BONDING OF SILICON TO NON-STANDARD SUBSTRATES

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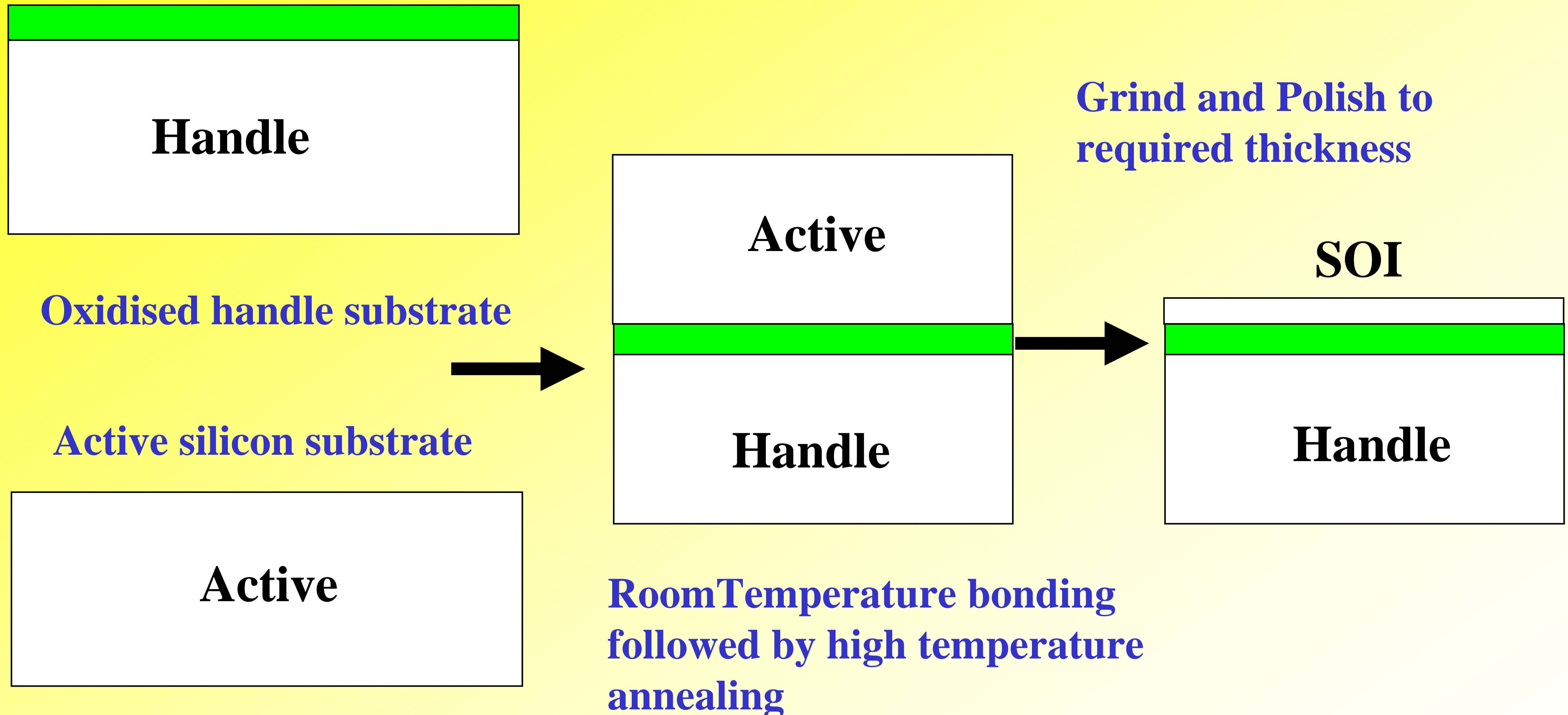
OUTLINE

- **Non-Standard Substrates**
  - **Glass**
  - **Sapphire**
- **Bonding of Silicon to Non-Standard Substrates**
  - **Anodic Bonding(Glass)**
  - **Modified Bonding process(Sapphire)**

Grind and Polish SOI



Non-Standard Substrates

Silicon-on-Glass

- Flat panel display
- Capacitive sensors
- Solar cells
- Micromachining

Silicon-on-Sapphire

- Improves thermal and high frequency performance of interconnects compared to SOI.
- Radiation Hradness
- Better heat dissipation than quartz
- Microwave cct applications

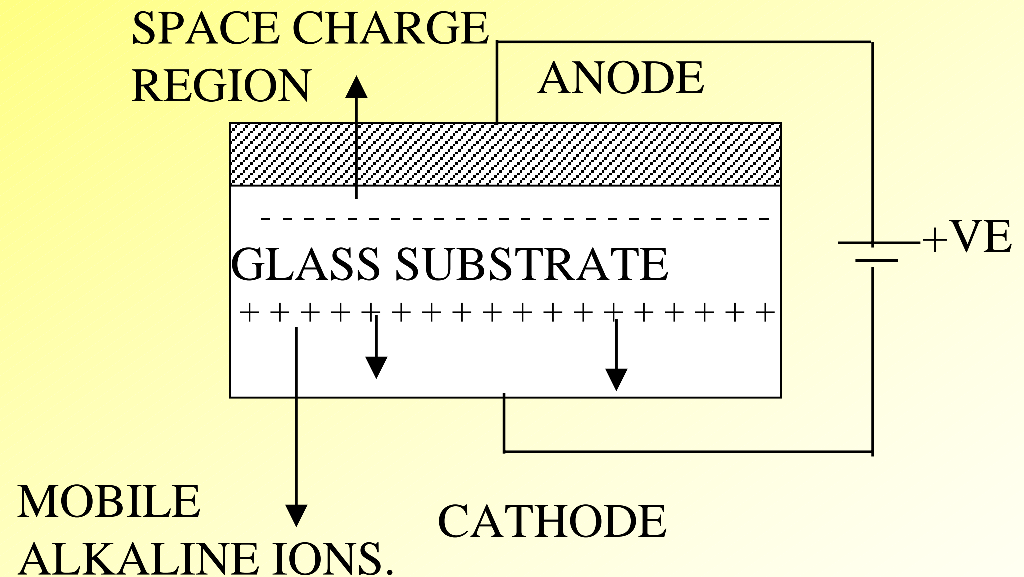
SOS previously achieved using epitaxial growth
-high density of dislocations
-high leakage current

Silicon-On-Glass

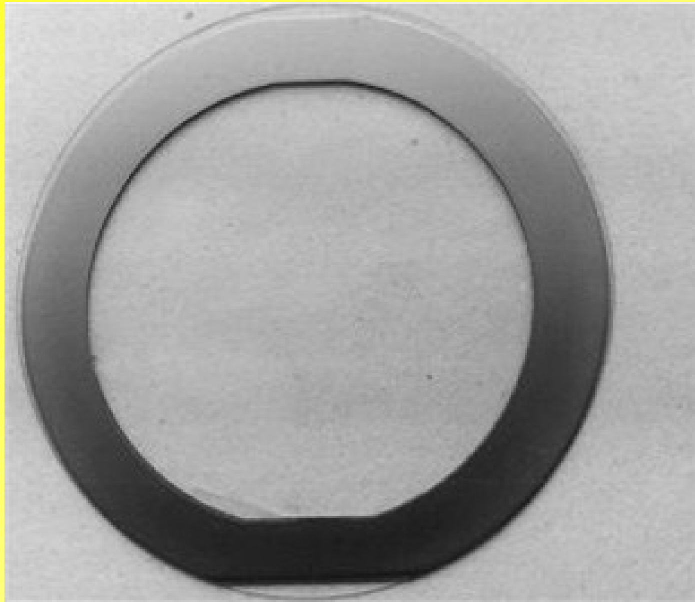
- **Anodic bonding of silicon and other materials to glass.**

550°C, 1000V, 1Hr

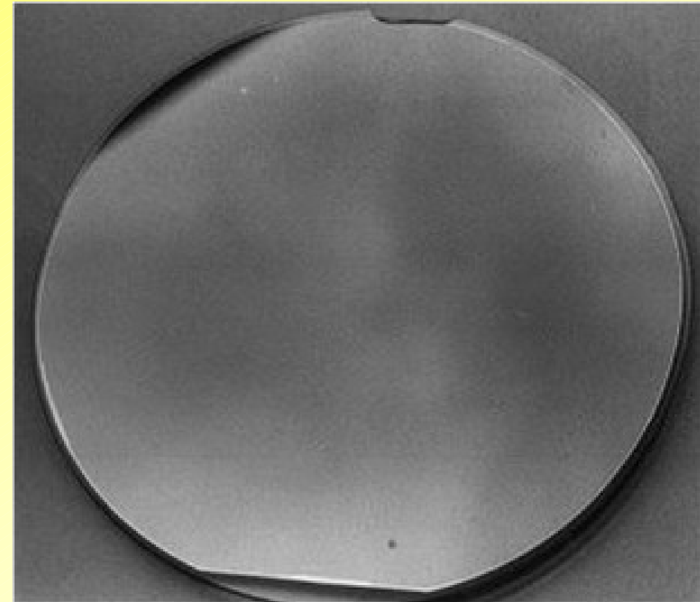
- **Problems**
  - **Thermal coefficient of expansion.**
  - **High Alkali content**
  - **Low Temperature Processing.**



Silicon-On-Glass



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**

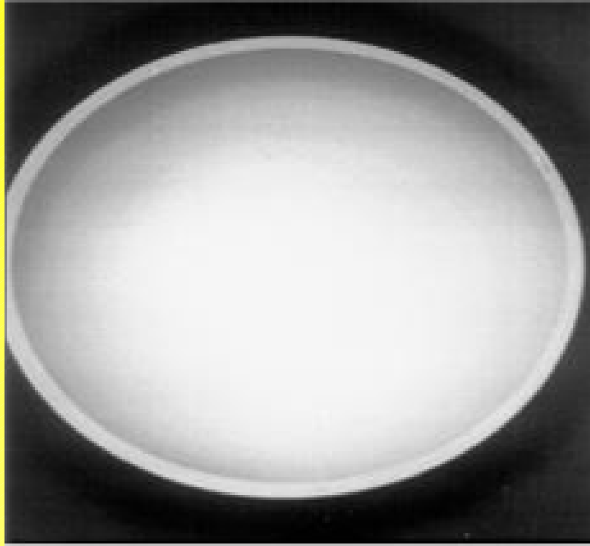
However:

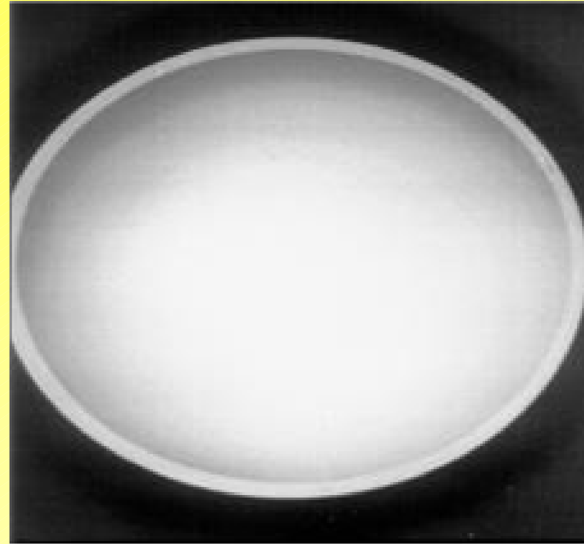
- **Thermal coef. of expansion not matched to Si.**

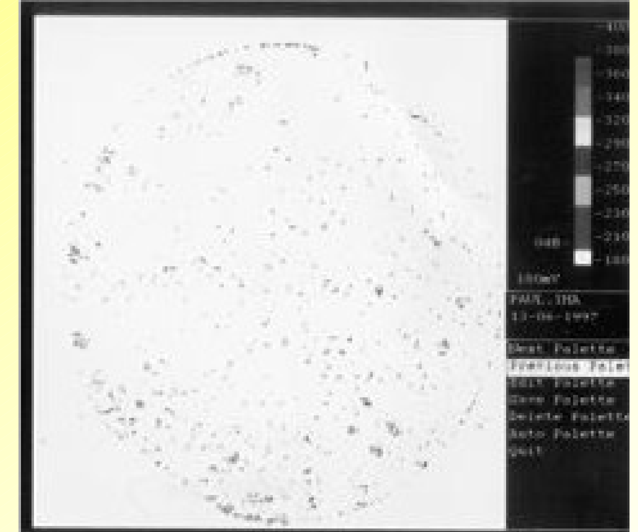
5 $\times 10^{-6}/^{o}C$ for sapphire compared to 3.6 $\times 10^{-6}/^{o}C$ for Si.

- **Silicon dioxide layer needed for bonding**

Bonding of Silicon to Sapphire







IR Image of Si/Sapphire
Room Temperature Bond

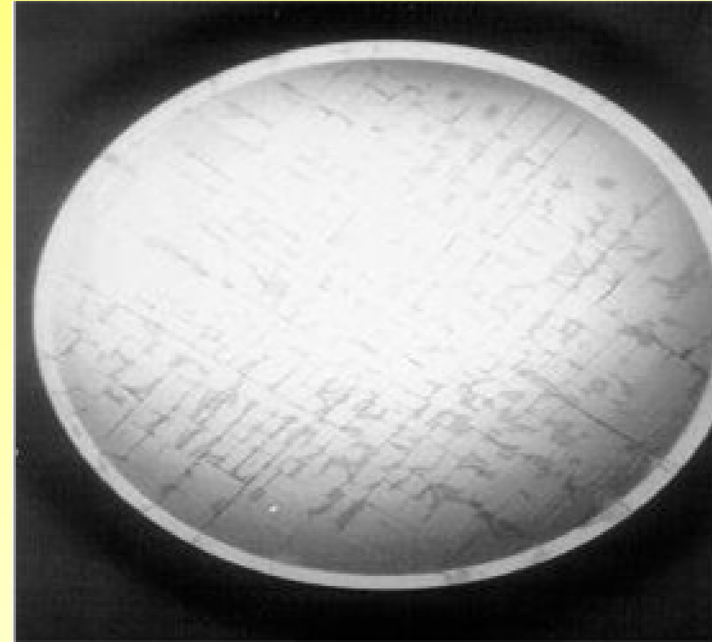
IR image of SiO_2 bond
after 250°C anneal.
Oxide Thick: 20nm

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

Void Free for SiO_2 bond

Thermal Coefficient of Expansion

Anneal at 250°C



Anneal at 300°C

Crack Propagation at 300°C due to thermal Expansion Mismatch

Solution To Thermal Expansion Problem

- Low Ramp Rate on annealing: 10°C/min
- Thermal oxide Required.
- Maximum <u>initial</u> 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