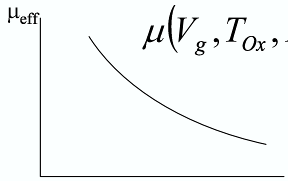
The Universal Mobility Curve

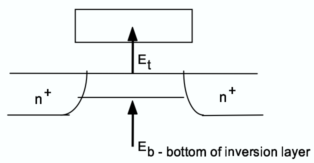


$$\mu\left(V_g, T_{Ox}, N_{sub}, V_{sb}\right) = \mu\left(E_{eff}\right)$$

$$\mu_{eff} = \frac{\mu_0}{1 + \left(E_{eff} / E_0\right)^{\nu}}$$

	electrons	holes
μ^0	540	185
ν	1.8	1
E_0 in Si	0.7MV/cm	0.45MV/cm

$$E_{eff} \equiv \frac{Q_{dep} + Q_{inv}/2}{\varepsilon_S}$$



$$E_b = \frac{Q_{dep}}{\varepsilon_S}$$

$$E_t = \frac{Q_{dep} + Q_{inv}}{\varepsilon_S}$$

$$\frac{E_b + E_t}{2} = \frac{Q_{dep} + Q_{inv}/2}{\varepsilon_S} \equiv E_{eff}$$

Effective Field

$$E_{eff} = \frac{Q_{dep} + Q_{inv}/2}{\varepsilon_S}$$

$$Q_{inv} = C_{Ox}\left(V_g - V_t\right)$$

$$V_t = V_{fb} + 2\varphi_B + \frac{Q_{dep}}{C_{Ox}}$$

For n^+/NMOS or p^+/PMOS

$$V_{fb} + 2\varphi_B \approx 0, V_t \approx \frac{Q_{dep}}{C_{Ox}}$$

therefore $Q_{dep} = C_{Ox}V_t$

$$E_{eff} = \frac{C_{Ox}V_t + C_{Ox}\frac{V_g - V_t}{2}}{\varepsilon_S} = \frac{C_{Ox}\left(V_g + V_t\right)}{2\varepsilon_S} = \frac{\varepsilon_{Ox}\left(V_g + V_t\right)}{T_{Ox}2\varepsilon_S} = \frac{V_g + V_t}{6T_{Ox}}$$

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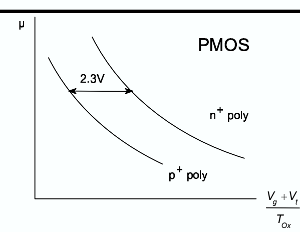
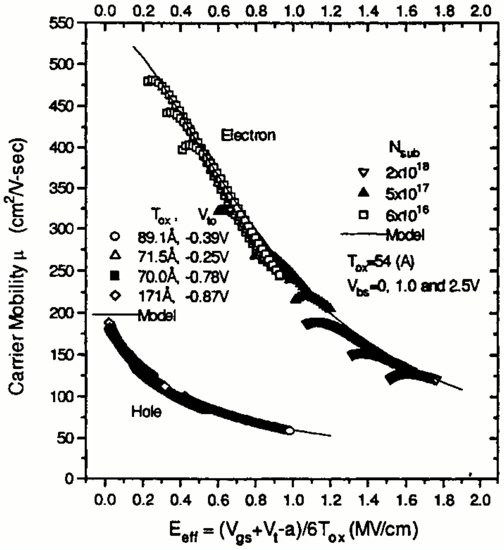
n^+/PMOS

$$E_{eff} = \frac{V_g + V_t - 2.3V}{6T_{Ox}}$$



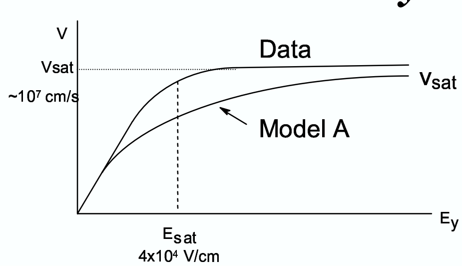
Universal Surface Mobilities



- *Phonon Scattering*
- *Coulombic Scattering*
- *Surface Roughness Scattering*

$(V_g+V_t+0.2V)/6T_{ox}$ can be shown to be the average vertical electric field in the inversion layer.

Velocity Saturation



Model A: $v = \dfrac{\mu_{eff} E}{1 + E / E_{sat}}$

At $E << E_{sat}$ $\quad v = \mu_{eff} E$

At $E >> E_{sat}$ $\quad v = \text{constant}\left(= E_{sat}\mu_{eff}\right)$