6.1.3 Summary to: 6.1 Si Oxide and LOCOS Process

- Silicondioxide (**SiO_2**) has been the "ideal" dielectric with many uses in chip manufacture
  - Only recently (**2007**) is it replaced by "low **k"** and "high **k**" dielectrics, i.e. dielectrics with a dielectric constant either lower or larger than that of **SiO_2**
  - "Low **k**" dielectrics (polymers, porous **SiO_2**, ..; the ideal material has not yet been found) are used for intermetal insulation; low **k** is important here to keep the **RC** time constants small
  - "High **k**" dielectrics (the present front runner is **HfO_2**) will replace the gate oxides. They can be somewhat thicker than **SiO_2** without sacrificing capacity, while strongly reducing tunneling currents.

- **Gate oxide for Transistors**
- **Dielectric in Capacitors**
- **Insulation**
- **Stress relieve layer**
- **Masking layer**
- **Screen oxide during Implantation**
- **Passivation**

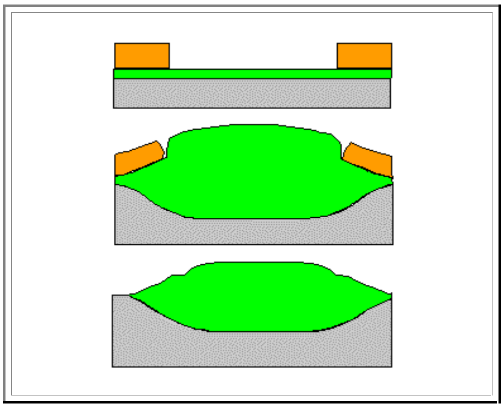
- **SiO_2** can be made in several ways:
  - Dry oxidation is relatively slow but gives best oxide qualities as defined by:
    - Uniformity
    - thickness control
    - Break down field strangt
    - Interface quality
    - Reliability

    Typical use: Highest quality gate oxid.
  - Wet oxidation is about 10 times faster; it is used whenever relatively thick oxides are needed.
    Typical use: Field oxide.
  - The other methods are needed whenever there is no **Si** available for oxidation (e.g. intermetal dielectrics).

- Dry thermal oxidation:
  $$2\,Si + O_2 \Rightarrow 2\,SiO_2$$
- Wet thermal oxidation:
  $$Si + 2\,H_2O \Rightarrow SiO_2 + 2\,H_2$$
- "Chemical Vapor Deposition" (next sub-chapter)
- "Spin-on techniques (next sub-chapter)
- "Anodic oxidation (presently not used in technology)

- As long as the process is diffusion controlled (i.e. the time it takes oxygen to diffuse through the already formed oxide determines rates, the thickness increases protorional to $t^{1/2}$
  - For thin oxides the growth rate is reaction controlled and the thickness - time dependence becomes complicated.

- Growing oxide only locally ("**LOCOS**") was a key process for field oxides.
  - Without a "buffer" oxide below the masking nitride, large mechanical strain develops, producing plastic deformation and thus dislocations around the oxide edges.
  - These "Oxide edge dislocations" kill the transistor.
  - Buffer oxides solve the problem, but create new problems: A "birds beak" develops, increasing lateral dimensions beyond the mask dimension.



- **LOCOS** is a good example for a universal feature of **Si** technology: Solutions to old problems create new problems. Solutions to the new problems... and so on. It follows:
  - Process complexity increases all the time.
  - New materials are needed all the time.

Questionnaire

Multiple Choice questions to all of 6.1