EE 701: Introduction to MEMS

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Wafer bonding

- This is a method of firmly joining two wafers to create a wafer stack.
- The method is employed in MEMS fabrication and device packaging.
- There are three main types:
  - Direct wafer bonding of silicon
  - Field-assisted bonding
  - Bonding with an intermediate layer

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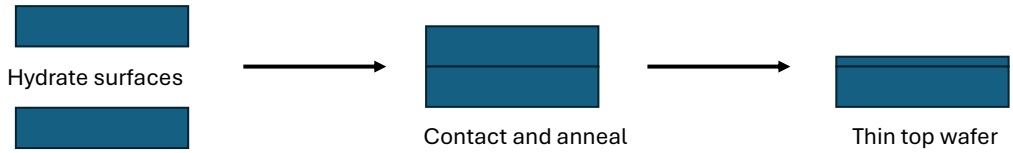
Direct wafer bonding

- The direct bonding of two silicon wafers requires high temperatures (~ 1000 ^{o}C)
- First step: Cleaning and hydration of surfaces to be bonded. Bond surfaces must be smooth and particle-free.
- Second step: Wafers are contacted and pressed together, using hydrogen bonding of the hydrated surfaces to provide adhesion. The contacted pair is placed in a high temperature furnace to fuse the two wafer together.
- Third step: The wafer stack can be thinned to the desired thickness.



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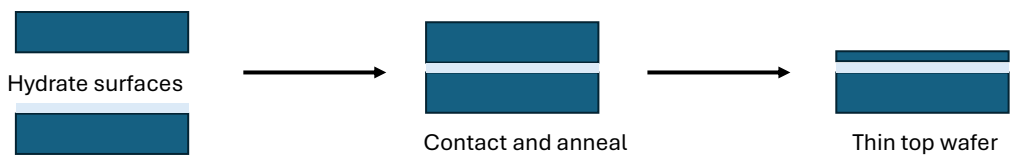
Direct wafer bonding

- A variant is the bonding of silicon wafer to an oxide coated second wafer.
- The surfaces are cleaned and hydrated, then contacted and annealed, and the top wafer is thinned as before.
- This results in the formation of a silicon-on-insulator wafer or BESOI wafer.



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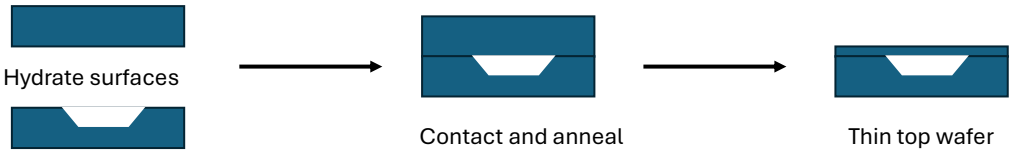
Direct wafer bonding

- Bonding can also be done on patterned wafers with cavities etched into them.
- This can result in the formation of diaphragms on a silicon wafer.
- Further processing can be conducted on the thinned top wafer e.g. to build transistors near the cavity.



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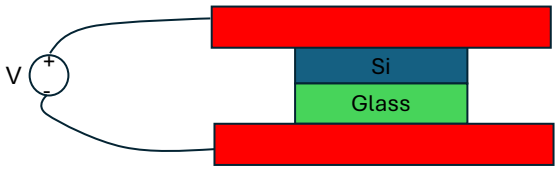
Anodic wafer bonding

- This involves the bonding of certain glasses to conductors (including silicon wafers)
- Mobile (for e.g. sodium) ions in the glass respond to high electric fields applied across the wafer stack.
- The two surfaces are brought into contact and held together due to the high electrostatic force across the interface (positively charged silicon wafer and negatively charged glass surface).
- At elevated temperatures, the two wafers can be fused together.



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Bonding with an intermediate layer

- Glass frit bonding: Glass frit layer is applied selectively to parts of the wafer using techniques such as screen printing. After a low temperature bake, the wafers are contacted and annealed, flowing the glass into a continuous layer that bonds the wafers together.
- Thermocompression bonding: Intermediate layers are metal films such as Au. Moderate pressure and temperature (~300 ^{o}C) is applied resulting in a Au-Au bond.
- Eutectic bonding: This utilizes intermediates that form a eutectic (substance that melts and solidifies at a temperature lower than each of the constituents) such as Au-Si, Al-Ge, Au-Sn. This is similar to a solder process.
- Polymer adhesives: Adhesives such as polyimides, silicones, epoxy resins can be employed to bond two wafers together after application of the polymer materials for bonding. This is a quick and easy way to bond wafers together but the bond quality is often limited due to the chemical / thermal stability of the polymer layers.

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