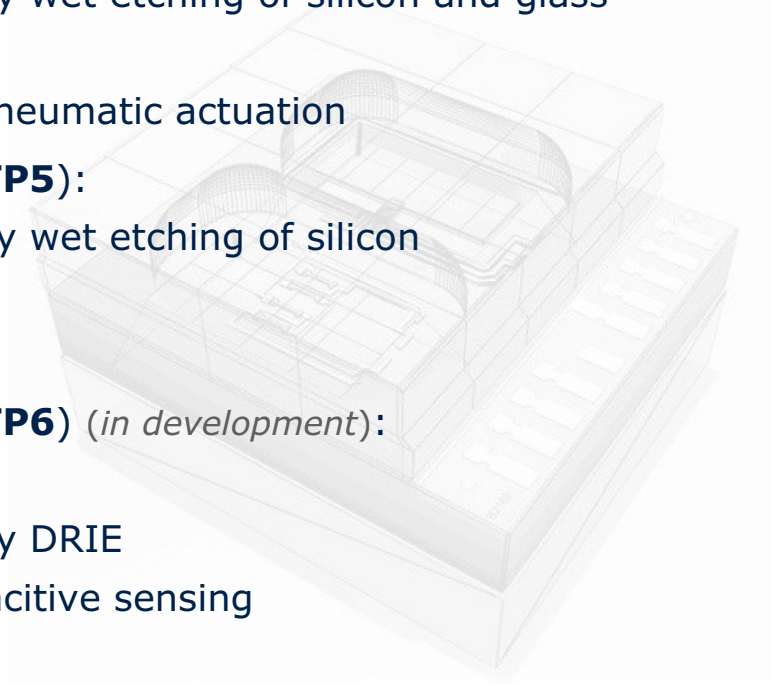
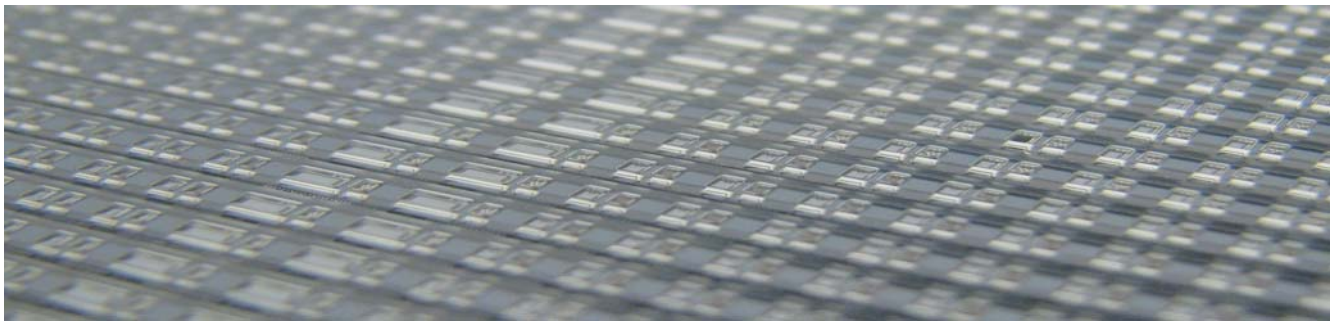
SensoNor's Technology Platforms

- Technology Platform 4 (**TP4**):
  - Bulk micromachining by wet etching of silicon and glass
  - Piezoresistive sensing
  - Thermal and thermo-pneumatic actuation
- Technology Platform 5 (**TP5**):
  - Bulk micromachining by wet etching of silicon
  - Capacitive sensing
  - Electrostatic actuation
- Technology Platform 6 (**TP6**) (*in development*):
  - SOI-based technology
  - Bulk micromachining by DRIE
  - Piezoresistive and capacitive sensing
  - Electrostatic actuation



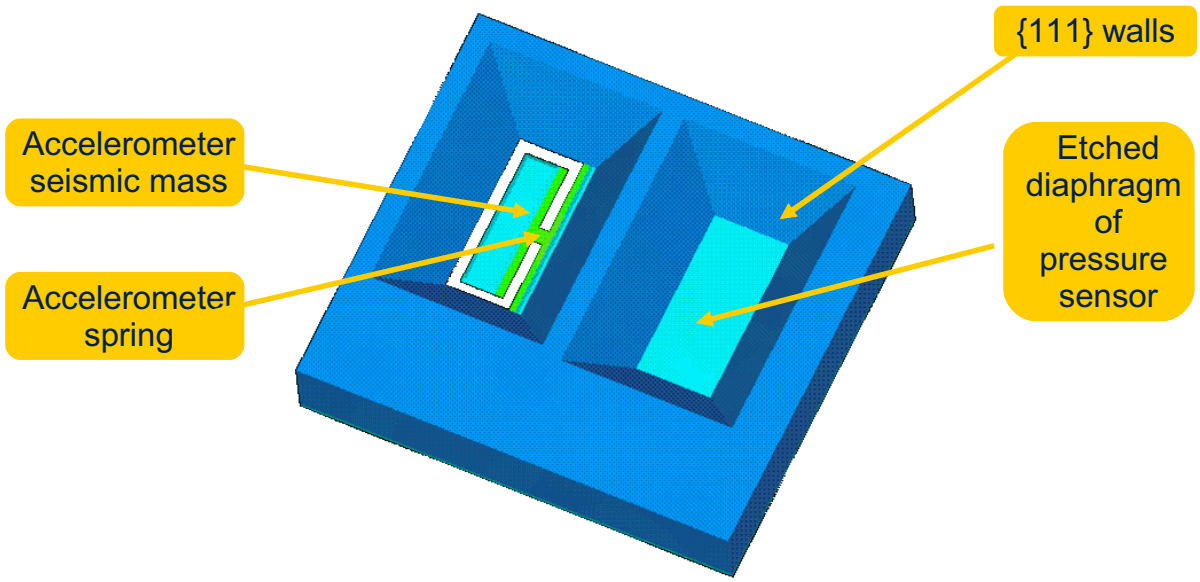
SensoNor's MEMS Processes

- Bulk micromachining of silicon by wet etching with electrochemical etch-stop (ECES)
- Dry etching of silicon
- Micromachining of glass
- Press-contacts for transfer of conductors
- Triple-stack anodic bonding



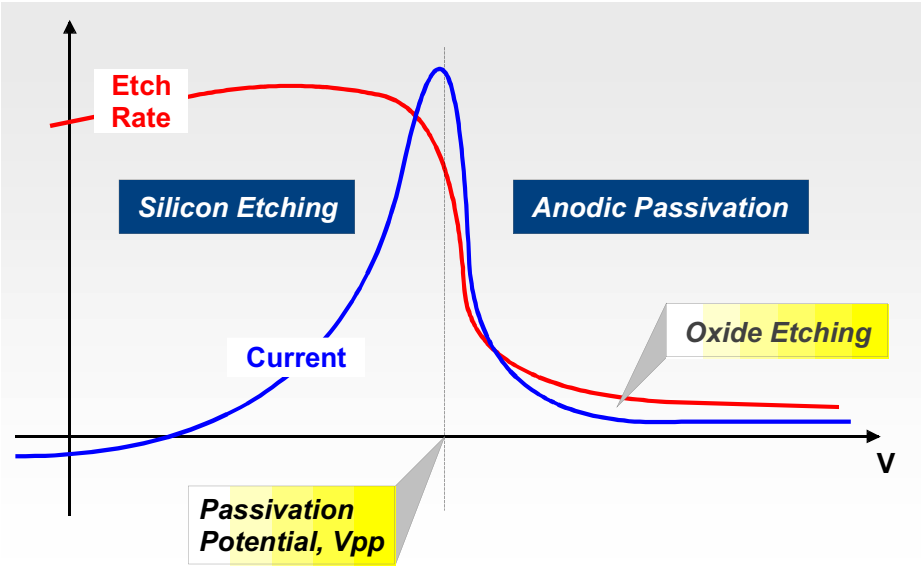
Bulk Micromachining of Silicon

- By wet, anisotropic etching with electrochemical etch-stop (ECES).
- For defining membranes and inertial masses.



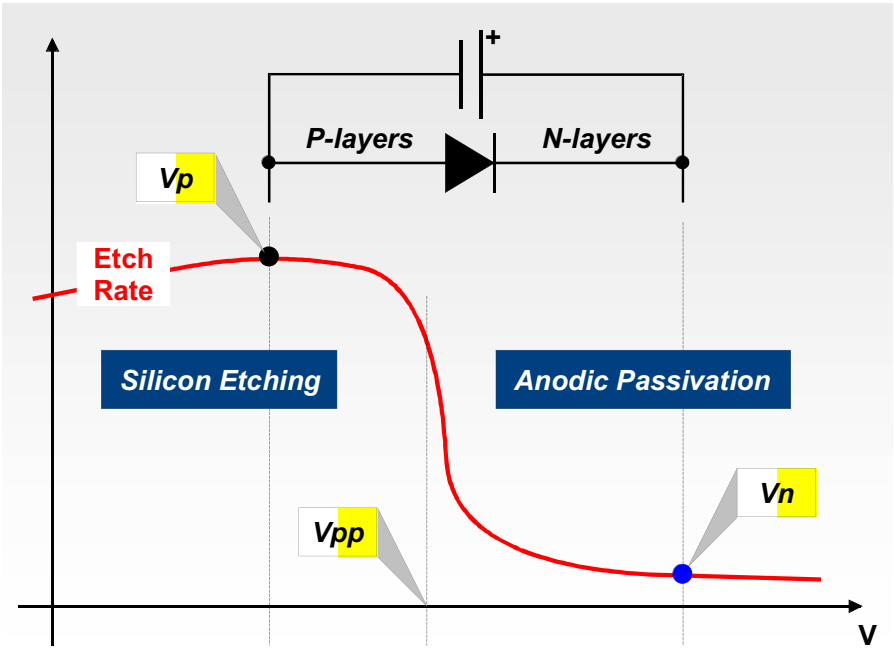
Electrochemical Etching

- Etch rate depends on the applied potential.
- Etching stops if a potential larger than Vpp is applied.

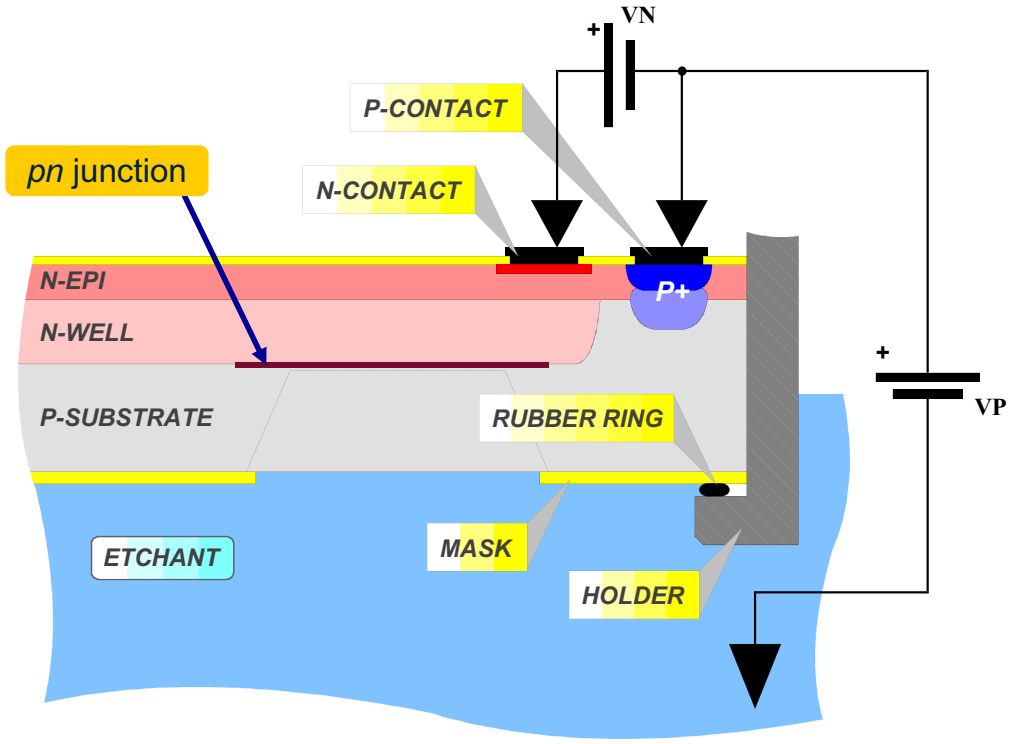


Electrochemical Etch-Stop Technique

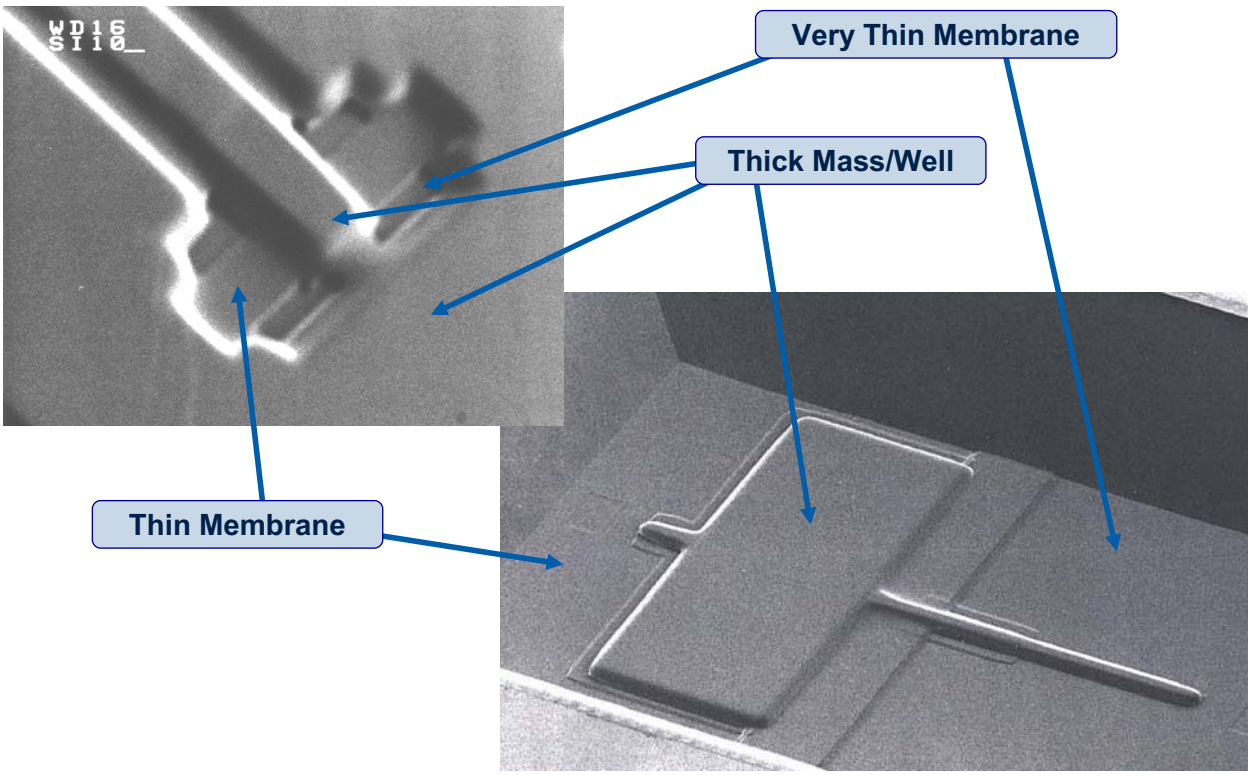
- Reverse biasing the *pn* junctions.



Etching Set-up

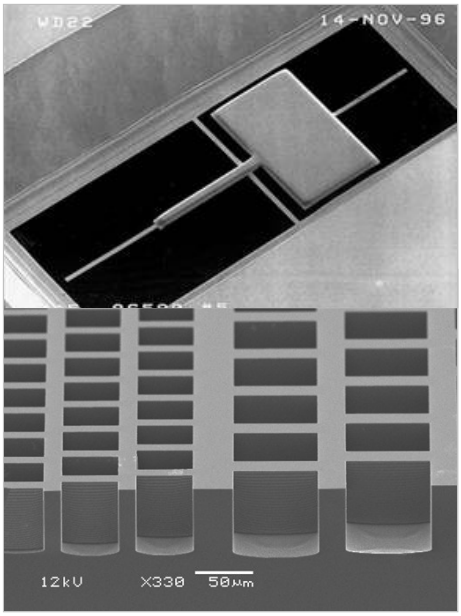


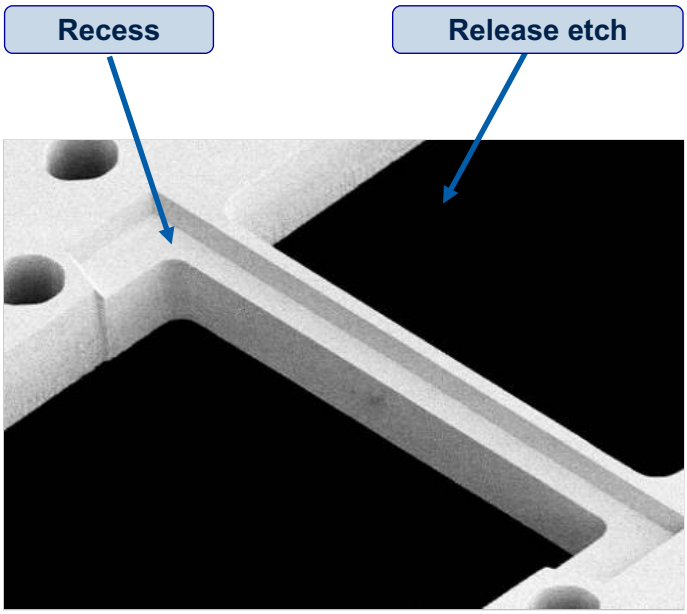
Etch-Stop on Multi-Level Junctions



Dry Etching of Silicon

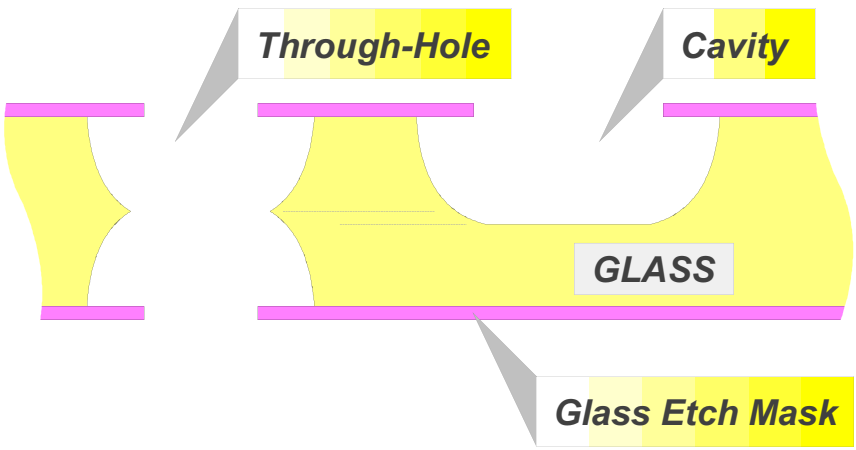
- By RIE or DRIE.
- For recesses and/or release etching of flexible structures.





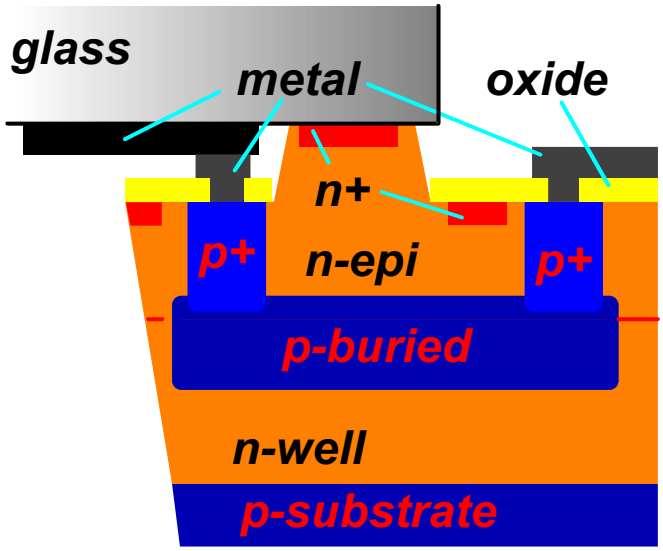
Micromachining of Glass

- By wet, isotropic etching of glass.
- For cavities and/or through-holes.



Press-Contacts

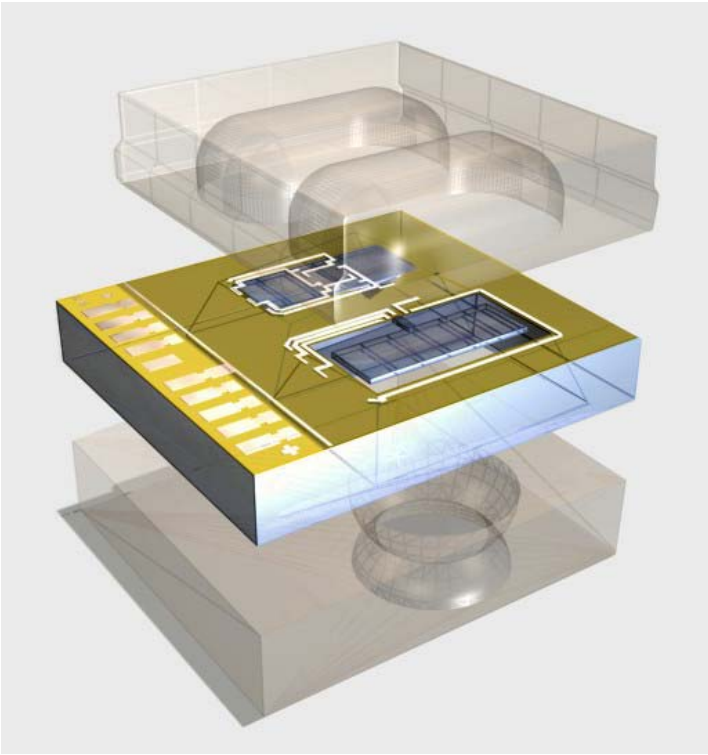
- Pressing two metal layers into each other during wafer bonding.
- For transferring conductors from glass to silicon.



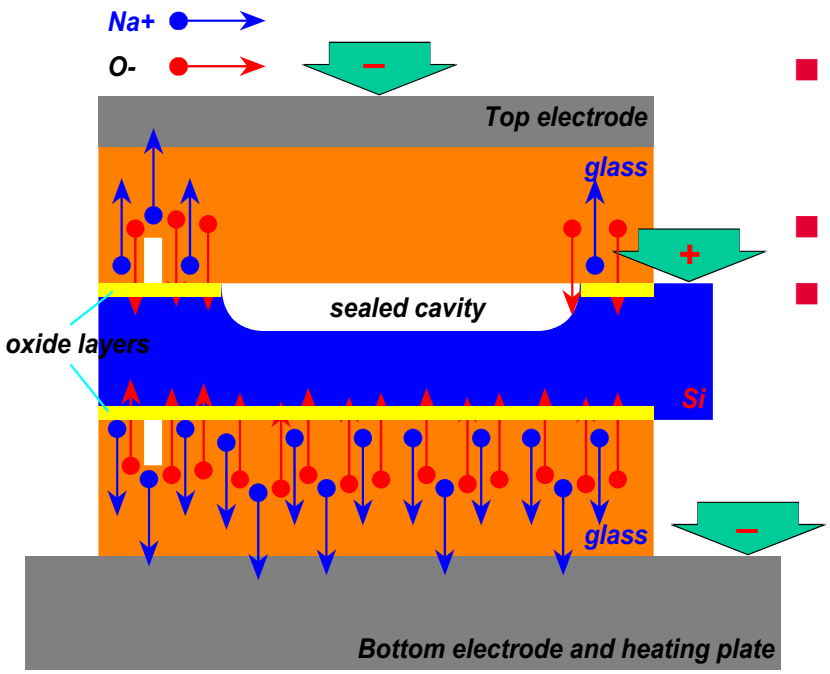
Triple-Stack Anodic Bonding

- Glass-Silicon-Glass triple-stack anodic bonding
- Sealed cavities (patented)
- Buried piezoresistors (patented)
- Buried conductor crossings (patented)

- Patents:
  - US5591679
  - EP0742581 B1

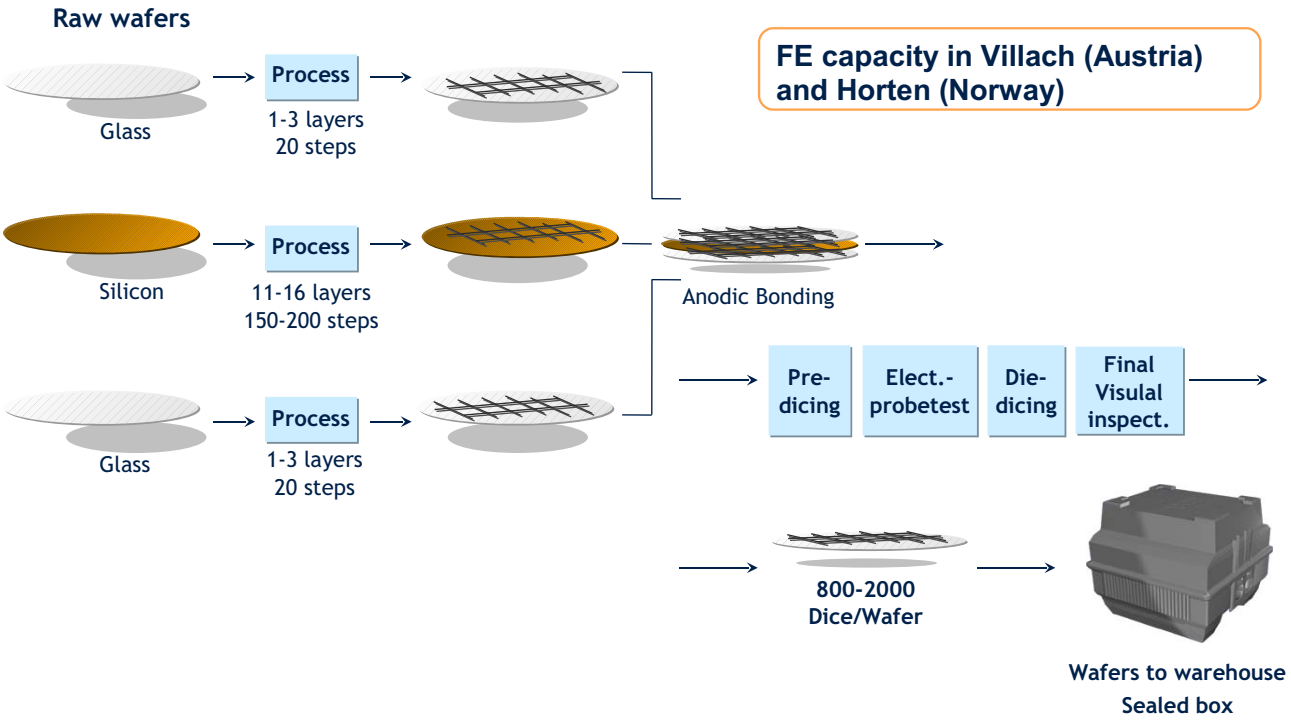


Mechanism of Anodic Bonding



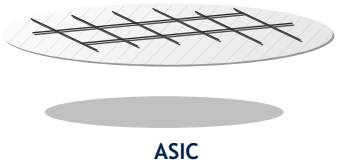
- Migration of the Na^+ and O^- ions
- Formation of a depleted region at the Si/glass interface
- Electrostatic pull
- Formation of an intermediate oxide layer which bonds the mated wafers

Front End / MEMS Processes

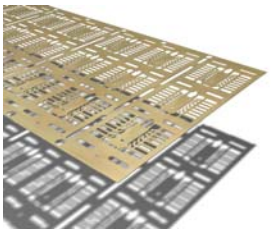


Back End Assembly & Test

BE assembly & test capacity in Horten (Norway), Regensburg (Germany) and Malacca (Malaysia)



ASIC



Lead-Frame

Sensor Dice

Assembly → Moulding → Electro plating → Trim & Form → Electrical testing → Laser marking → Packing

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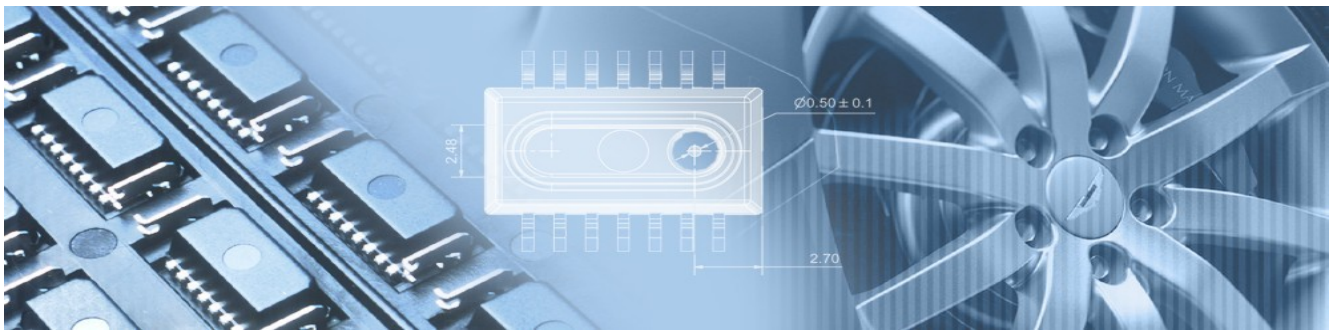
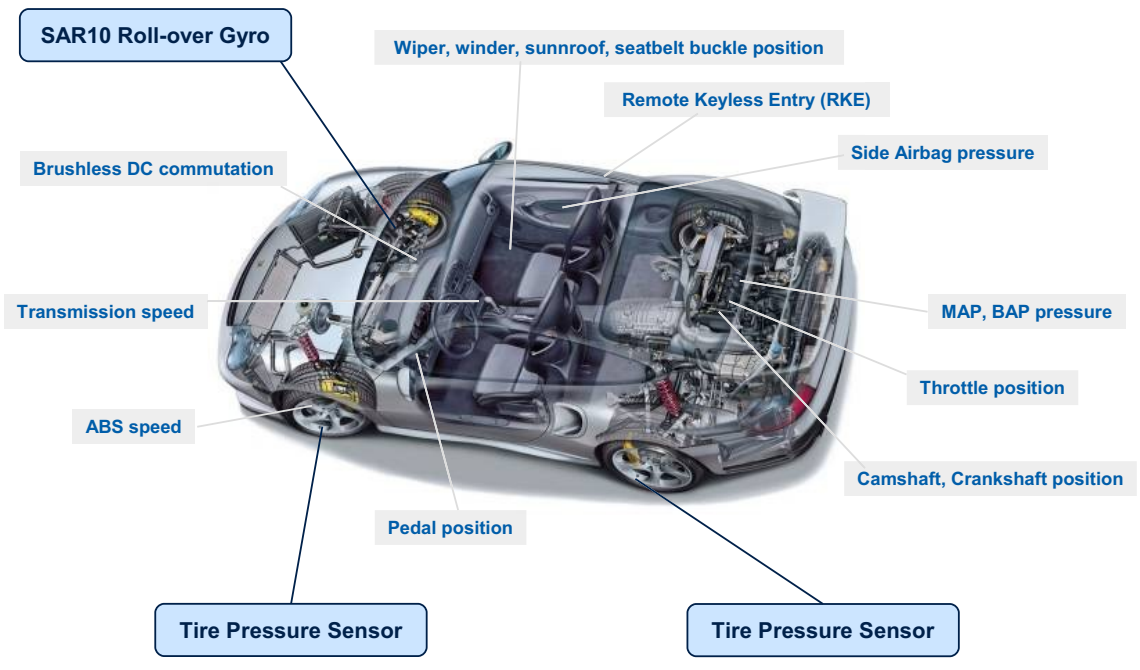
SensoNor's Products

- Tire Pressure Monitoring Systems (TMPS)
- Pressure sensor elements
- Angular Rate Sensors ("Gyro")
- MultiMEMS MPW service

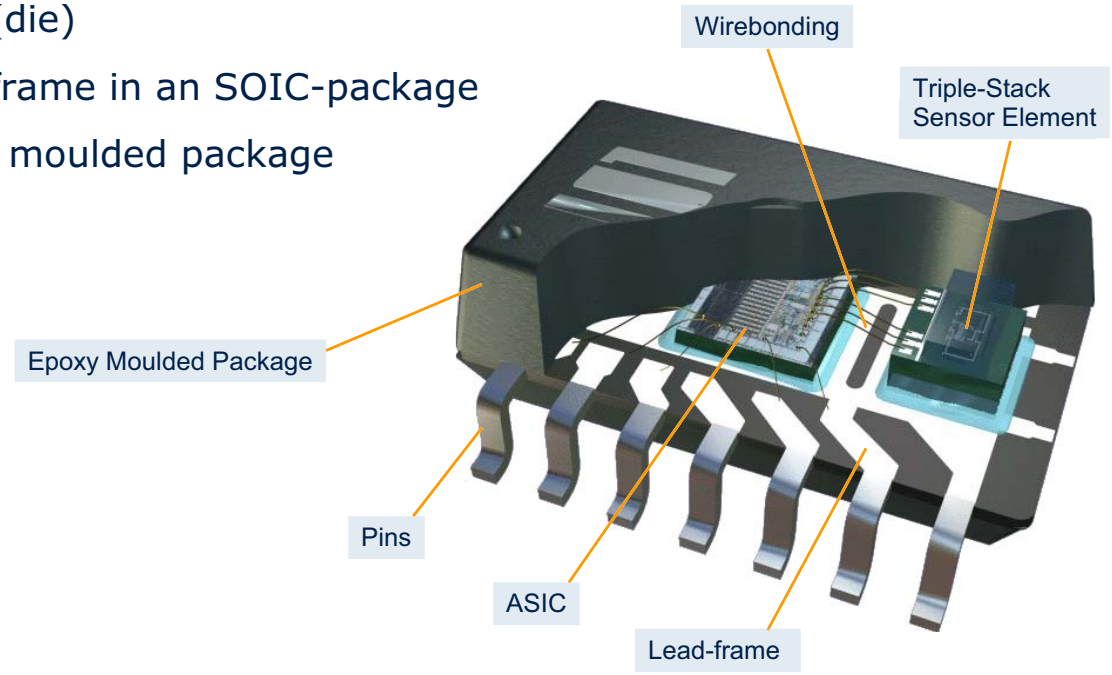


SensoNor's Sensors in Automotive



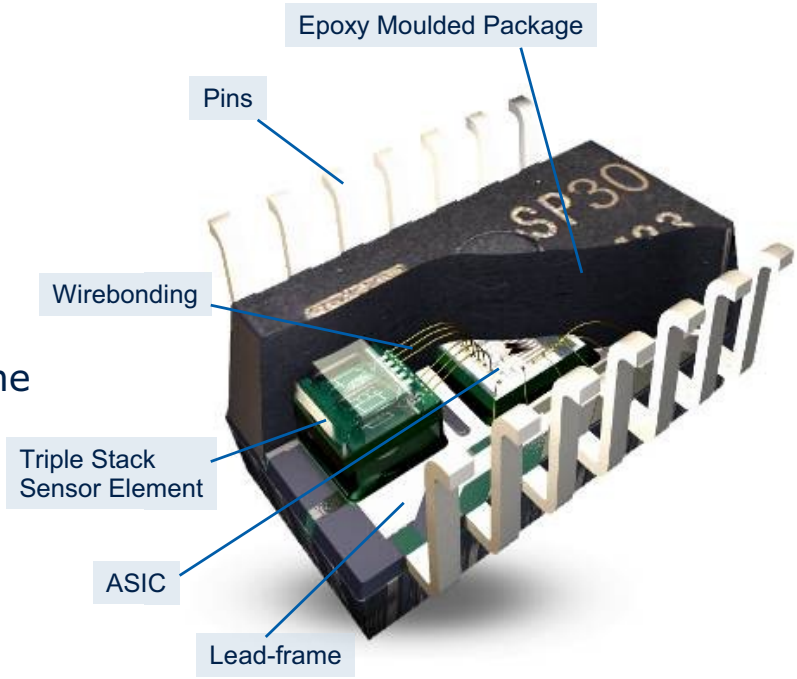
SensoNor's Products – Configuration

- Sensor element (die)
- ASIC (die)
- Lead-frame in an SOIC-package
- Epoxy moulded package

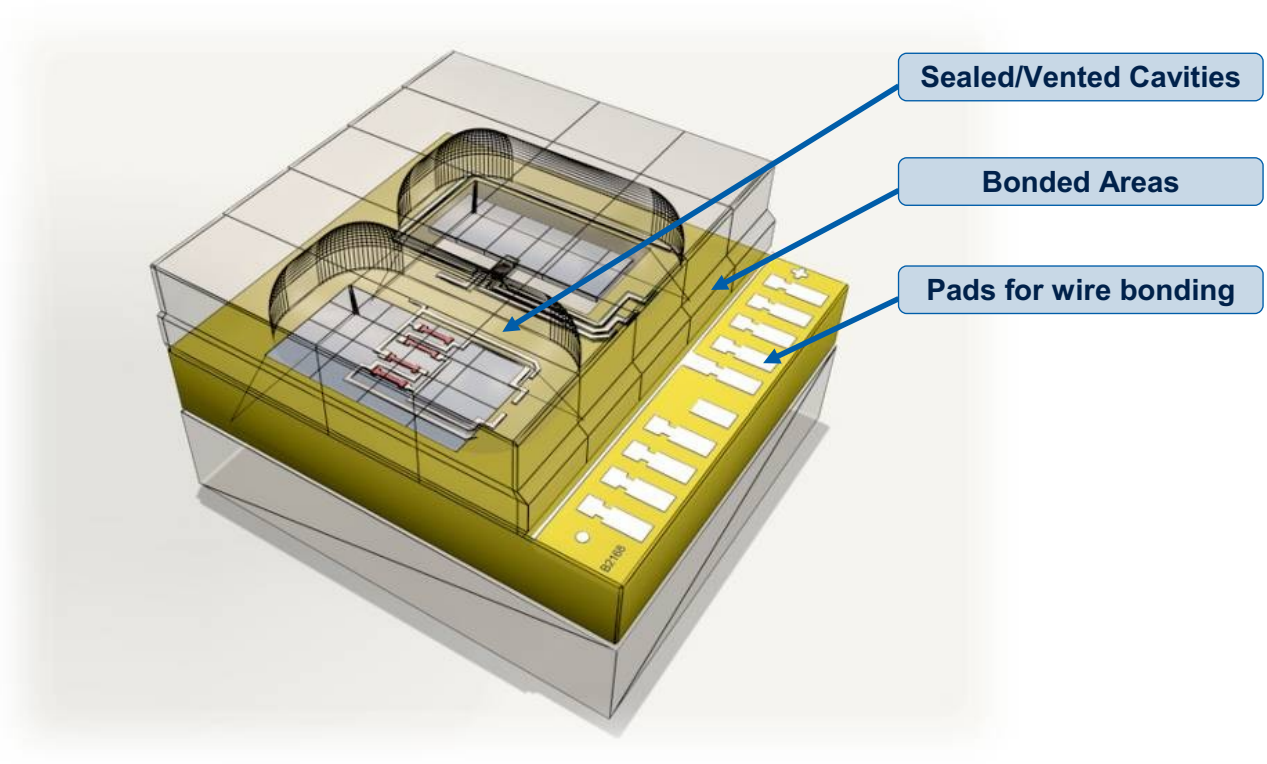


TPMS (SP30)

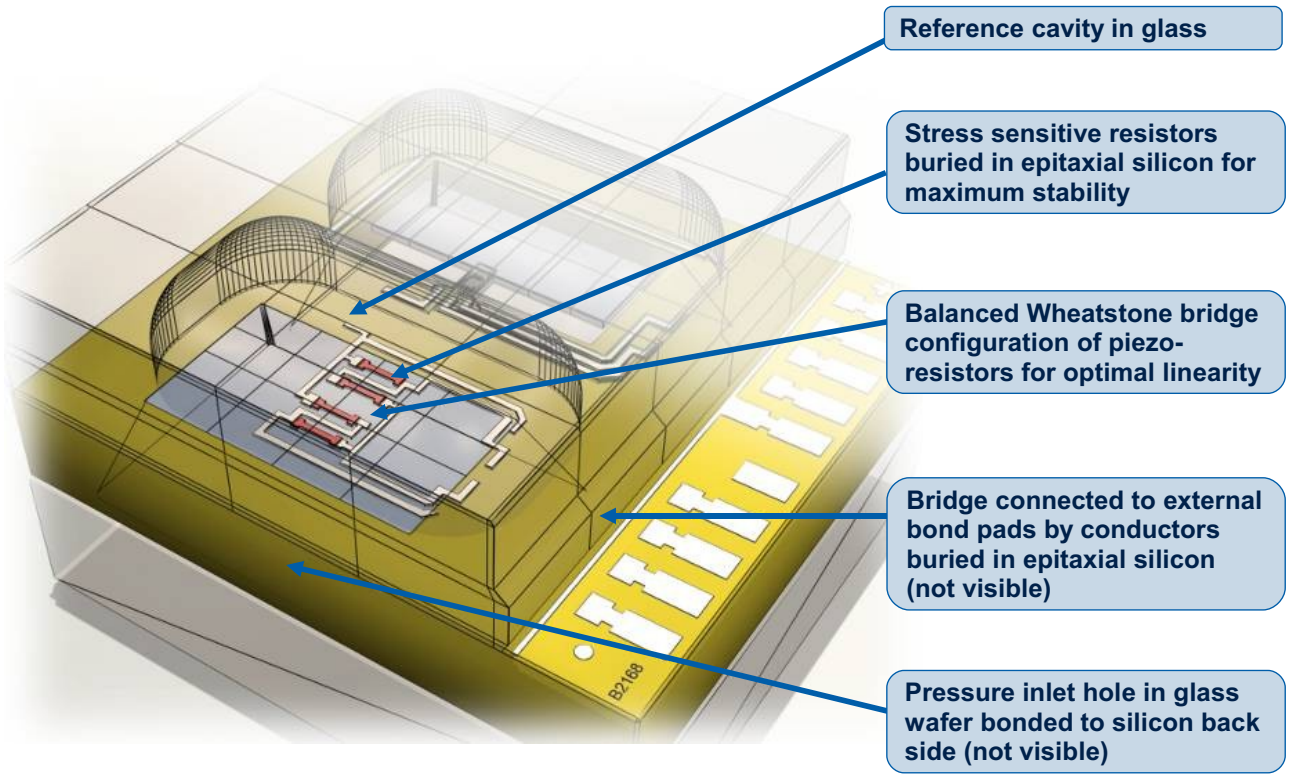
- SW412 sensor element
  - Pressure sensor
  - Accelerometer (to detect rolling)
- SP30-type ASIC
  - ADC
  - µ-controller
- Assembly on lead-frame in an SOIC-package



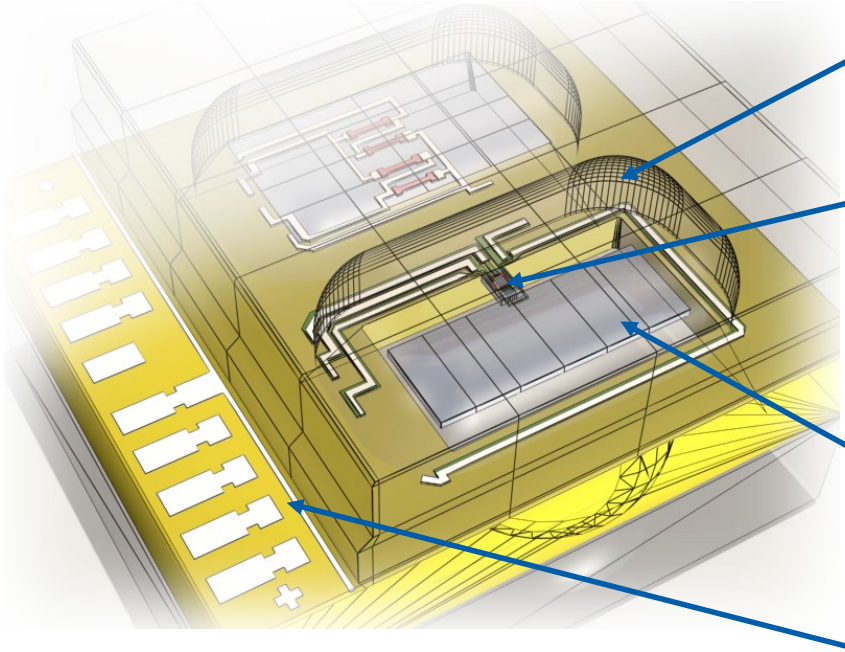
SW412 – Physical Configuration



SW412 – Pressure Element

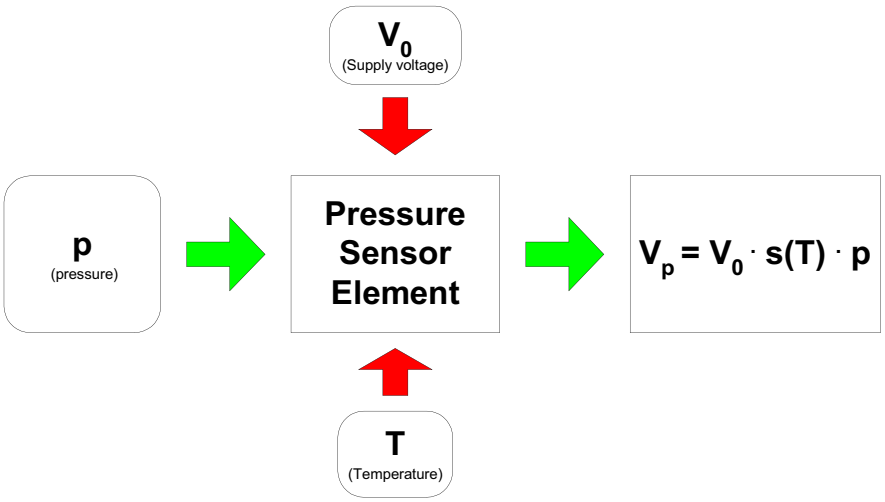


SW412 – Acceleration Element



SW412 – Principle

- Converts gas pressure to a voltage signal.
- Calibration factors:
  - Sensitivity and zero-point as function of temperature.



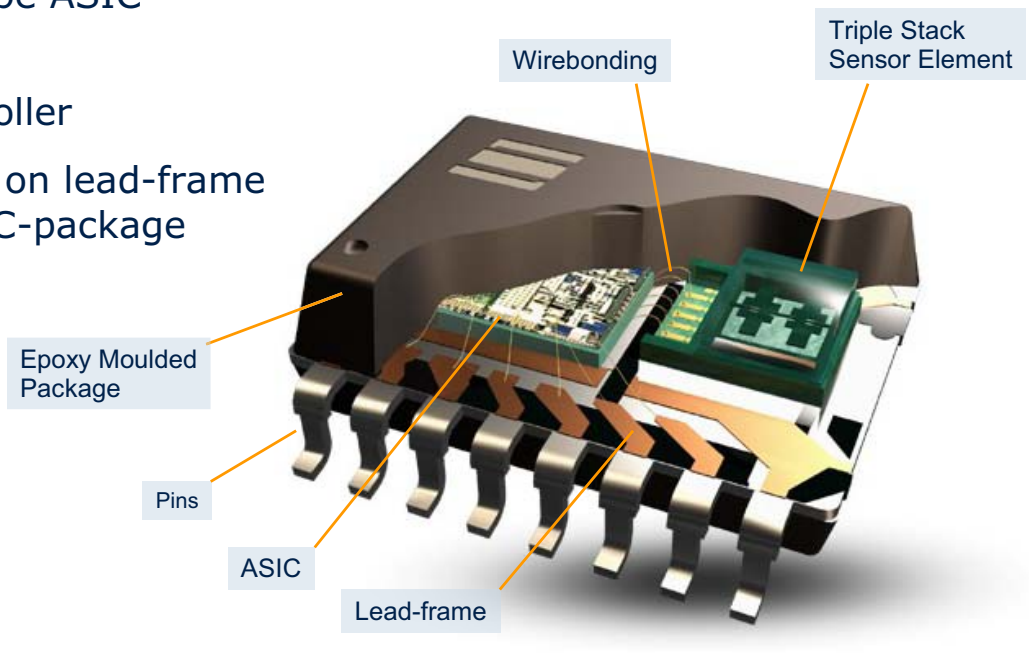
Tire Pressure Monitoring Module

Why It Pays to Monitor the Tire Pressure

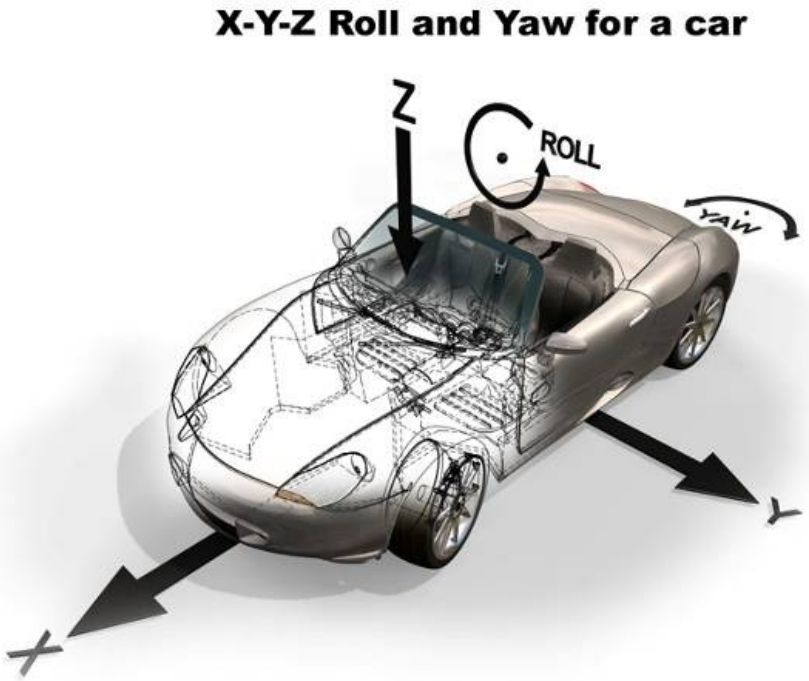
- One fifth of all tyres are up to 40% under their correct pressure
- A 10% drop in pressure cuts a tyre`s service life by 15%
- For each fall of 0.2 bars under correct tyre pressure, fuel consumption increases by 1.5%
- 75% of all flat tyres are the result of insufficient pressure or a gradual loss of tyre pressure due to a leak
- Tyre problems are the third most common cause of vehicle breakdowns
- In the U.S., around 250 000 accidents a year can be traced to insufficient tyre pressure

GYRO (SAR10)

- SW510 sensor element
- SAR10-type ASIC
  - ADC
  - µ-controller
- Assembly on lead-frame in an SOIC-package

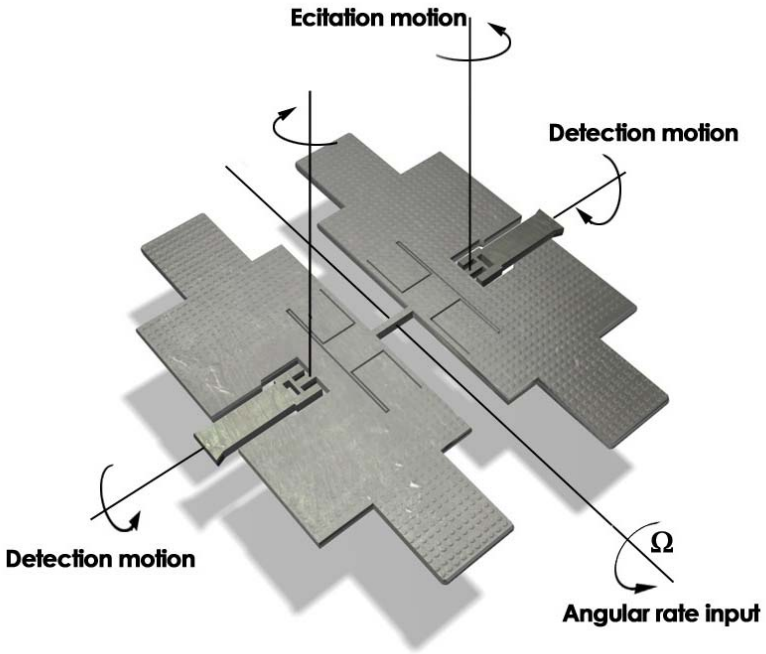


SAR10 – Sensitive Axes



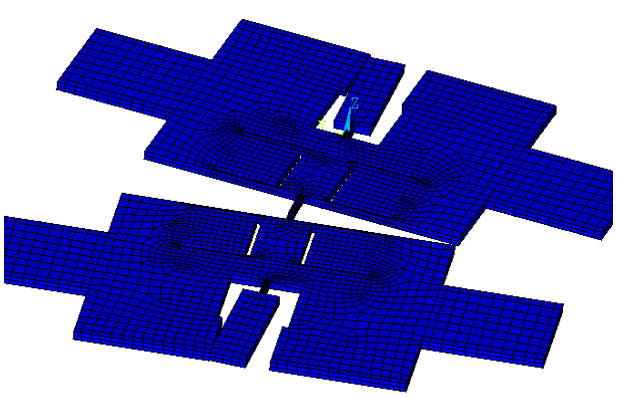
SW510 - Principle

- Resonating structure in butterfly configuration

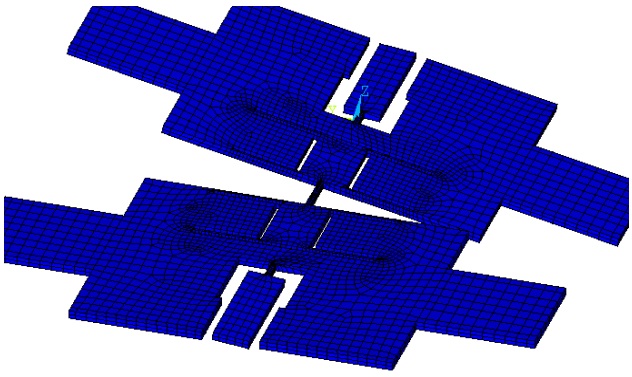


SW510 – Sensing Coriolis Force

- Excitation: Mode 2 (bending of beams).
- Detection: Mode 3 (torsion of beams).

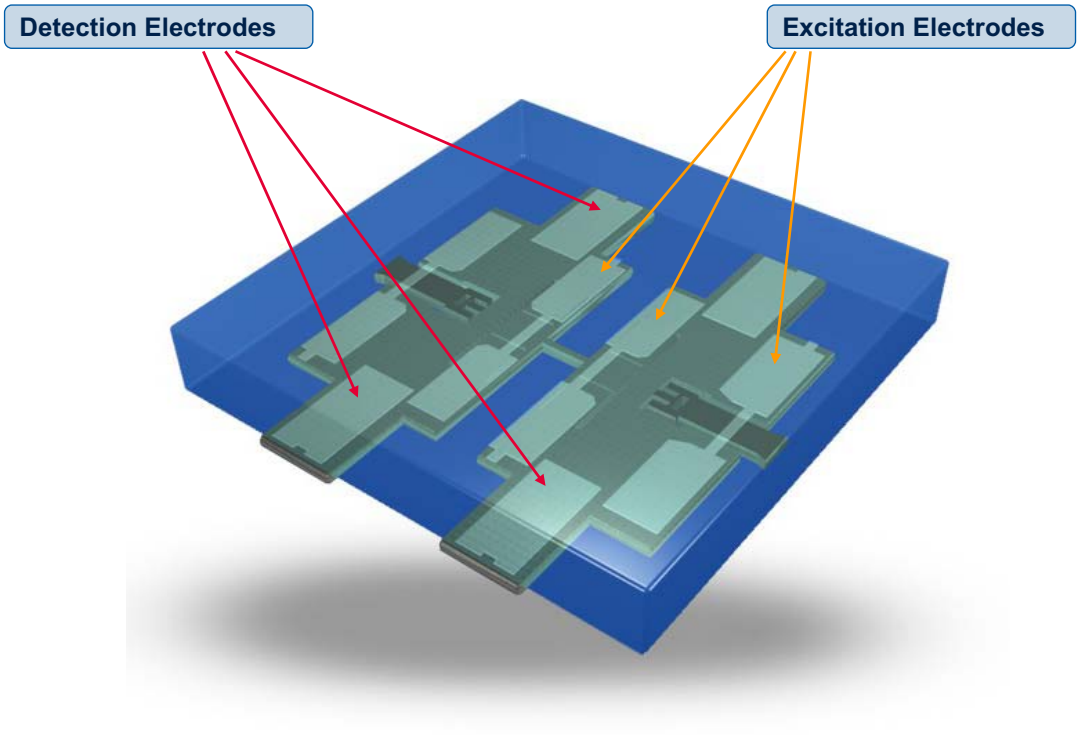


Excitation



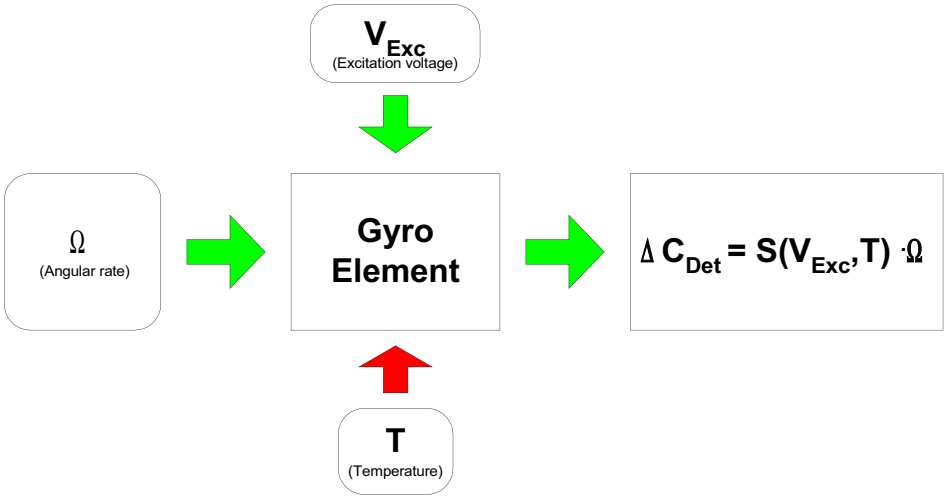
Detection

SW510 – Electrodes



SW510 - Principle

- Converts rotation to a modulated capacitance signal.
- Operates together with the ASIC in a closed loop configuration.
- Calibration factors:
  - Sensitivity and zero-point as function of temperature.



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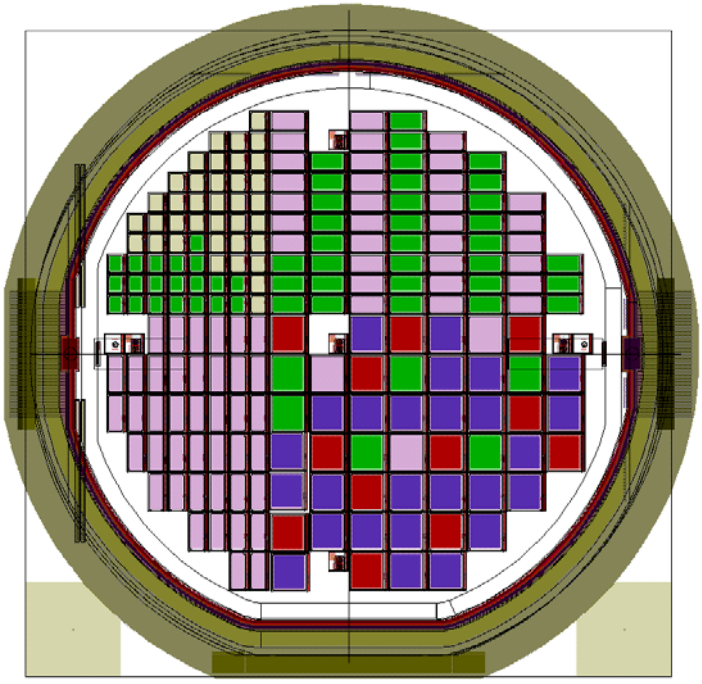
MultiMEMS MPW

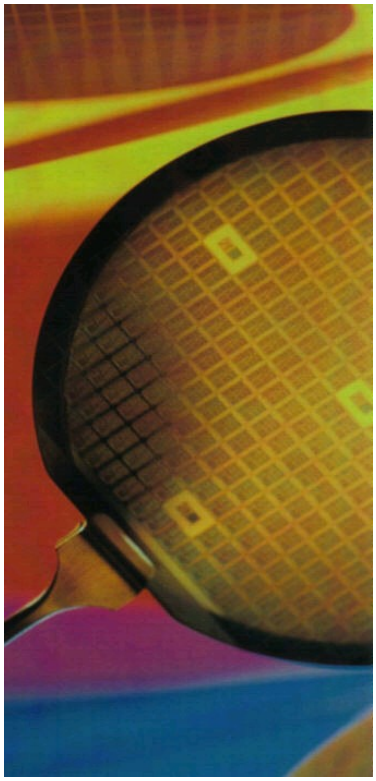
- Manufacturing Service
  - Based on SensoNor's well-established bulk silicon and glass micromachining technologies.
- Aim: to offer easy access to SensoNor’s proven technology to the universities, R&D centres, and industry.
- Schedule: 2 runs / year.
- Web-based support: www.multimems.com

Why MPW?



- Share the cost with other users!
  - Easy access to industrial manufacturing process in a cost effective way
  - Low-cost for prototyping compared with a custom run
- Can be used for low volume production
- Direct transfer to high volume production

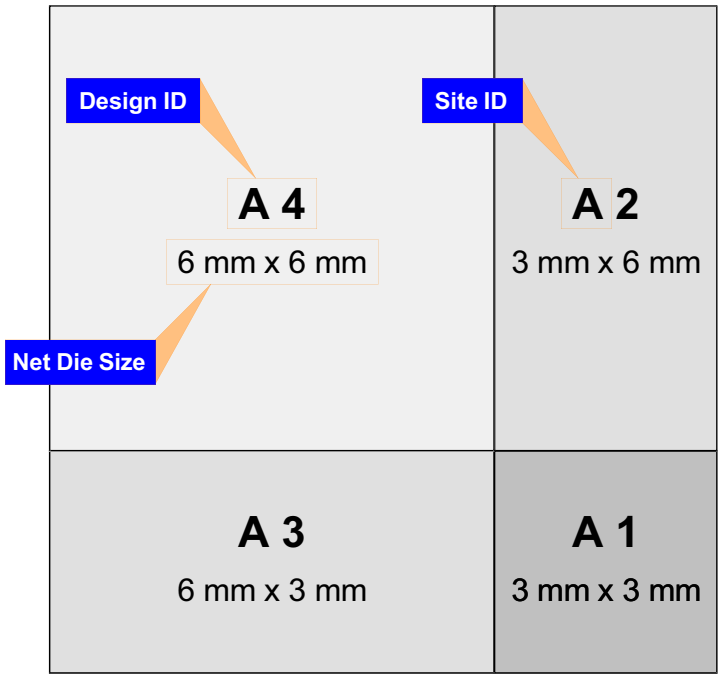
MultiMEMS MPW Highlights



- Designs are compiled on a single mask set
- MultiMEMS Dice of four sizes
- Main features:
  - Piezoresistive detection
  - Thermal excitation
  - Thermopneumatic actuation
  - Anisotropic etching of bulk silicon
  - 2 types of diaphragms
  - Release etch by RIE
  - Patented buried conductor crossings
  - Micromachined glass with
    - Sealed or vented cavities
    - Through-holes
  - Triple-stack anodic bonding

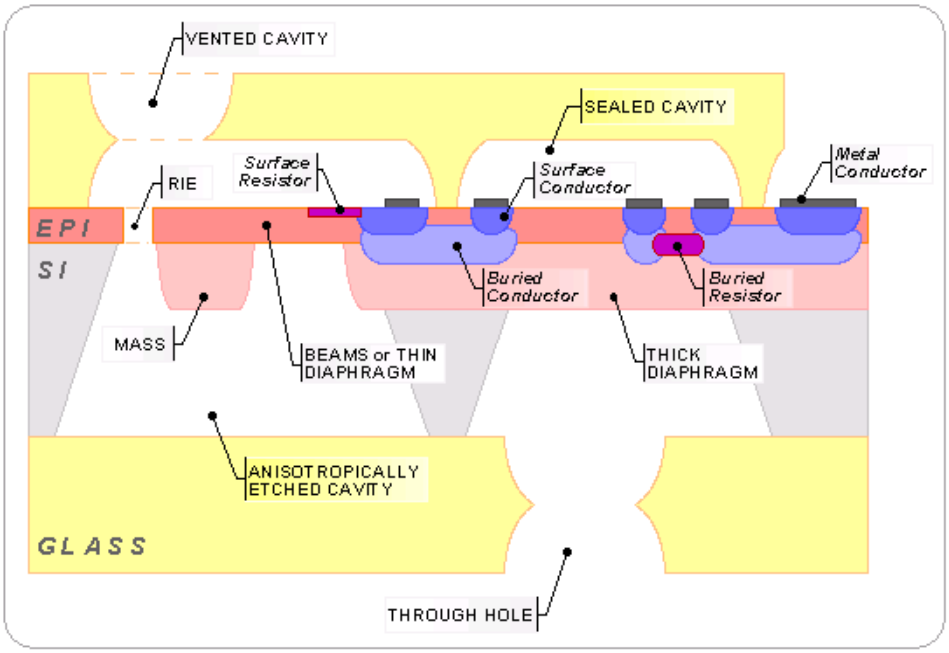
MultiMEMS Dice and Prices

- 20 design sites:
  - Labelled from A to V
  - 4 die sizes each
- Prices:
  - Academic users:
    - **1000 €**, 3 x 3 mm2
    - **1250 €**, 3 x 6 mm2
    - **1000 €**, 6 x 3 mm2
    - **1500 €**, 6 x 6 mm2
- Non-academic users: **4000 €... 6000 €**
- Delivery of ca. **100 dice**



MultiMEMS MPW Process

- Based on Infineon's TMPS products



MultiMEMS Applications

- Absolute and relative *pressure* sensors
- *Inertial* devices, such as accelerometers, force sensors, angular-rate sensors
- Physical *gas* sensors
- *Heat* and *radiation* sensors, such as thermopiles and bolometers
- *Microfluidic* devices, such as flow sensors, pumps and valves
- *Optical* devices, such as micromirrors
- *Energy harvesters* and resonators
- *Biosensors* and other *biomedical* devices

How To Access

www.multimems.com

- Download and sign the **License Agreement** (first time users only)
  - You will receive the **MultiMEMS Design Handbook**
- Download the desired **Layout Tools** and prepare the design(s)
- Download, fill in and sign the **MPW Booking Form**
  - You will receive a **Project Identification Document**
- Submit the design(s)
  - You will receive a **Report**
- Delivery of
  - 100 devices
  - Measurement results and certificates

Never stop thinking