

6.1.3 Summary to: 6.1 Si Oxide and LOCOS Process

Silicon dioxide (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 strength
- Interface quality
- Reliability

Typical use: Highest quality gate oxide.

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:
 $2 \text{Si} + \text{O}_2 \Rightarrow 2 \text{SiO}_2$
- Wet thermal oxidation:
 $\text{Si} + 2 \text{H}_2\text{O} \Rightarrow \text{SiO}_2 + 2 \text{H}_2$
- "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 proportional 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.

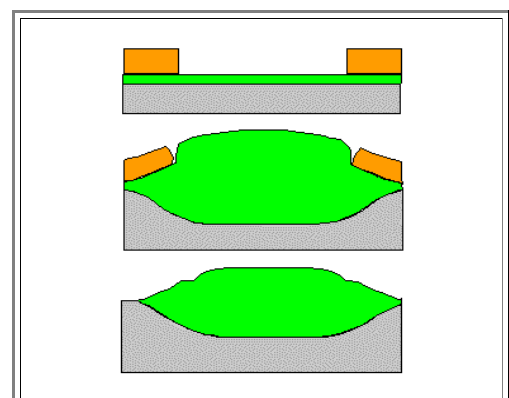
Without a "buffer" oxide below the masking nitride, large mechanical strain develops, producing plastic deformation and thus dislocations around the oxide edges.

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