EE 421 / ECG 621

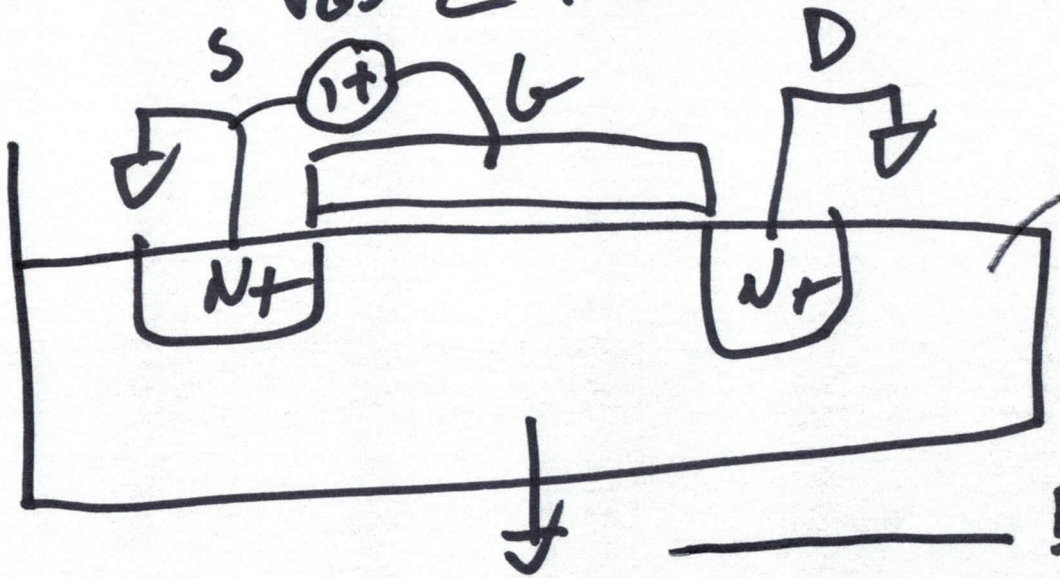
Digital IC Design

OCT. 4, 2023

Lecture 11

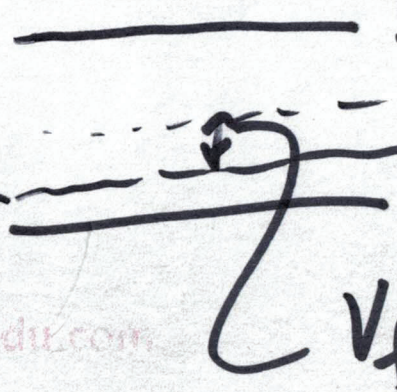
fermi energy

prob. of elec = 50%



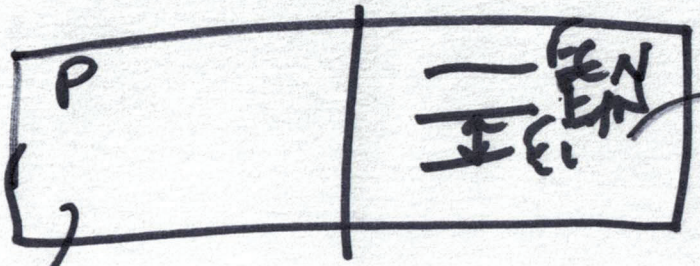
doping of substrate, NA

# of acceptor atoms, $\frac{Atoms}{cm^3}$



$V_{fp} = \frac{1}{q} \cdot E_{fp}$

$V_{fp} = \frac{-kT}{q} \ln \frac{NA}{n_i}$ n_i intrinsic



$$V_{fN} = \frac{KT}{q} \ln \frac{N_D}{n_i}$$

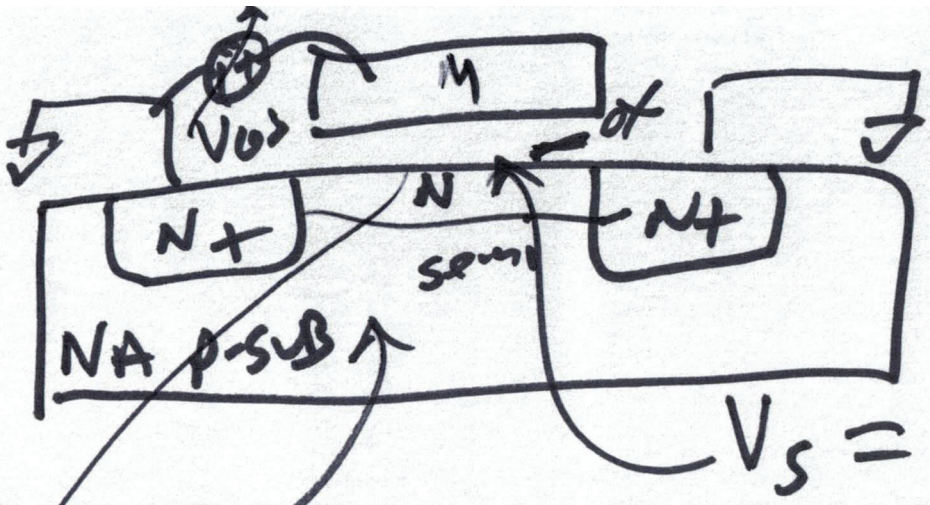
$$V_{fP} = -\frac{KT}{q} \ln \frac{N_A}{n_i} = \frac{KT}{q} \ln \left(\frac{N_A}{n_i}\right)^{-1}$$

$$\ln a - \ln b = \ln \frac{a}{b} \qquad -\ln a = \ln a^{-1}$$

$$V_{fP} = \frac{KT}{q} \ln \frac{n_i}{N_A}$$

$$V_{bi} = V_{fN} - V_{fP} = \frac{KT}{q} \ln \frac{N_A}{n_i} - \frac{KT}{q} \ln \frac{n_i}{N_A}$$

$$\rightarrow V_{bi} = \frac{KT}{q} \ln \frac{N_A N_D}{n_i^2}$$



V_S = surface potential

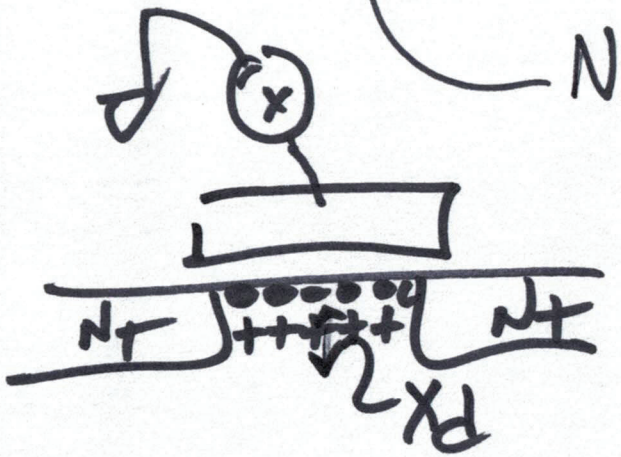
$$V_{fp} = \frac{-kT}{q} \ln \frac{N_A}{N_i}$$

$V_S = V_{fp}$, NO applied voltage

$N_A \rightarrow 0 \rightarrow N_H$ (# of electrons)

depletion

at V_{thn} (threshold voltage)

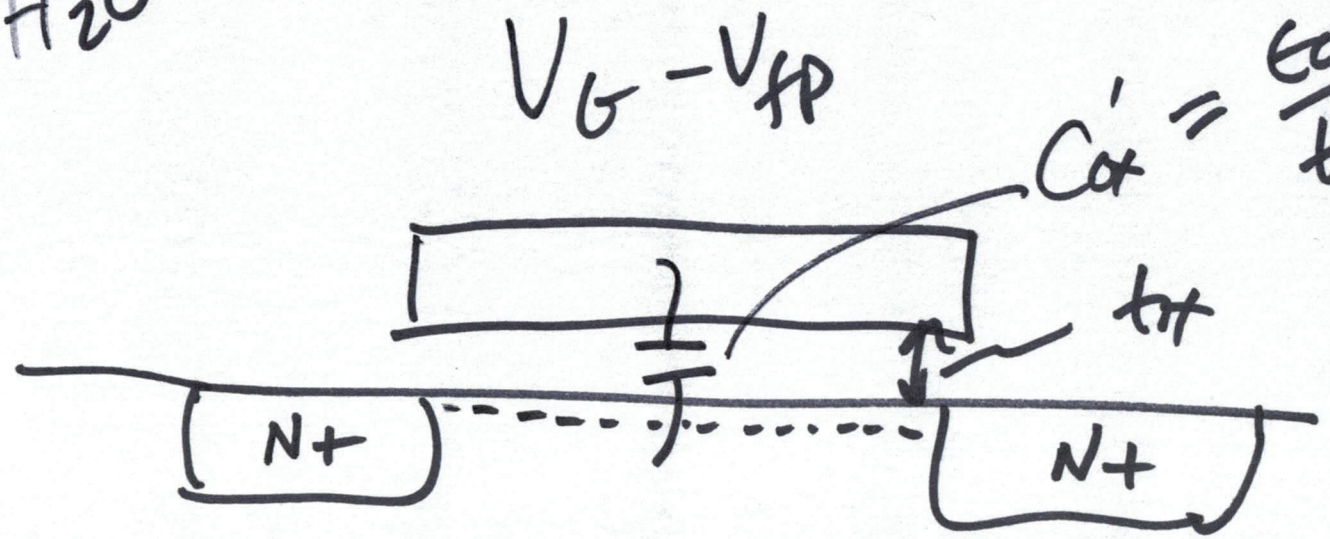


$V_G - V_{ox} + V_{ox} - V_{fp}$

CHIPS ACT

H_2O

$V_G - V_{fp}$

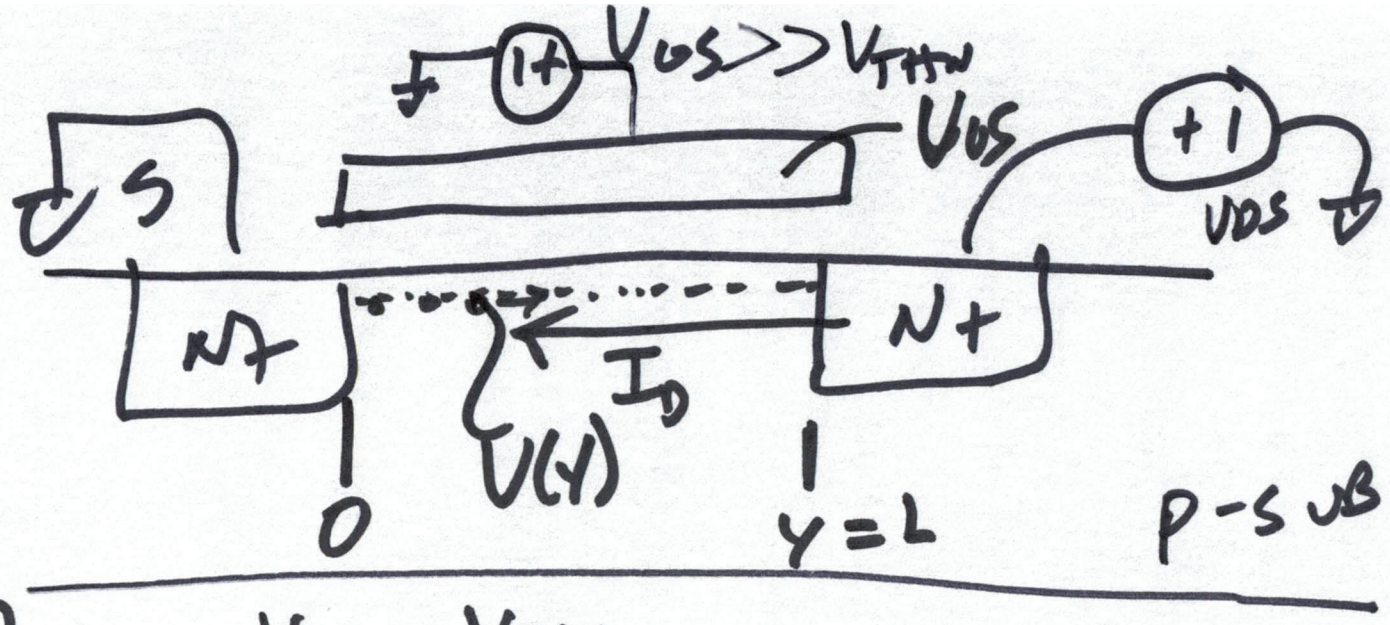


$CV = Q$

p-sub

$$V_{THN} = \frac{Q_b'}{C_{ox}'} - \frac{Q_{ss}'}{C_{ox}'} - V_G - V_{fp} - 2V_{fp}$$

contact potentials



$CV = Q$

$V_{GS} = V_{THN}$

$$Q_b' = C_{ox}' \cdot V_{THN}$$

$$Q_{CH}' = Q_b' + Q_{mI}'$$

Q_{CH}': inverted total channel

Q_{mI}': available to conduct current

$$Q_{CH}' = (V_{GS} - V(y)) \cdot (C_{ox}'$$