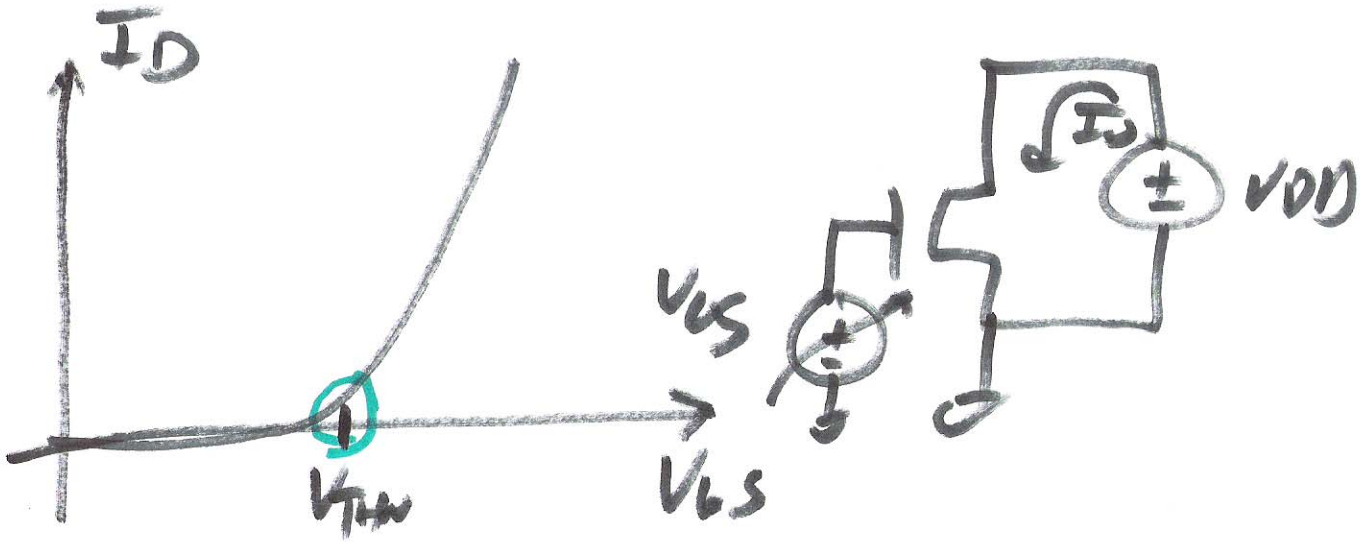
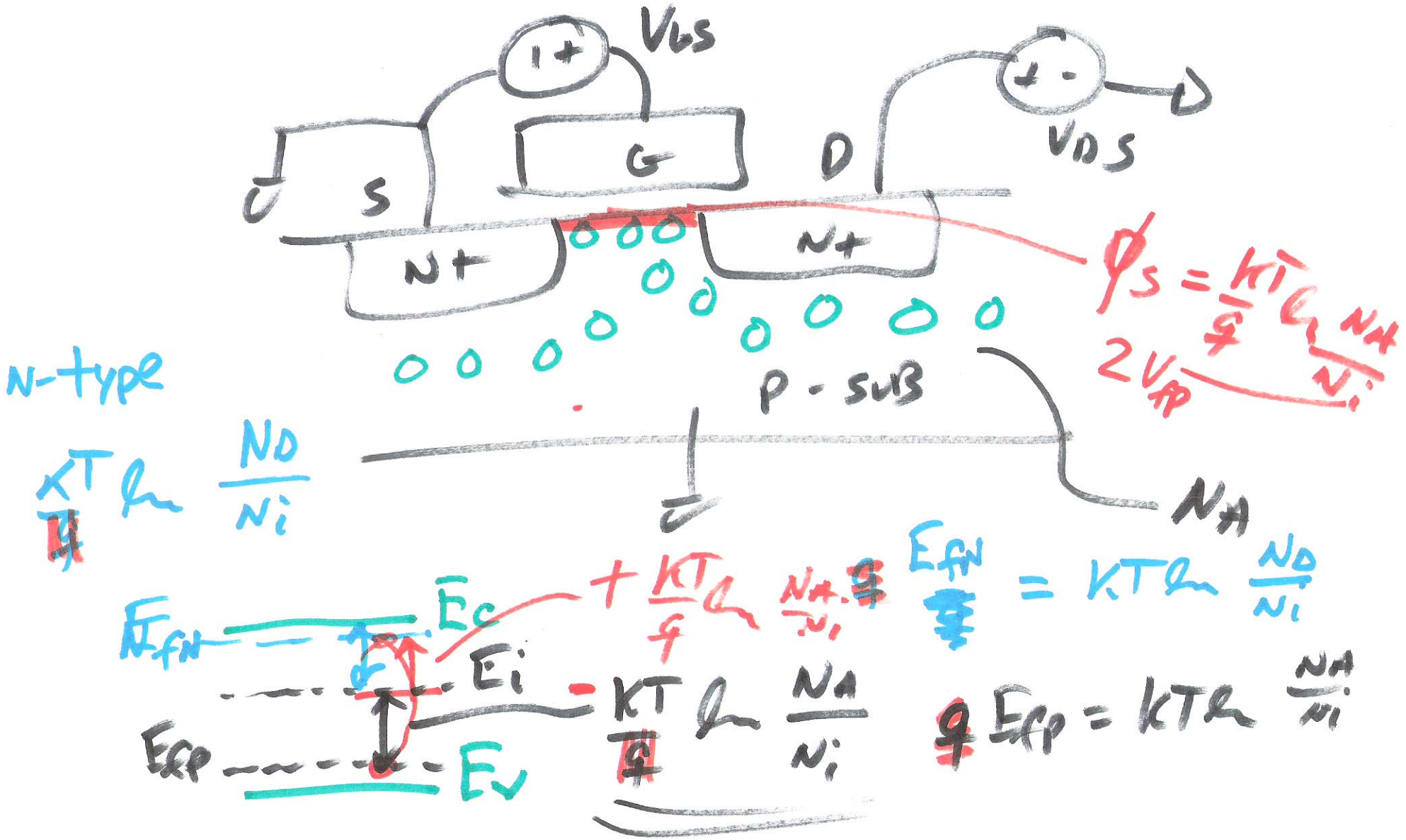
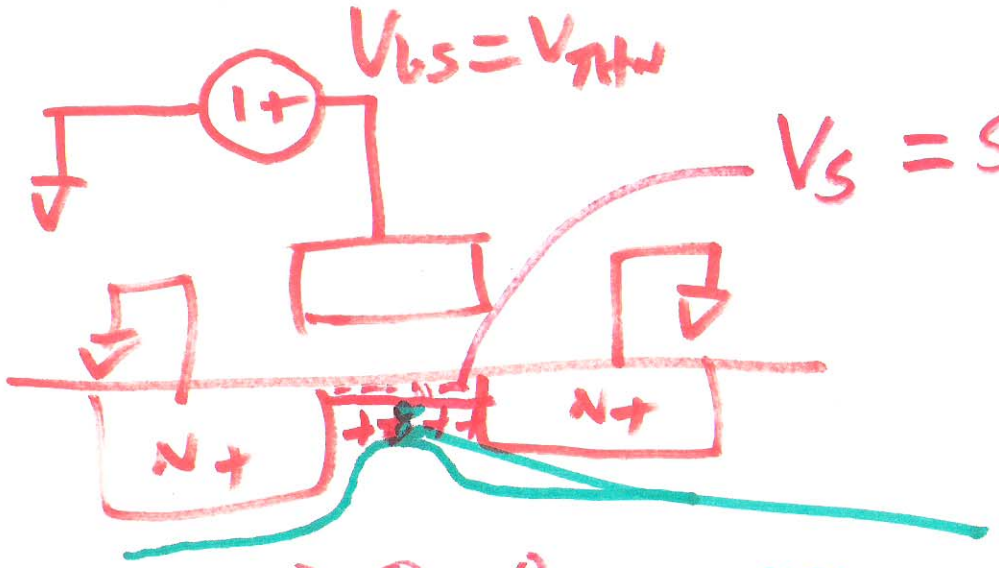
Lecture 15

October 20, 2014

Threshold Voltage




1+
VGS
S
G
D
+ -
VDS
N+
N+
P - SUB
N-type
$\frac{KT}{q}\ln\frac{N_D}{N_i}$
N_A
$\phi_s = \frac{KT}{q}\ln\frac{N_A}{N_i}$
$2V_{FP}$
E_{FN}
E_C
E_i
E_{FP}
E_V
ϕ
$+\frac{KT}{q}\ln\frac{N_A}{N_i}$
$E_{FN} = KT\ln\frac{N_D}{N_i}$
$\frac{KT}{q}\ln\frac{N_A}{N_i}$
$E_{FP} = KT\ln\frac{N_A}{N_i}$



V_S = surface potential

$$Q_b' = q N_A \cdot X_d$$

$$X_d = \sqrt{2\epsilon_{Si} q N_A |V_S - V_{fp}|}$$

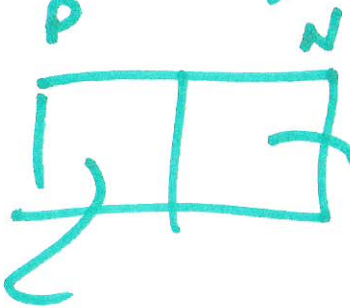
$$V_{fp} = -\frac{kT}{q} \ln \frac{N_A}{n_i}$$

$$C_{ox}' \cdot \frac{L}{W} = (_{ox}$$

$$Q_b' \cdot L \cdot W = Q_b$$

$$X_d = \sqrt{\frac{2\epsilon_{Si} |V_S - V_{fp}|}{q N_A}}$$

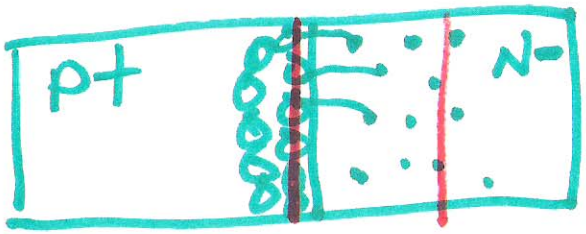
(e.g. $-300mV$)



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

$$-|V_{fp2} - V_{fN}| =$$

$$V_{fN} - V_{fp} = \frac{kT}{q} \ln \frac{N_A N_D}{n_i^2} \quad V_{fp} = -\frac{kT}{q} \ln \frac{N_A}{n_i}$$



$$Q_{b0}' = \sqrt{2\varepsilon_{si} q N_A |V_s - V_{fp}|}$$

Q_{b0}' ↑ source V = Bulk V

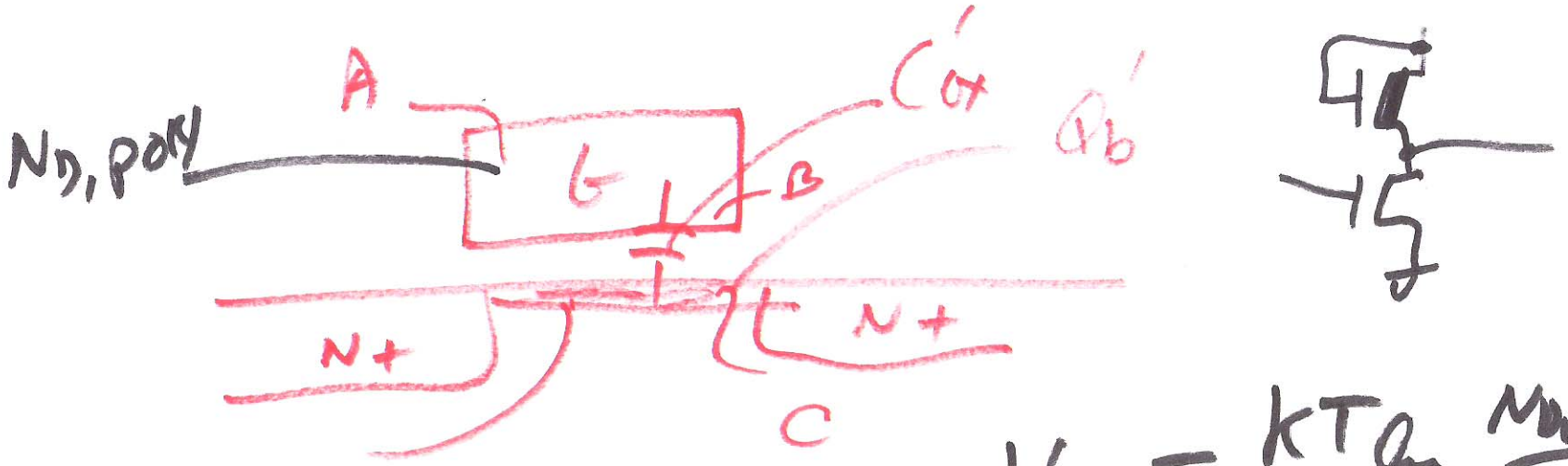
at $V_{bs} = V_{THN}$

$$Q_{b0}' = \sqrt{2\varepsilon_{si} q N_A |V_s - V_{fp}|}$$

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

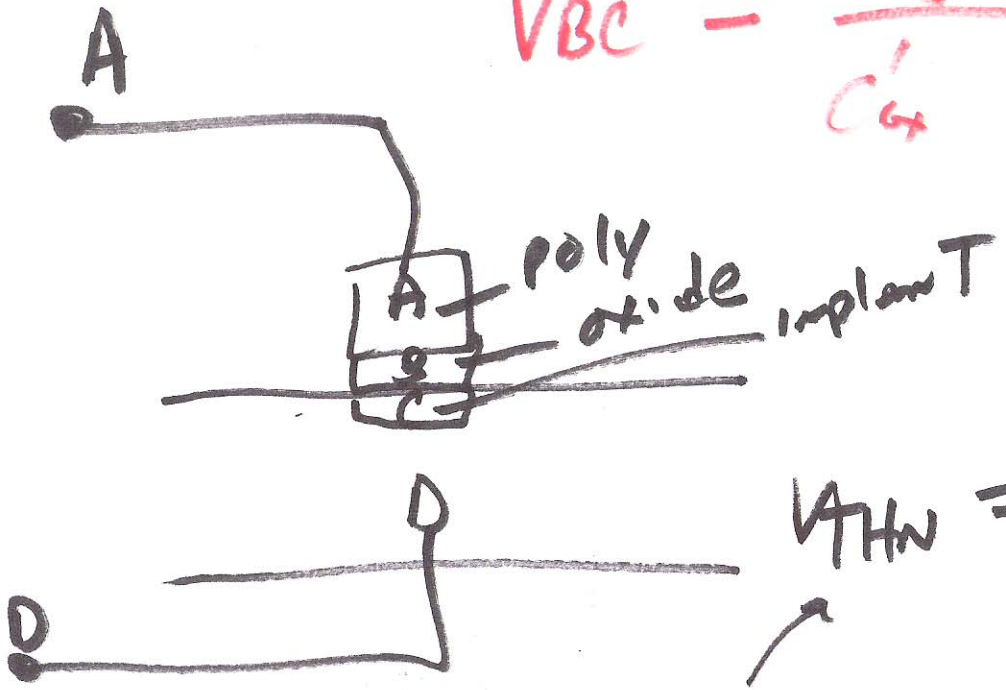
$$= \sqrt{2\varepsilon_{si} q N_A |2V_s|}$$

$$V_s = \frac{KT}{q} \ln \frac{N_A}{n_i}$$



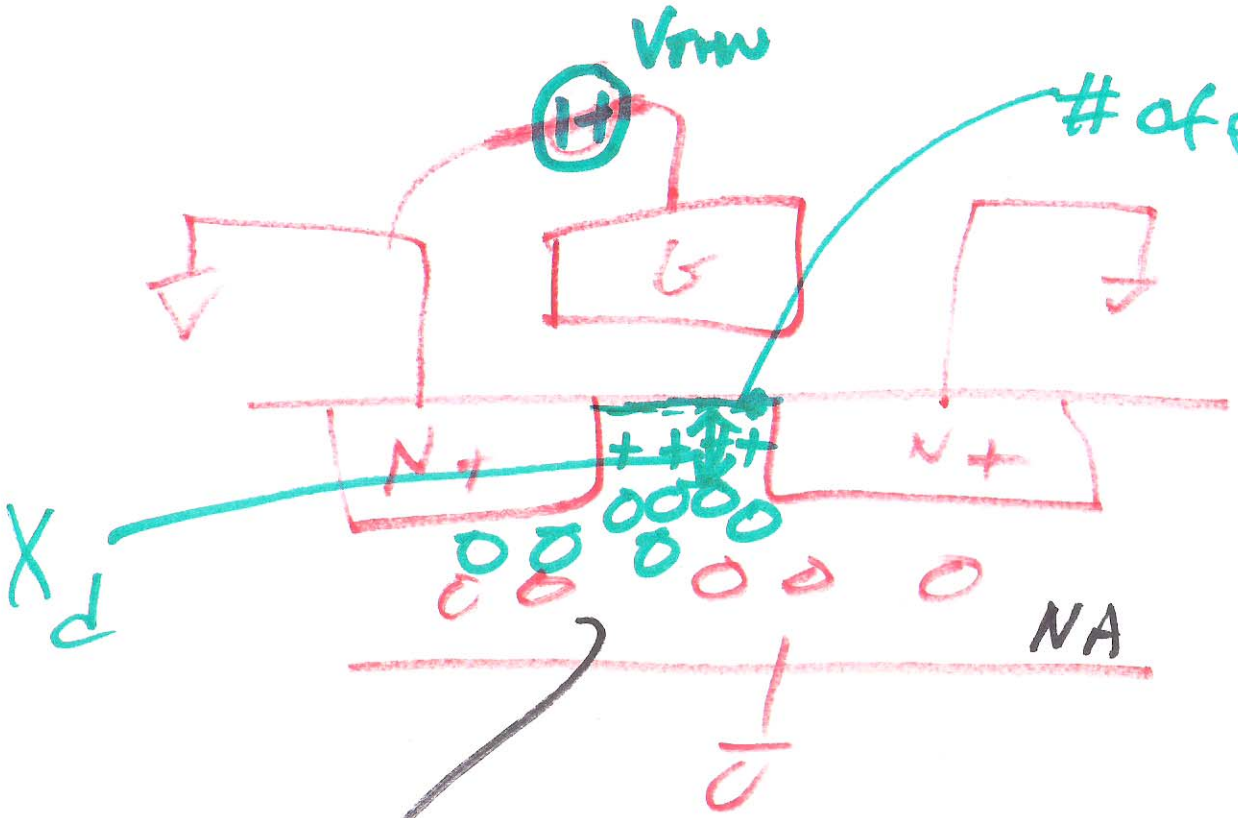
$$V_{BC} = \frac{Q_b'}{C_{ox}'}$$

$$V_G = \frac{kT}{q} \ln \frac{N_{A\,poly}}{n_i}$$



$$V_A - V_D + V_B - V_C + V_C - V_D = V_A - V_D$$

$$V_{THN} = \frac{kT}{q} \ln \frac{N_{D\,poly}}{n_i} - \frac{kT}{q} \ln \frac{N_A}{n_i} + \frac{Q_B'}{C_{ox}'}$$



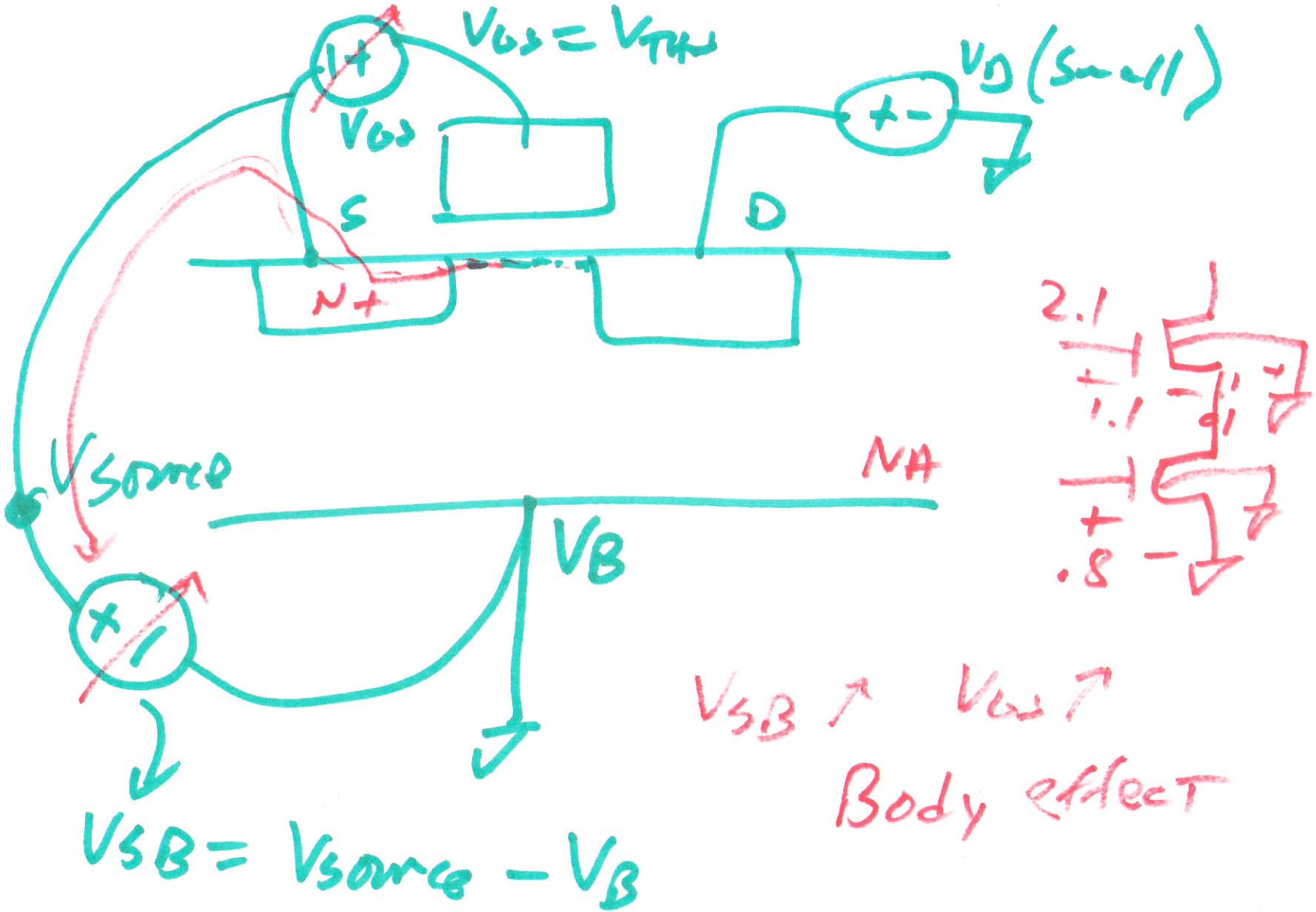
# of electrons N_A

$$\frac{C}{n^2}$$

$$V_S = +\frac{kT}{q}\ln\frac{N_A}{n_i}$$

X_d

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


$V_{GS} = V_{THN}$
V_{GS}
V_D (small)
S
D
N+
NA
V_{SOURCE}
V_B
$V_{SB} = V_{SOURCE} - V_B$
2.1
1.1
.8
V_{SB} ↑ V_{th} ↑
Body effect