



PHILIPS

Innovation
Services

MEMS devices
& micro-assembly

Development & prototyping of MEMS inkjet devices

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MicroNano Conference 14 December 2016

Outline

- Intro Philips MEMS foundry & micro-assembly
- Print head challenge
- The solution
 - Print head design
 - Wafer processing
 - Micro-assembly
- Conclusions



Philips MEMS foundry & micro-assembly

- State-of-the-art cleanroom 2650 m²
- Flexibility in materials and substrates
- High-end micro-assembly factory
- **Development + Manufacturing**
- Certified ISO 9001, ISO 13485



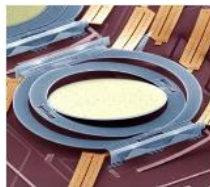
Flow sensor



Air pressure sensor



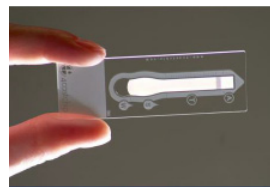
Micro pump



MEMS mirror



IR sensor for ear thermometer

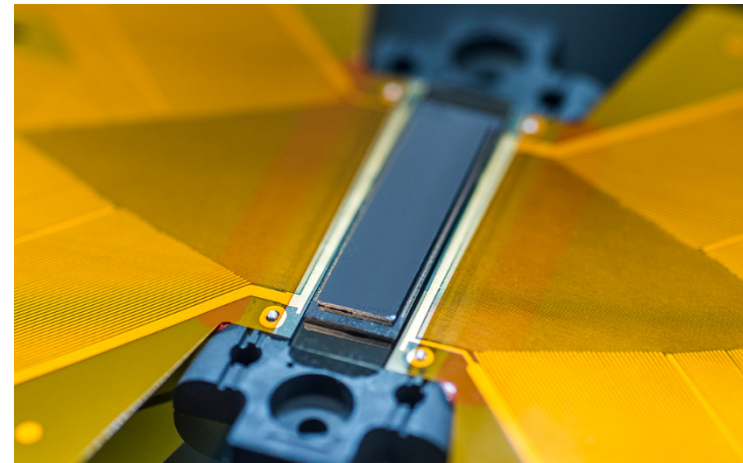


Micro fluidic chips



Print head challenge

- The classic design = micro-machined parts and micro-assembly
 - > Good performance
 - > Relatively large
 - > Expensive to produce
 - > Limited printing resolution
 - > Limited integration capabilities
- MEMS inkjet devices offer many benefits:
 - > Smaller and lighter physical size
 - > Higher precision and speed
 - > Lower cost price

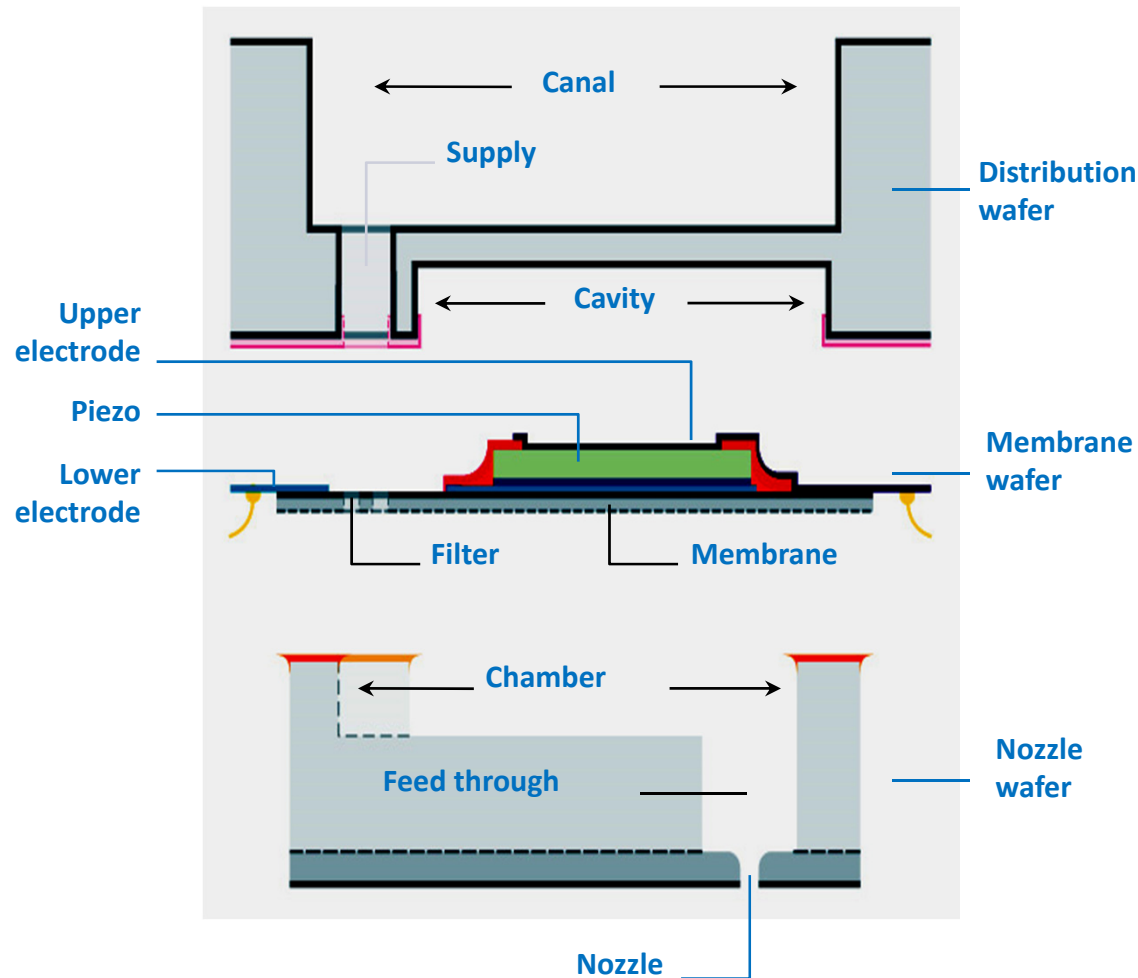


Main challenge:

Development of efficient manufacturing process in the shortest possible time frame

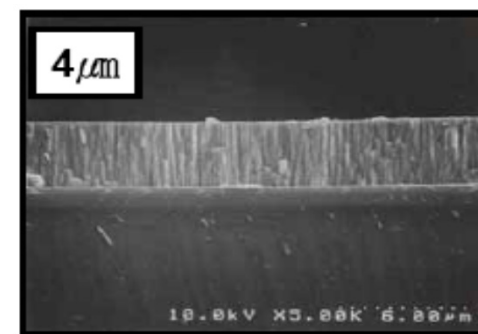
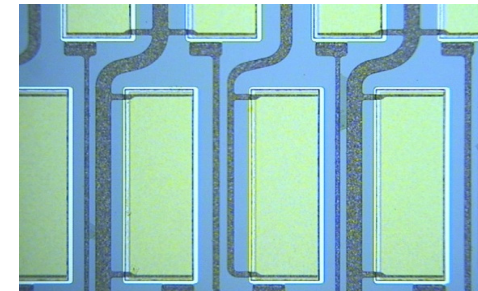
The solution: 3D integration + advanced technology

Design dimensions

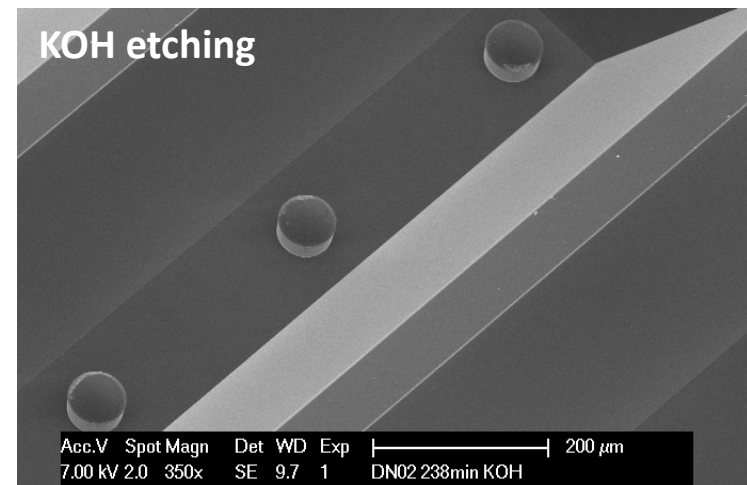
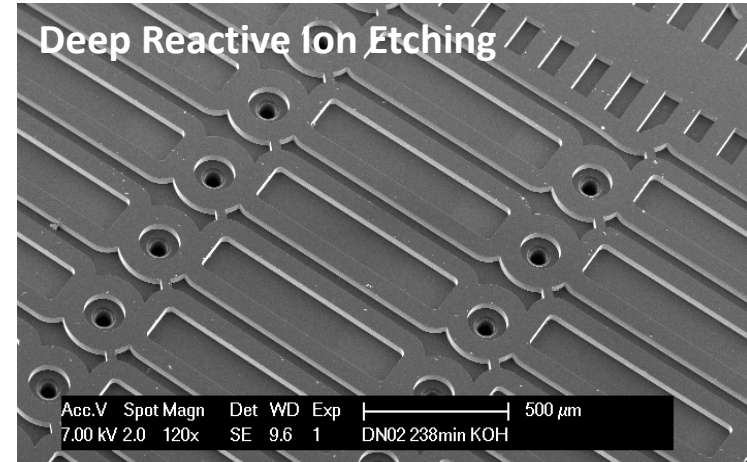
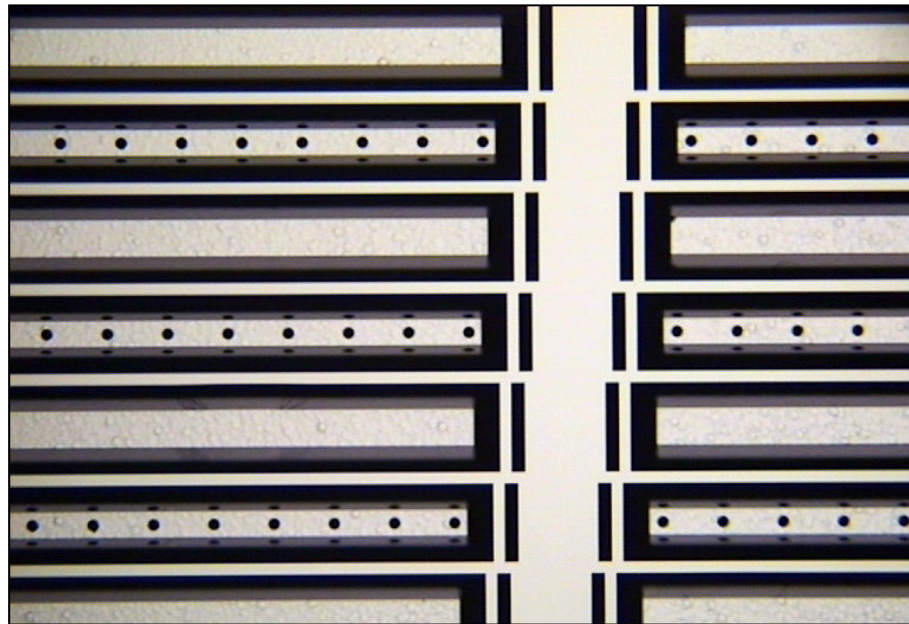
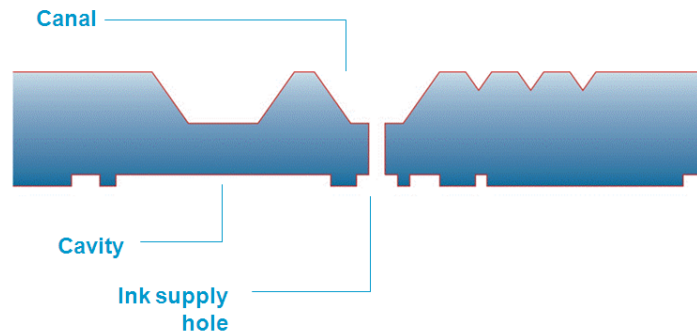


MEMS inkjet head dimensions

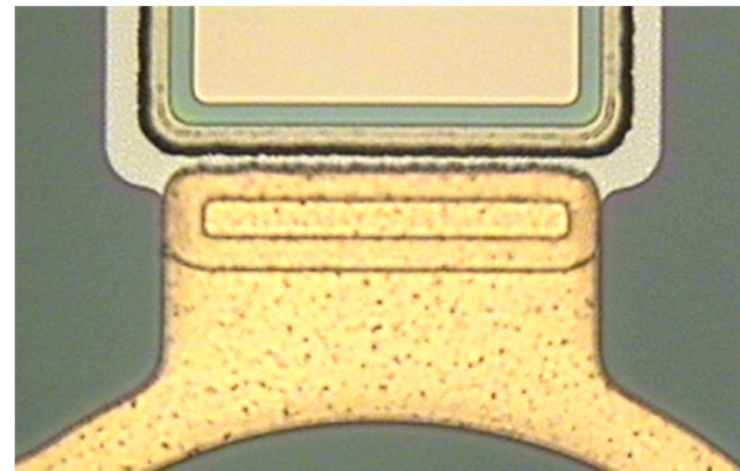
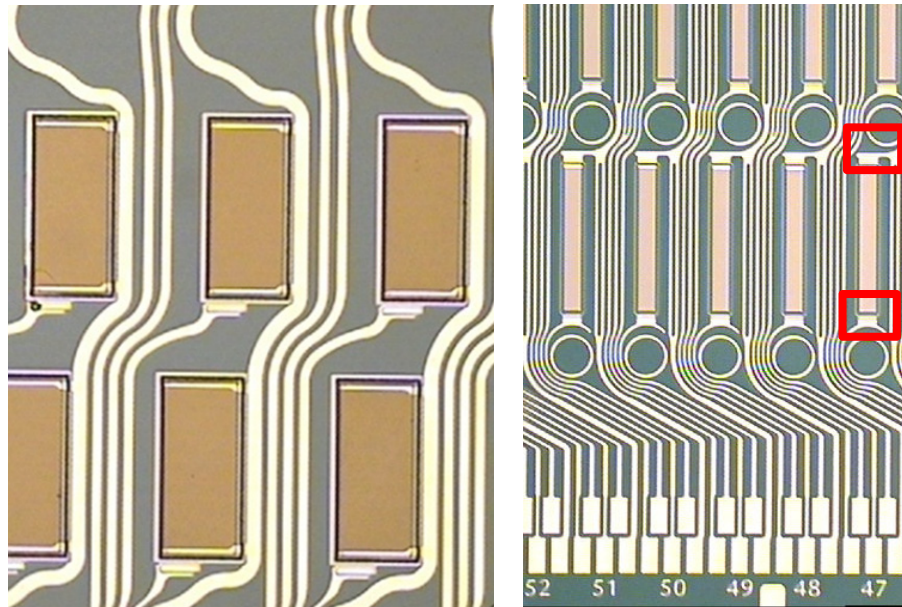
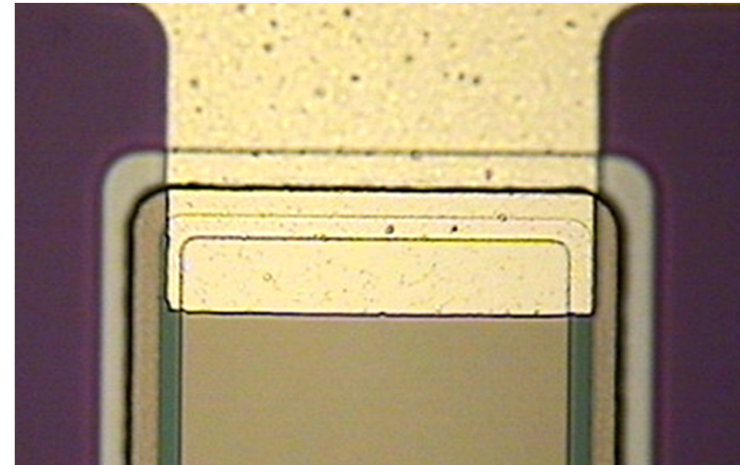
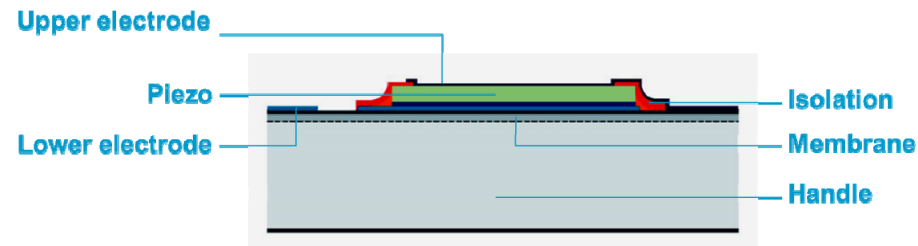
- 1-5 μm thin film PZT
- Nozzle 20-40 μm , several nozzle shapes
- 100's x 100's μm actuator size
- Membrane thickness \sim 1-15 μm
- d_{31} in a range 100-150 pm/V
- 1-30 pL droplet
- Resolution 150-1200 dpi



Distribution wafer: double-sided processing

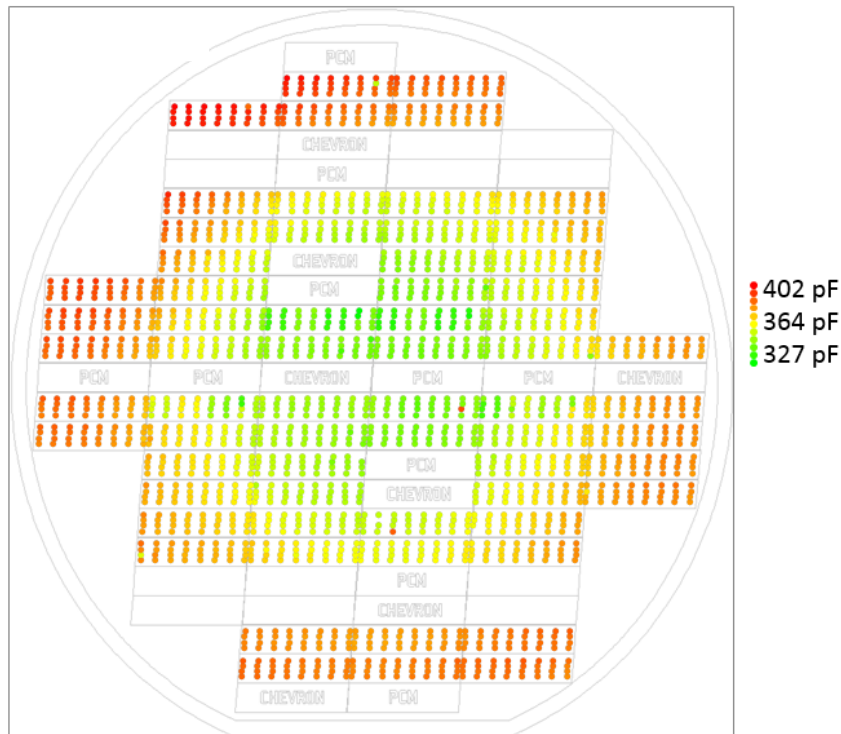


Membrane wafer: SOI wafer processing and PZT structuring

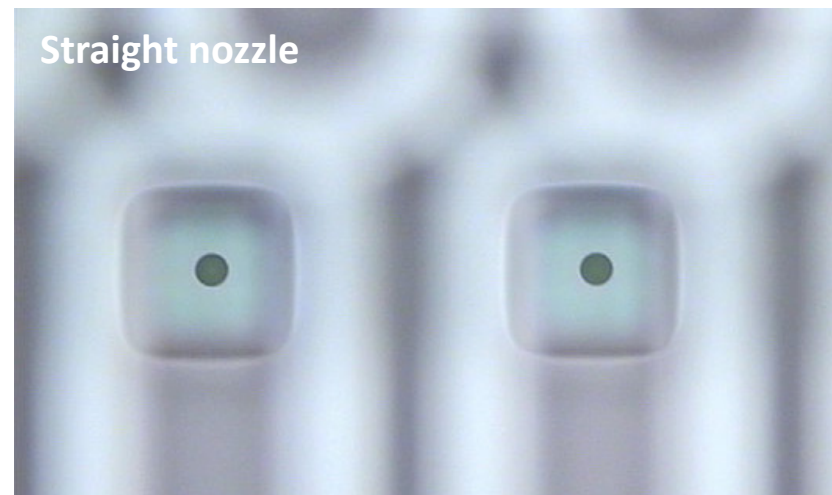
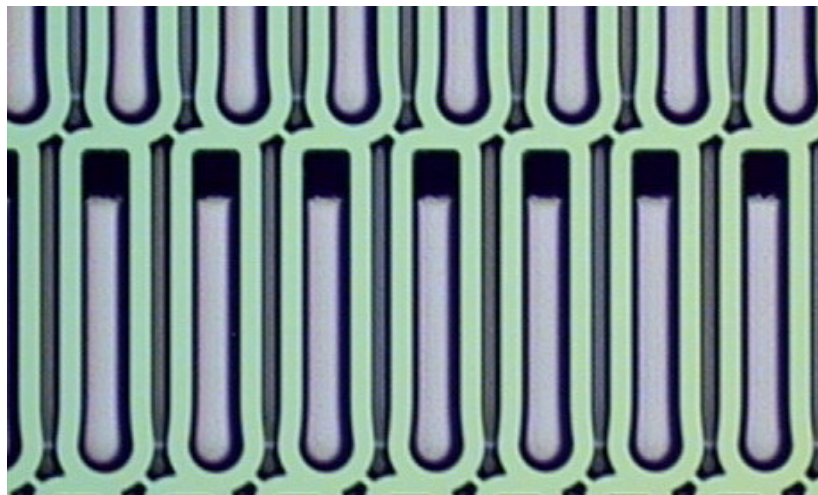
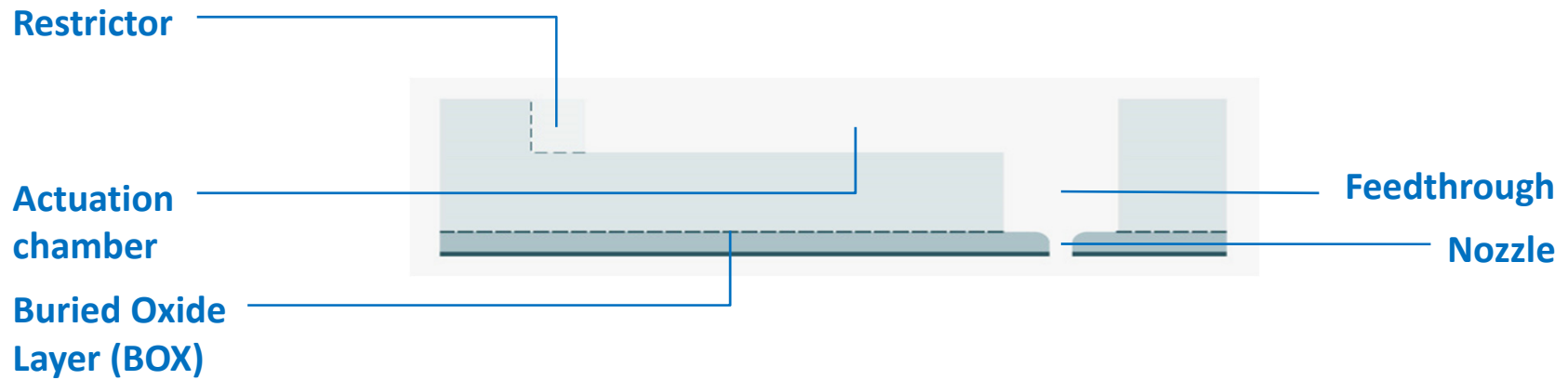


Good performance: capacitance distribution and low defect rate

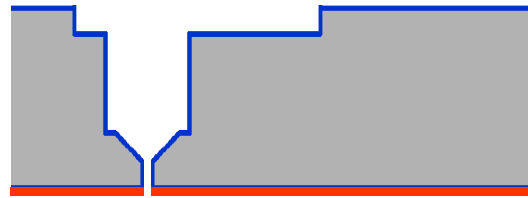
Capacitance distribution



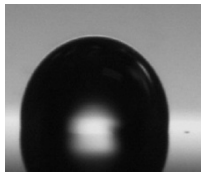
Nozzle wafer: double-sided processing of SOI wafer



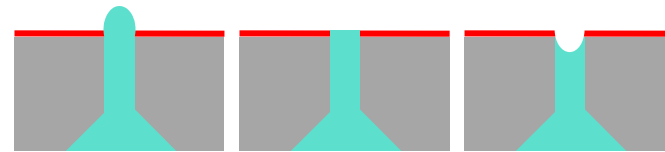
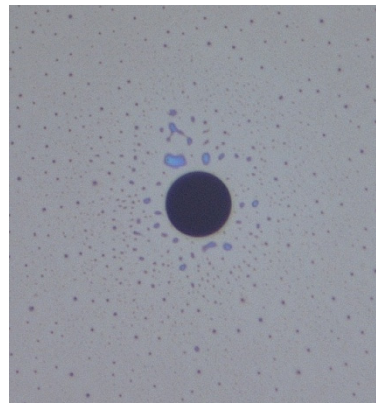
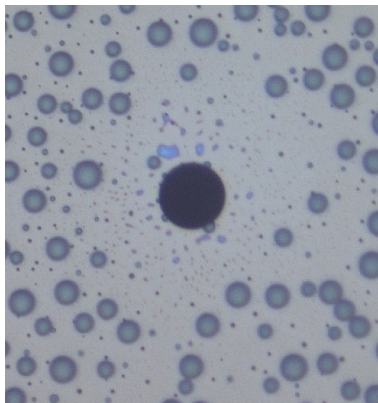
Anti-wetting nozzle plate for stable jetting



Hydrophobic coating on nozzle plate

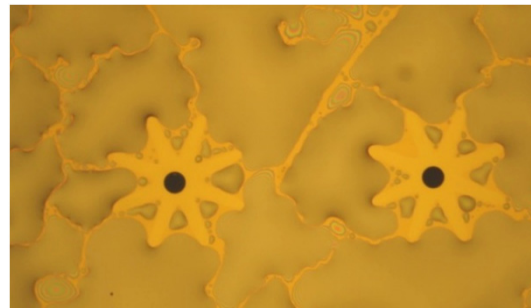


Hydrophobicity test

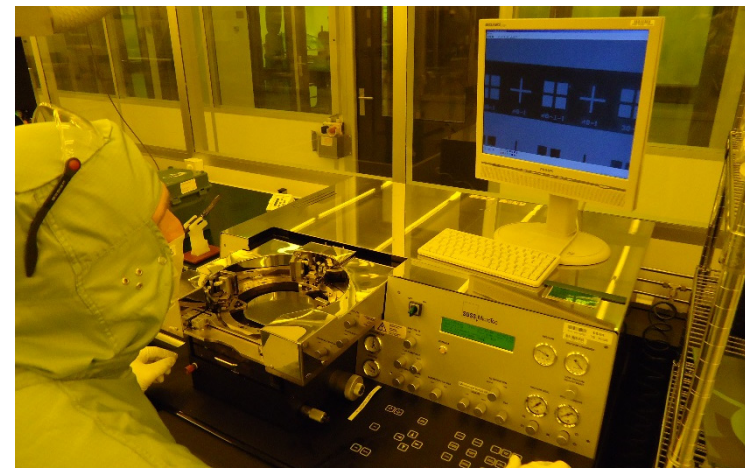
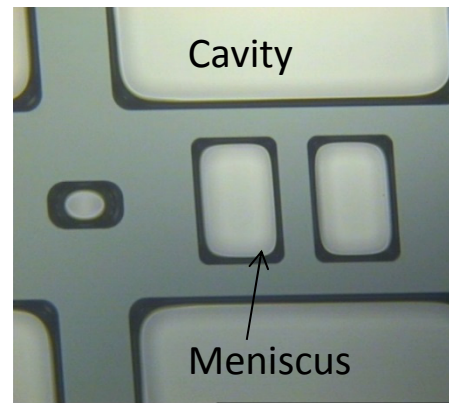
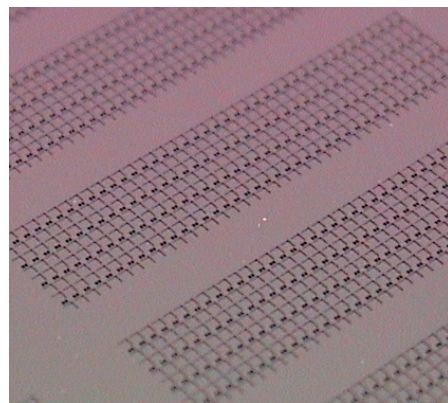
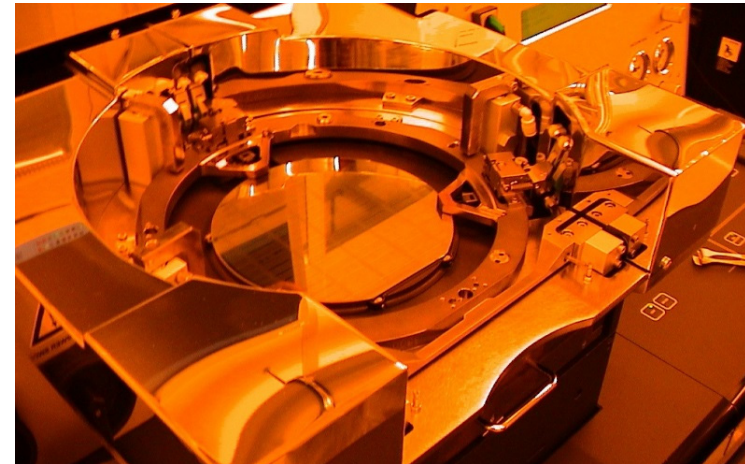
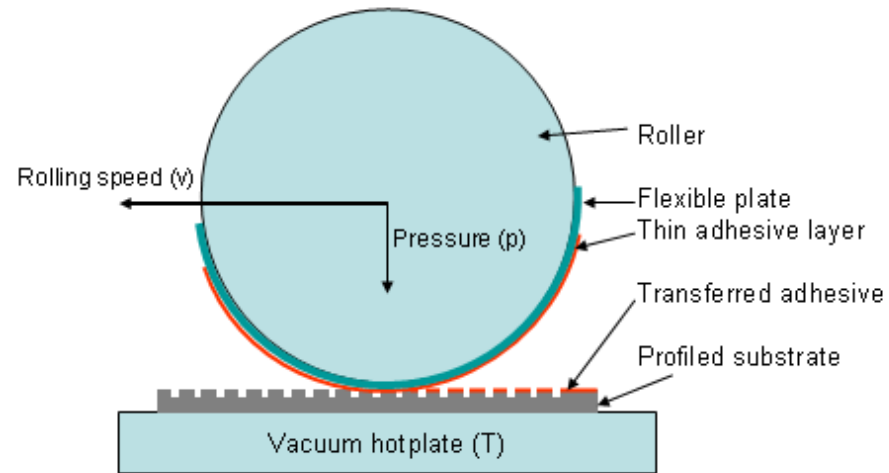


convex
+10 cm H₂O

concave
-10 cm H₂O



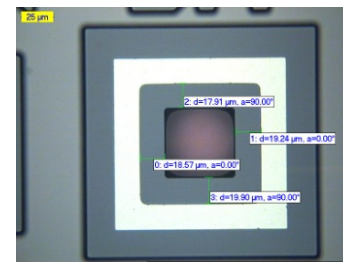
Advanced adhesive wafer bonding technology



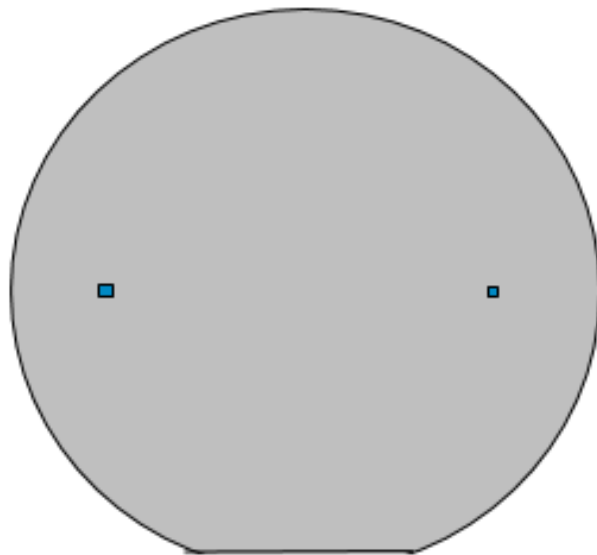
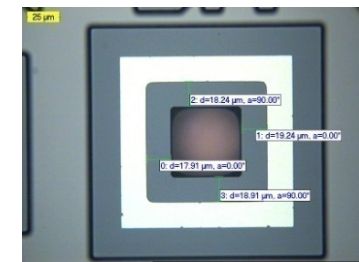
Results alignment DM stack bonding



Left side

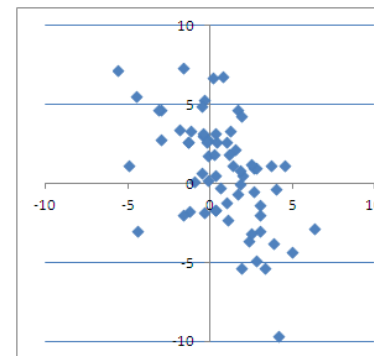


Right side

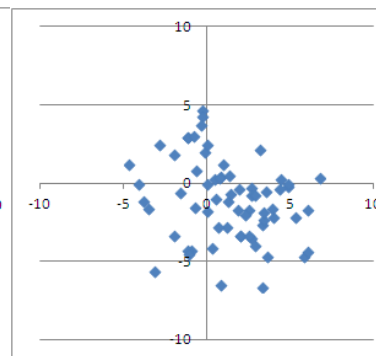


Alignment (micron)

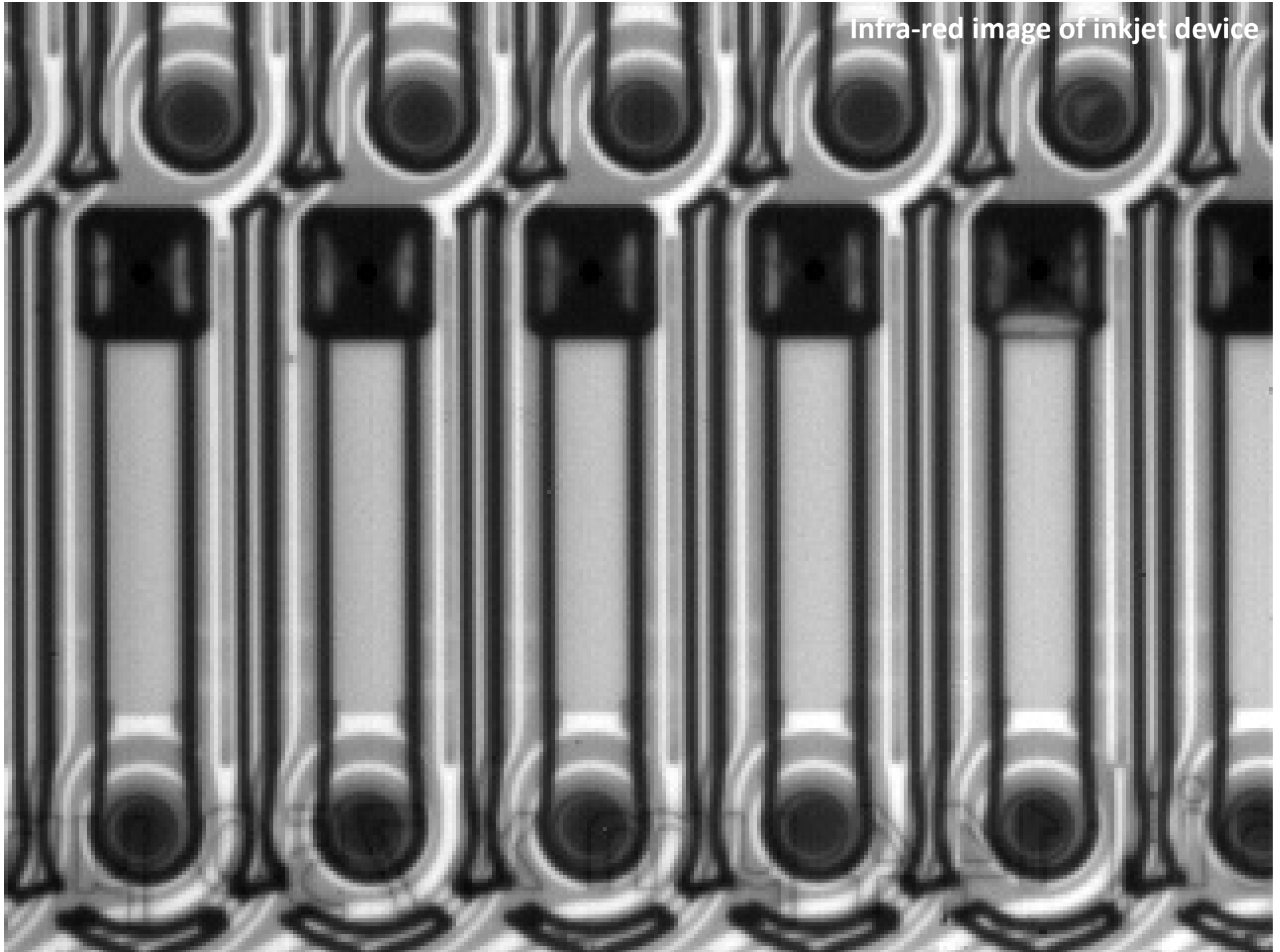
Left side



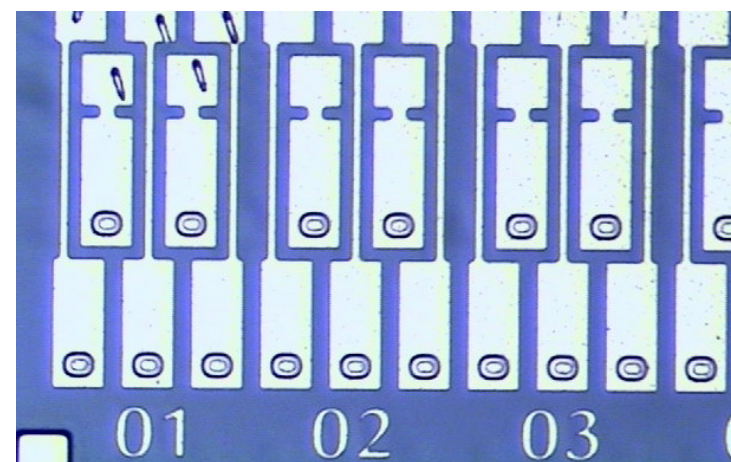
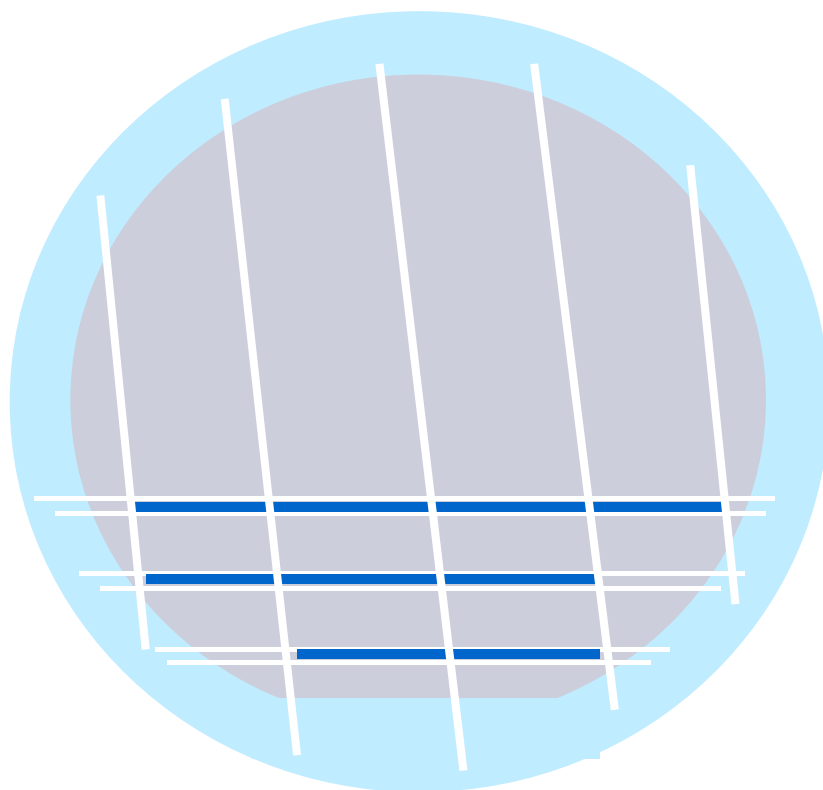
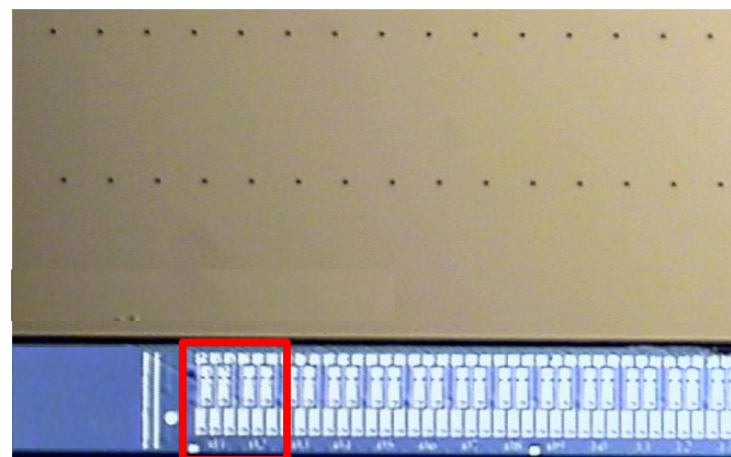
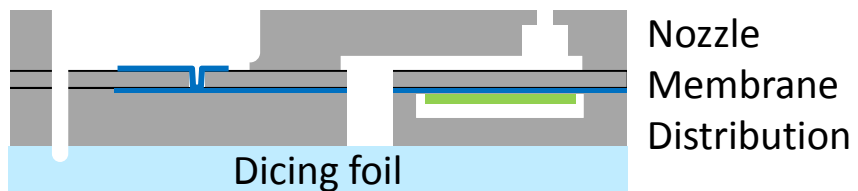
Right side



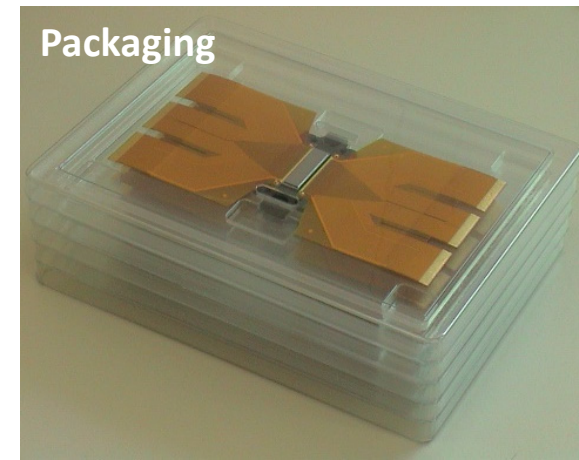
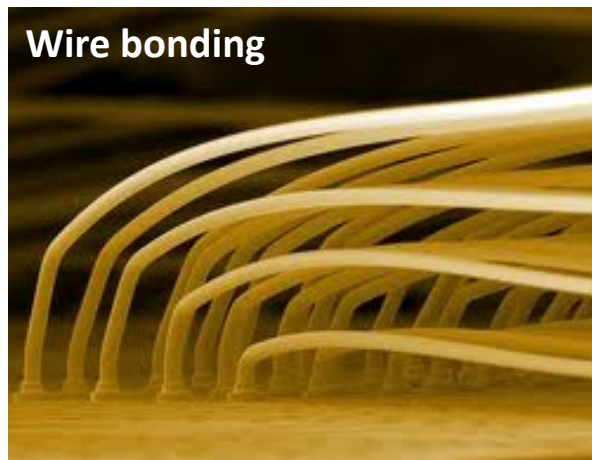
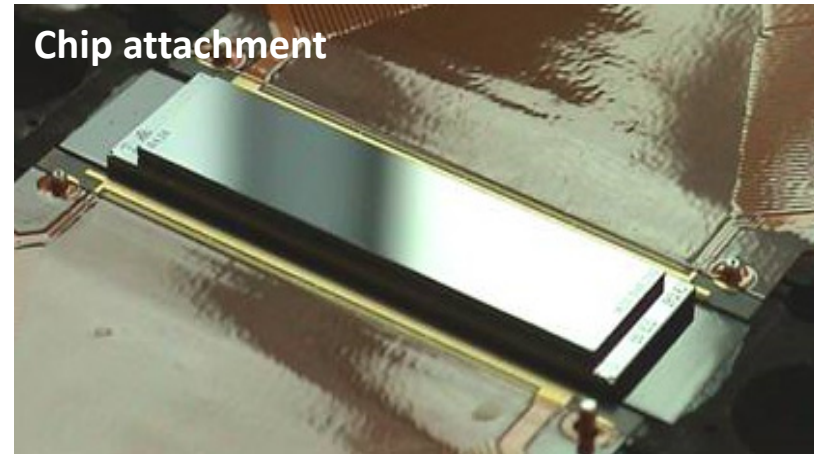
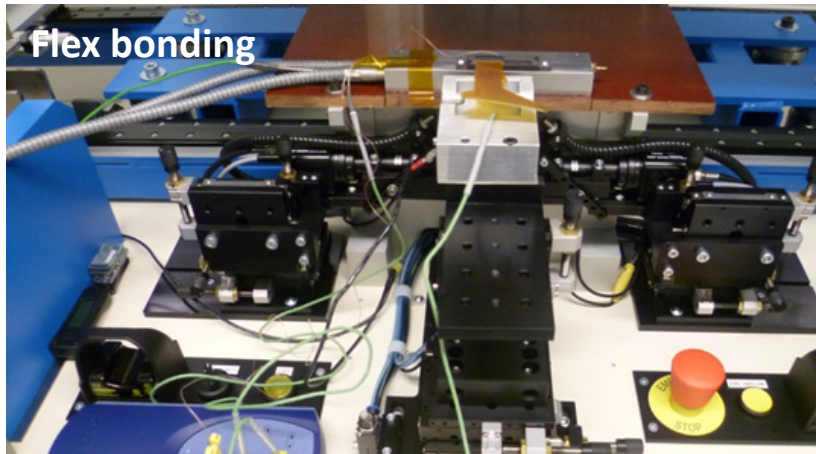
Infra-red image of inkjet device



Bond pad release & dicing



Chip assembly



Conclusions

- Our MEMS foundry and Micro-Assembly factory provide unique capabilities for the development and manufacturing of MEMS inkjet devices
- This is achieved by 3D integration and advanced process technology:
 - Double-sided processing
 - DRIE etching
 - KOH etching
 - Adhesive wafer bonding
 - Chip Assembly
- These capabilities are available to customers that seek efficient development, fast prototyping and smooth scale up to medium volume production of high-quality custom inkjet printheads

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