BONDING OF SILICON TO NON-STANDARD SUBSTRATES
OUTLINE

• Non-Standard Substrates
  – Glass
  – Sapphire
• Bonding of Silicon to Non-Standard Substrates
  – Anodic Bonding(Glass)
  – Modified Bonding process(Sapphire)
Grind and Polish SOI

Grind and Polish to required thickness

Handle

Oxidised handle substrate

Active silicon substrate

Active

Active

Room Temperature bonding followed by high temperature annealing

Handle

SOI

Handle
## Non-Standard Substrates

<table>
<thead>
<tr>
<th>Silicon-on-Glass</th>
<th>Silicon-on-Sapphire</th>
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<td>• Flat panel display</td>
<td>• Improves thermal and high frequency performance of interconnects compared to SOI.</td>
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<td>• Capacitive sensors</td>
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<td>• Solar cells</td>
<td>• Radiation Hardness</td>
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<tr>
<td>• Micromachining</td>
<td>• Better heat dissipation than quartz</td>
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<td>• Microwave cct applications</td>
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SOS previously achieved using epitaxial growth
- high density of dislocations
- high leakage current
Silicon-On-Glass

- Anodic bonding of silicon and other materials to glass.
  
  550°C, 1000V, 1Hr

- Problems
  - Thermal coefficient of expansion.
  - High Alkali content
  - Low Temperature Processing.
Selective bonding of silicon to glass

Silicon dioxide/glass bond

Bond temperature 550°C, Bonding Voltage 1000V, Bonding Time 1Hr
Silicon-On-Sapphire

Dislocation free SOS can be achieved through:

- Wafer bonding Techniques
- Active wafer thinning technology

However:

- Thermal coef. of expansion not matched to Si. 5 $\times 10^{-6}/^\circ$C for sapphire compared to 3.6 $\times 10^{-6}/^\circ$C for Si.
- Silicon dioxide layer needed for bonding
Bonding of Silicon to Sapphire

IR Image of Si/Sapphire Room Temperature Bond
Void Free for SiO₂ bond

IR image of SiO₂ bond after 250°C anneal. Oxide Thick: 20nm

S.A.M image of Si bond After 250°C anneal

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Thermal Coefficient of Expansion

Anneal at 250\(^\circ\)C

Anneal at 300\(^\circ\)C

Crack Propagation at 300\(^\circ\)C due to thermal Expansion Mismatch

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Solution To Thermal Expansion Problem

- Low Ramp Rate on annealing: 10°C/min
- Thermal oxide Required.
- Maximum initial anneal temperature: 250°C
- Thinning to an SOS layer to a thickness <20µm
  - Increase bonding temperature 350°C
  - Improve bond strength with no fracturing.
  - Allows Grinding/Etchback
Sub-Micron SOS Without Thin Oxide

- Low temperature process (crack propagation)
- Replace the thin silicon dioxide layer with:
  - Thin polysilicon layer on the Sapphire
  - Thin sputtered Silicon layer
- Silicon - Silicon Bonding
- Smartcut approach to achieve thin SOS layer.
Proposed Polysilicon/Smartcut Approach

- Smartcut/Ion Cleave Implant into Silicon
- Low Temperature Polysilicon deposition and Touch Polish
- SILICON-SILICON BONDING
- Low temperature Bond strength anneal
- High Temperature Anneal
- Mechanical split.

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