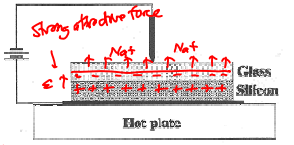
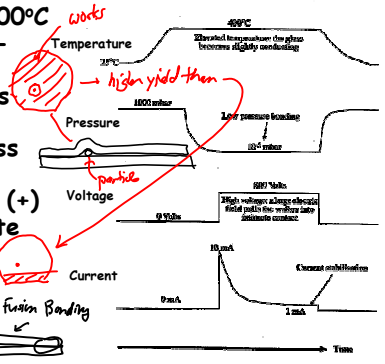
Anodic Bonding

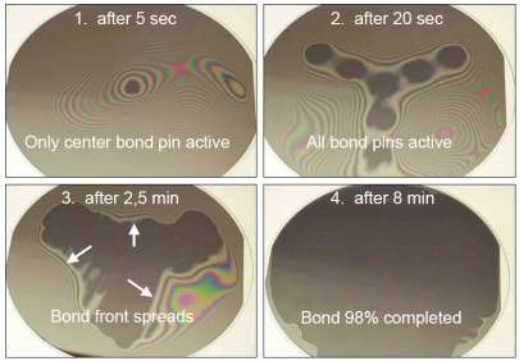
- Bonds an electron conducting material (e.g., Si) to an ion conducting material (e.g., sodium glass = Pyrex)
- Procedure/Mechanism:
  - Press Si and glass together
  - Elevate temperature: 180-500°C
  - Apply (+) voltage to Si: 200-1500V
    - (+) voltage repels Na^+ ions from the glass surface
    - Get net (-) charge at glass surface
    - Attractive force between (+) Si and (-) glass → intimate contact allows fusing at elevated temp.
  - Current drops to zero when bonding is complete





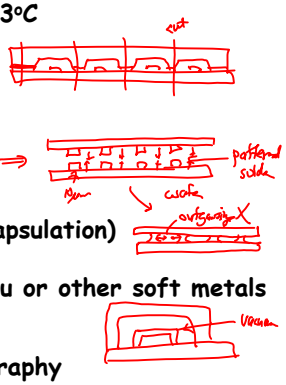
Anodic Bonding (cont.)

- Advantage: high pressure of electrostatic attraction smoothes out defects
- Below: 100 mm wafers, Pyrex glass 500 μm-thick, 430°C, 800V, N_2 @ 1000 mbar



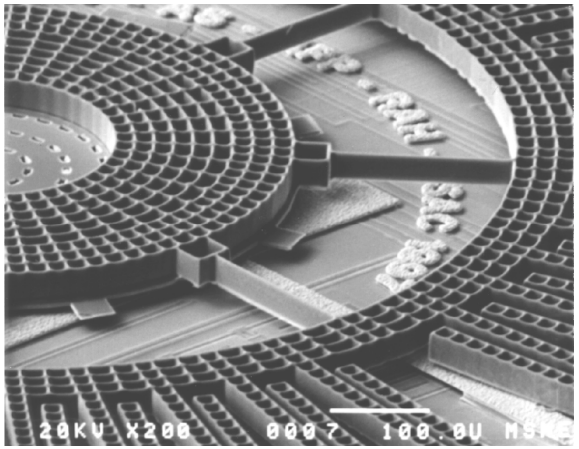
Metal Layer Bonding

- Pattern seal rings and bond pads photolithographically
- **Eutectic bonding**
  - Uses eutectic point in metal-Si phase diagrams to form silicides
  - Au and Si have eutectic point at 363°C
  - Low temperature process
  - Can bond slightly rough surfaces
  - Issue: Au contamination of CMOS
- **Solder bonding**
  - PbSn (183°C), AuSn (280°C)
  - Lower-T process
  - Can bond very rough surfaces
  - Issue: outgassing (not good for encapsulation)
- **Thermocompression**
  - Commonly done with electroplated Au or other soft metals
  - Room temperature to 300°C
  - Lowest-T process
  - Can bond rough surfaces with topography



Thermocompression Bonding

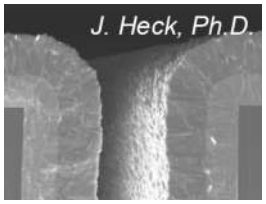
- Below: Transfer of hexsil actuator onto CMOS wafer

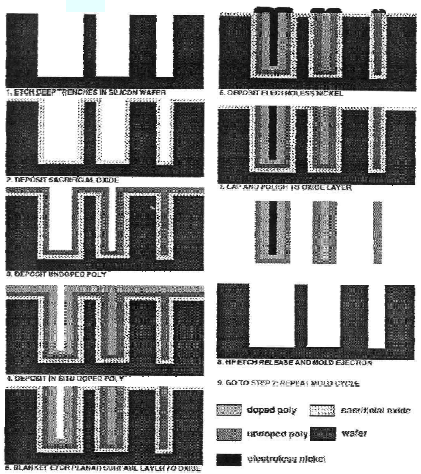


[Singh, et al, Transducers'97]

Hexsil MEMS

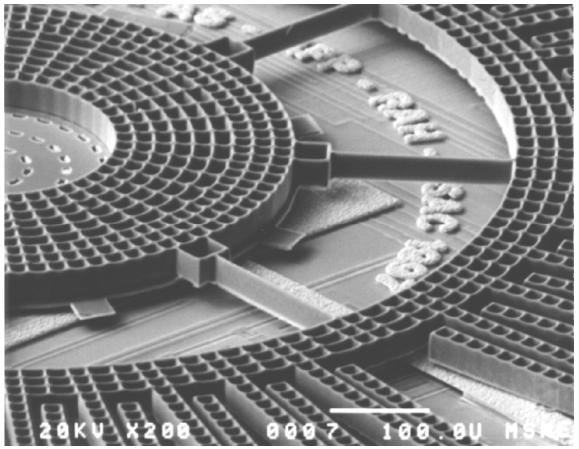
- Achieves high aspect ratio structures using conformal thin films in mold trenches
- Parts are demolded (and transferred to another wafer)
- Mold can be reused
- Design with honeycomb structure for strength





Hexsil MEMS Actuator

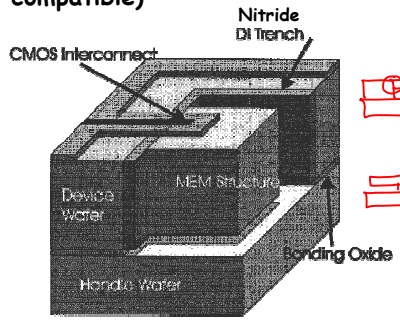
- Below: Transfer of hexsil actuator onto CMOS wafer

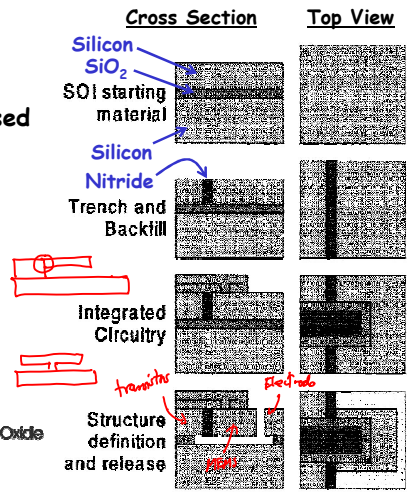


[Singh, et al, Transducers'97]

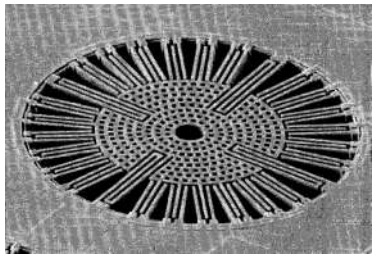
Silicon-on-Insulator (SOI) MEMS

- No bonding required
- Si mechanical structures anchored by oxide pedestals
- Rest of the silicon can be used for transistors (i.e., CMOS compatible)



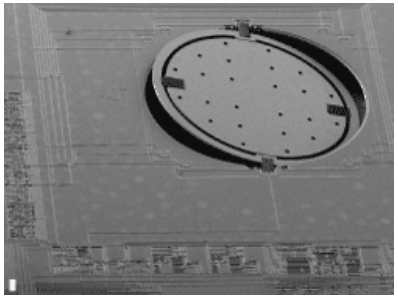


SOI MEMS Examples



[Brosnihan]

Micromirror
[Analog Devices]



The SCREAM Process

- SCREAM: Single Crystal Reactive Etching and Metallization process