

# Rapid Prototyping and Packaging of Micro Sensors for Niche Products

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IAB member in the PATENT DfMM project



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## Outline

- Introduction to DELTA
- What is DELTA MS then?
- 'Our packaging mission'
- Facilities
- Two examples
- Round up



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## DELTA: We help ideas meet the real world

- Focus areas:
  - the leading testing company in Europe
  - Microelectronics / Microsystems
    - ASIC Design
    - Prototyping – debugging
    - Production, test and QA
    - Fab. less operation (> 10 mio./year)
  - Light & Optics
  - Acoustics & Vibration
  - EMC & climatic test



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## About DELTA Microsystems

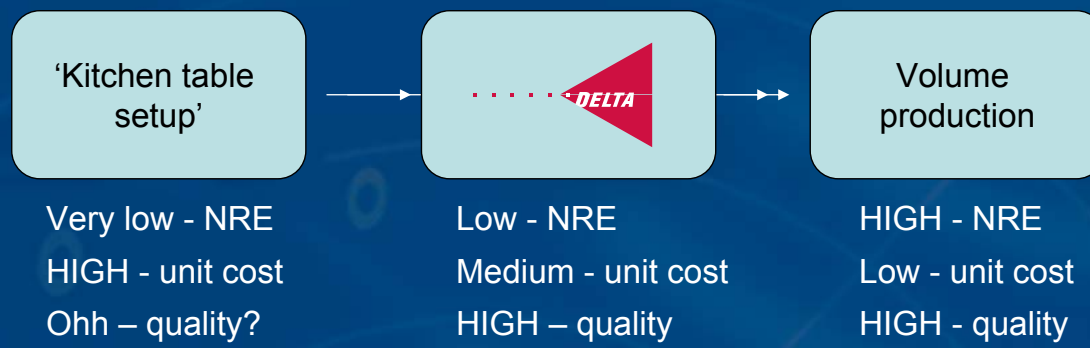
- Microsystems group – historically
  - Test, failure analysis and qualification service
    - SEM / EDX
    - Cross sectioning
    - Scanning Acoustic Microscopy (SAM)
  - Prototype services
    - Wire bonding (wedge-wedge or ball-wedge, Al or Au)
    - Stud ball bumping
    - Flip chip process
  - Wafer level test - most adv. in Europe
    - Pressure sensor, accelerometers, microphones, cantilever chips
  - Micro-sensor development – fab less production
    - ...



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## Our packaging mission: From idea to the real world



- Typical customers looking for an OEM solution:
  - Niche companies
  - Small → medium enterprises with limited R&D facilities
  - Start ups

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## Typical start up of new micro sensor business

- Feasibility study
- Demonstration phase – proof of concept evaluation
- Prototyping - small series
- 1. generation: Low NRE – High production (unit) cost
  - Market response?
- 2. generation:
  - Option 1: Low / medium volume – medium unit cost – medium NRE (Niche)
  - Option 2: Medium / high volume – low unit cost – high NRE (Start ups and others)

DELTA as 'one-stop-shop' guarantees the quality!

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## DELTA's approach to product development

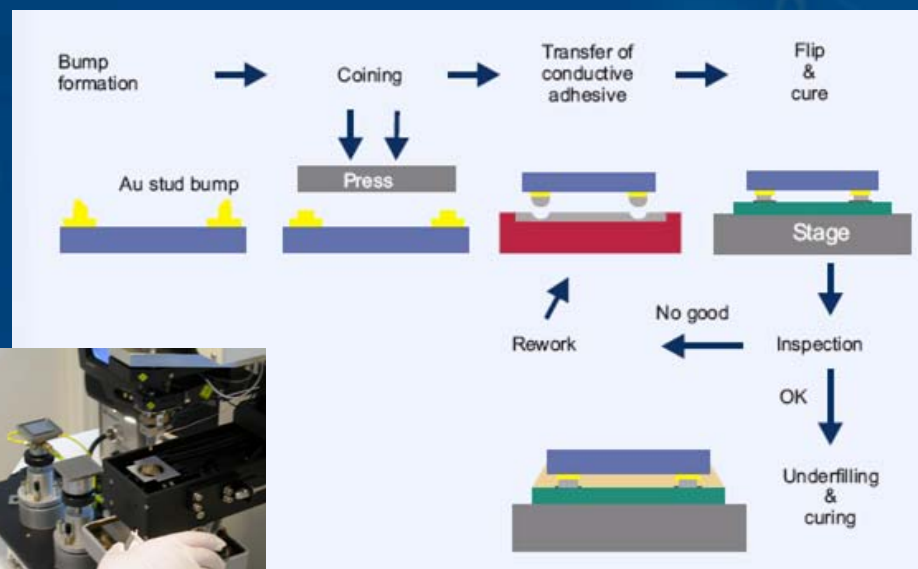
- Solidworks 3D modeling – for easy visualization and communication internally and externally (complex system design)
- More focus on the sensor function – less on the package:
  - Low risk packaging → rapid evaluation of sensor performance
- Simulation is important but doesn't say it all:
  - Balance between simulation and test → Quality!
- Innovative use of standard packaging methods:
  - Underfill around cavities to partially expose the sensitive area of a sensor to the environment
  - Sensors and electrodes embedded in the substrate
  - The substrate as part of the packaging

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## Stud Bump Bumping process for IC chips

- Chip bonded face down
- Footprint and volume minimized



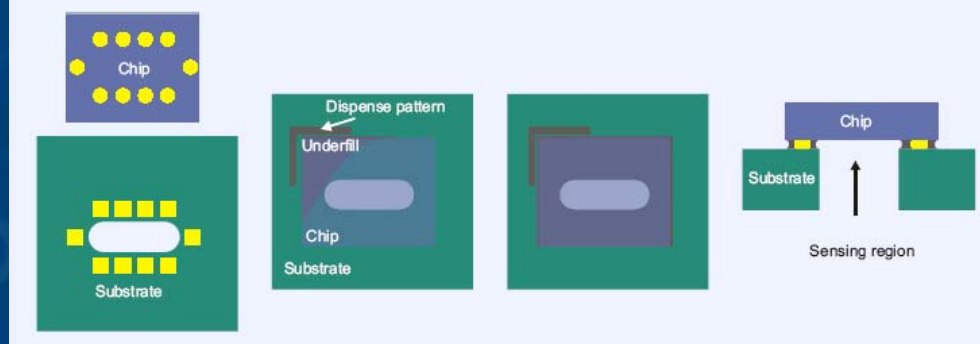
Flip chip process

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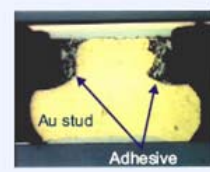
## Modified SBB process for micro sensor chips

### Enclosed cavity sealed with underfill

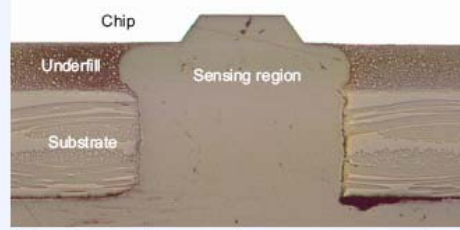


- Low temperature
- Clean process
- Local protection
  - Chemical
  - Mechanical

### Conductive adhesive



### Flip chip on printed circuit board



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## Microsystem facilities at DELTA

- Clean room class ISO 7, 70 m<sup>2</sup>
- Microsystems packaging:
  - Wire bonding / gold bumping
  - Flip chip process
  - Mounting, gluing and under-filling (automatic dispenser)
  - Surface preparation: Plasma / wet chemical for optimal bonding
  - Encapsulation: Molding, spraying, potting
- Material characterization and failure analysis
  - DSC (differential scanning calorimetry)
  - Tensiometer
  - SAM, SEM/EDX and X-ray



Wire bonding



Auto dispense

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## Examples of sensor system development

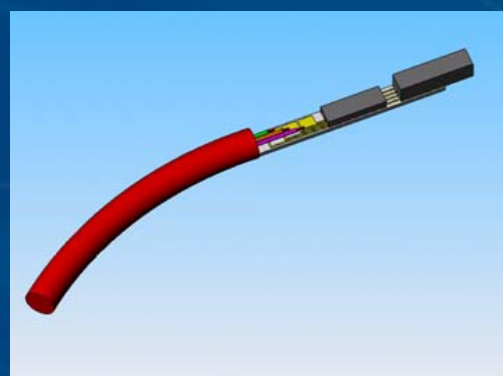
- Mostly customer driven projects = confidential information
- Two examples I'm allowed to talk about:
  - Pressure sensor
  - Needle sensor

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## Pressure sensor - Encapsulation

- Sensor for harsh chemical environment
- Should withstand pressures up to 7 bar
- Encapsulation should not introduce stress

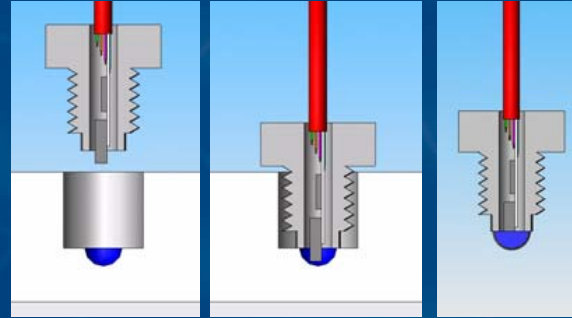
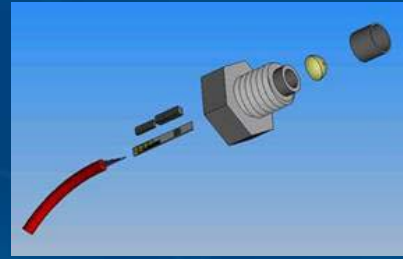


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## Pressure sensor – Packaging

- Standard M10 metric bolt with  $\varnothing 7.5$  mm hole
- Substrate with sensor chip and ASIC mounted in bolt
- Dome of soft polymer molded around sensor chip
- Hole filled with silicone and the wire fastened with epoxy
- Thin gold film deposited as diffusion barrier

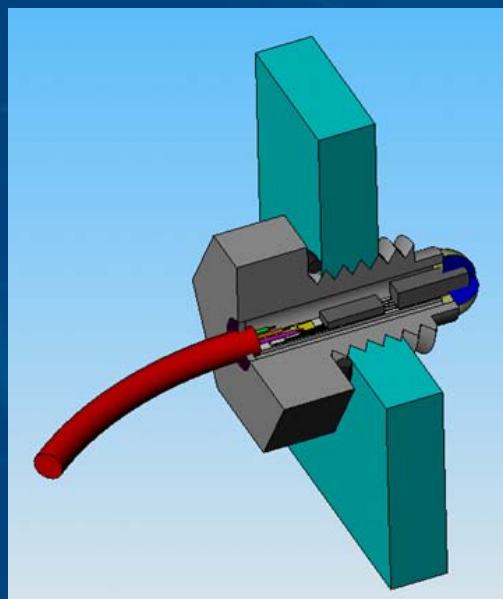


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## Pressure sensor – cont.

- Mounting without introducing stress

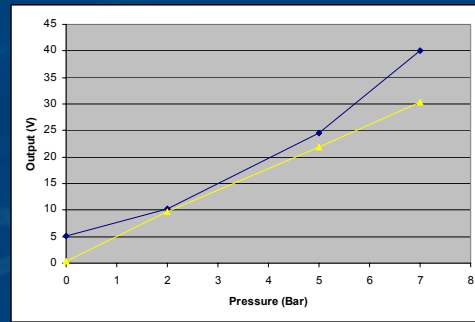


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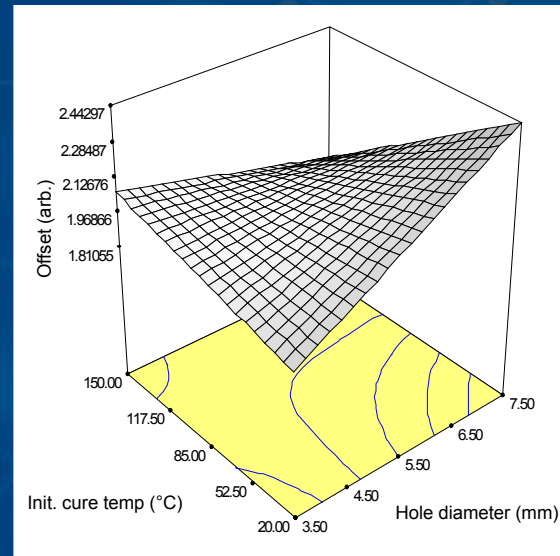
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## Pressure sensor – Test and analysis

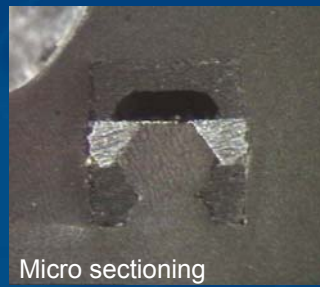
### Test



### Process optimization through DOE software



### Failure analysis



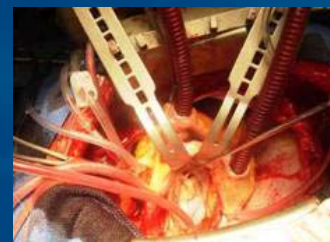
Micro sectioning

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## 2. Example: The needle sensor

- Objective: develop a miniature needle-shaped sensor which has:
  - A bio-impedance sensor (resistance and phase angle)
  - A pH sensor
  - A temperature sensor
- Application within e.g.
  - Heart operations
  - Organ transplant / transportation



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## The needle sensor – Design

### Considerations:

- Space constraint  
=  $\varnothing 3$  mm at the moment
- Sharp tip  
= use the  $\text{Al}_2\text{O}_3$  substrate  
not the polymer
- Integration  
= place the electrodes on the substrate
- Simple package  
= one shoot molding using the substrate as  
part of the package

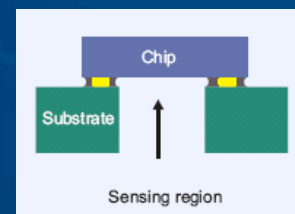


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## The needle sensor – Fabrication

- Modified SBB
  - Bump both substrate and chip
- Wire soldering
- Macromelt Molding
  - low temp (200-230°C)
  - low pressure (3-5 bar)
  - affordable molds (~1,500 €)
  - Fast (4 sec. + 6 sec.)



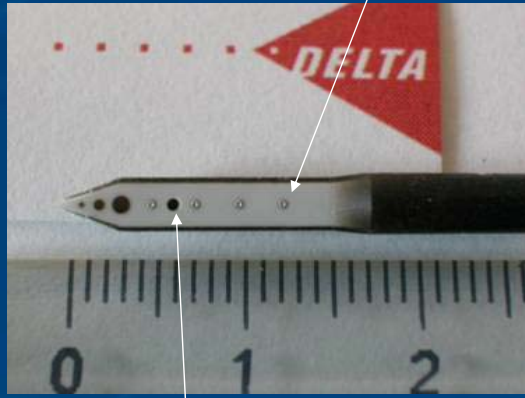
Molding equipment

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## Packaged needle sensor

4 metal electrodes for measuring bio-impedance



Hole for measuring pH

28 mm long  
3 mm in diameter

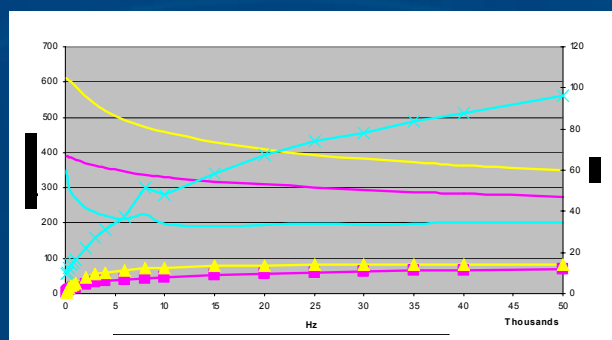
Wire

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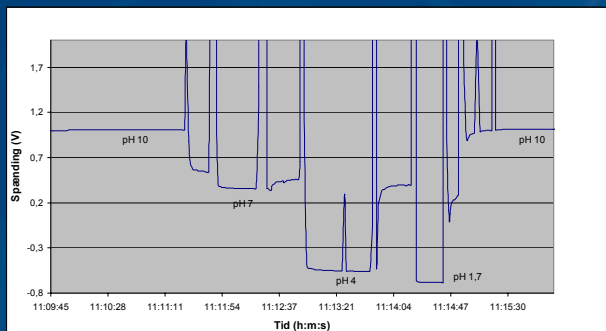


## The needle sensor – Characterization

Impedance



pH



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## The last slide ...

- Small scale, niche products do not justify high NRE cost
- DELTAs solution:
  - Fast microsystem design supported by in-house expertise (Light&Optics, Acoustics&Vibration, EMC, climatic test ...)
  - Fast prototyping using known methods – to reduce NRE
  - Unique process for low volume production optimized for micro sensors
    - Modified Flip chip SBB
    - Macromelt molding
  - High quality - ensured by DELTAs comprehensive analysis and test knowledge
  - That why we say...

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