NANYANG TECHNOLOGICAL UNIVERSITY

Course: EE3013/ Semiconductor Devices and Processing

School: School of Electrical and Electronic Engineering

Part I - Highlights

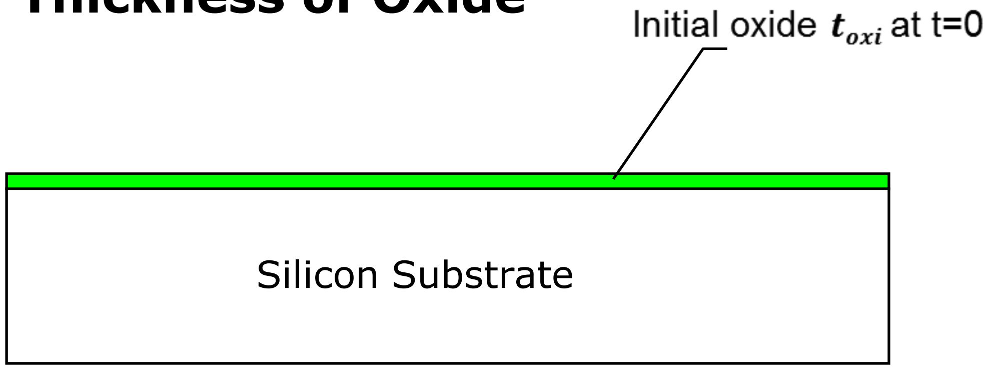
Week 7 - Thermal Oxidation

Thermal Oxidation

- **Applications:**
  - Mask for implantation and diffusion,
  - Isolation,
  - Gate oxide of MOS structures for insulation, and
  - Surface passivation.

- There are two oxidation methods:
  - Dry oxidation, and
  - Wet oxidation.

- **Thickness of Oxide**



$$t = \frac{t_{ox}^2}{B} + \frac{t_{ox}}{B/A} - \tau$$

or $t_{ox}^2 + At_{ox} = B(t + \tau)$ *(Equation 7.34)*

where $A = \frac{2D}{k_s}$, $B = \frac{2DN_0}{M}$ and $\tau = \frac{t_{oxi}^2}{B} + \frac{t_{oxi}}{B/A}$

t is time, t_{oxi} is the initial oxide thickness on the wafer before oxidation and τ is the time required to grow the initial oxide.

Thickness of Oxide

$$t_{ox} = \frac{-A + \sqrt{A^2 + 4B(t+\tau)}}{2}$$ *(Equation 7.35)*

- For **short time** with $t + \tau << A^2/4B$:

$$t_{ox} = \frac{B}{A}(t+\tau)$$ *(Equation 7.36)*

- For **long time** with $t + \tau >> A^2/4B, \ \ t > \tau$:

$$t_{ox} = \sqrt{Bt}$$ *(Equation 7.37)*

Note:

- B/A is called **linear rate** coefficient. (Growth rate is limited by the reaction at the silicon interface; it depends on Si-Si bond strength and not by diffusivity.)
- B is called **parabolic rate** coefficient. (Oxidation rate is diffusion limited.)

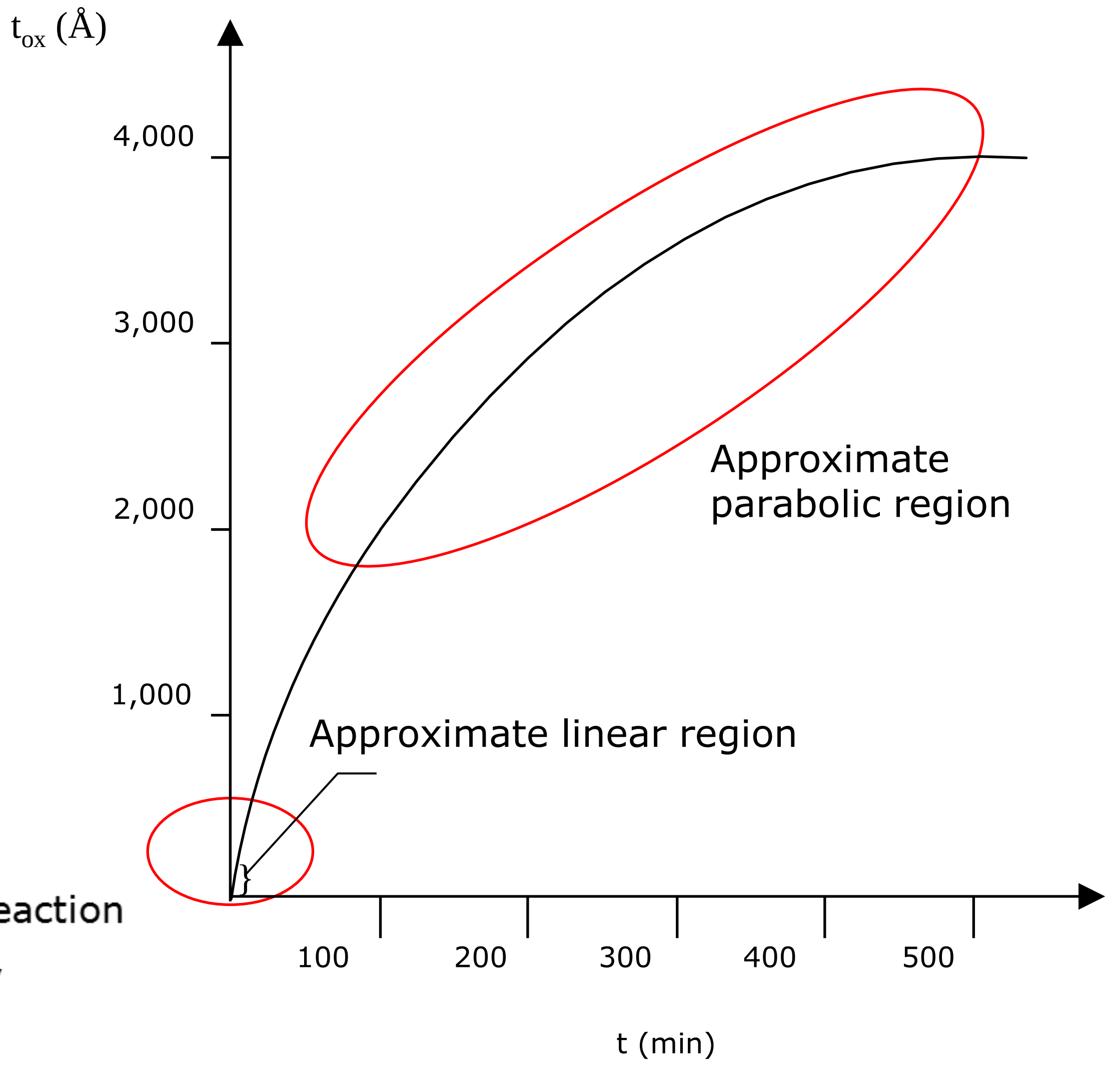


Figure 7.40

Thickness of Oxide (Cont'd.)

Factors affecting Oxidation Rate

- Growth techniques: wet versus dry
- Growth temperature
- Pressure
- Crystal orientation: (100) versus (111)
- Impurity doping

Oxide Thickness Measurement Techniques

- Color Chart
- Ellipsometry
- TEM (Transmission Electron Microscopy)