Modern Reliability Issues

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Reliability Issues

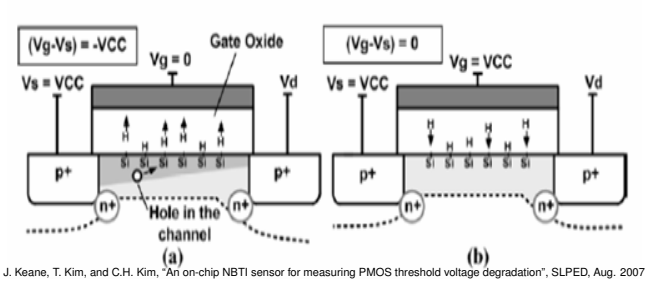
Numerous reliability issues

1. Radiation Tolerance
   - single event upset SEU
2. Metal Migration
3. Hot Electrons
4. Negative Bias Temperature Instability (NBTI)

Negative Bias Temperature Instability

- NBTI affects PMOS transistors when gate bias is negative
  - Causes dissociation of hydrogen that lies at interface between channel and insulator
  - More traps at the interface shifts threshold
- Consists of stress phase and recover phase
- Can result in over 50% reduction in device performance!

NBTI

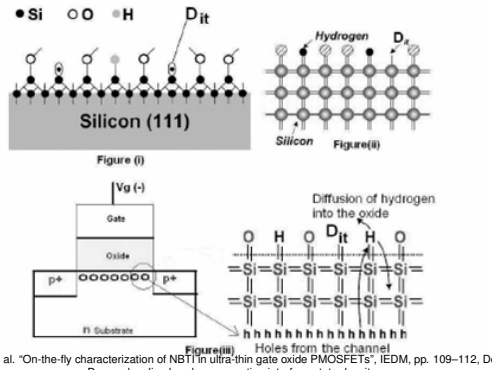


J. Keane, T. Kim, and C.H. Kim, "An on-chip NBTI sensor for measuring PMOS threshold voltage degradation", SLPED, Aug. 2007

(a) Stress phase (b) Recovery phase

NBTI Mechanism

Holes migrate from channel to replace hydrogen

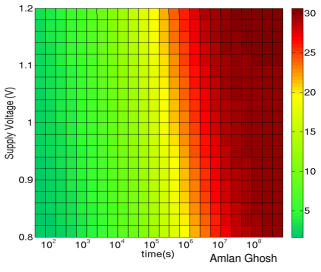


M. Denais, et. al. "On-the-fly characterization of NBTI in ultra-thin gate oxide PMOSFETs", IEDM, pp. 109–112, Dec. 2004
D_{it} are dangling bonds representing interface state density.

Threshold Degradation

Following chart shows degradation with time and supply voltage for theoretical process.

- actual process values highly protected by foundries



Color axis is shift from nominal V_{th} in mV