EE 320 Lecture 4

Feb. 4, 2013

$100k = \frac{1MHz}{10}$

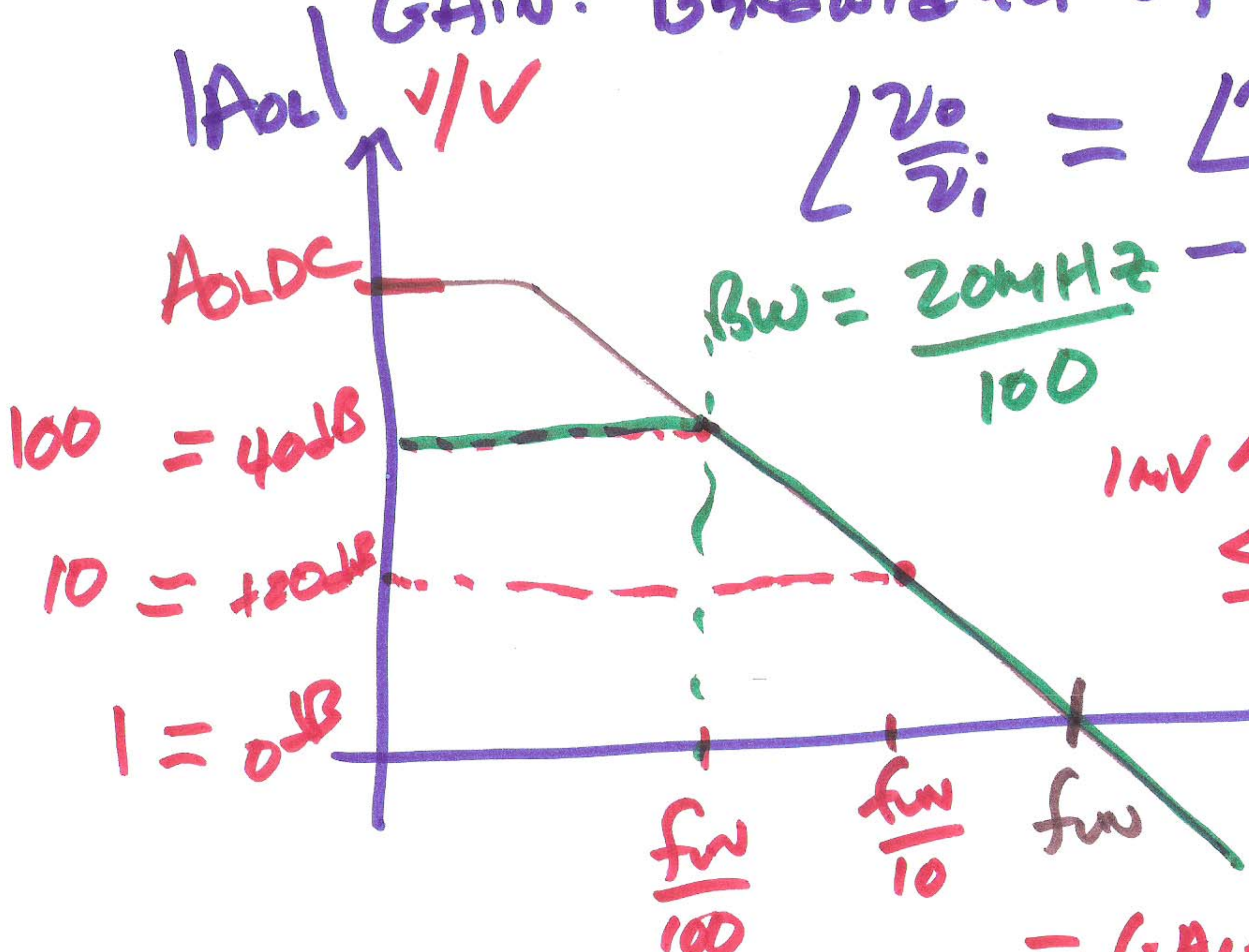
GAIN · Bandwidth of op-Amps

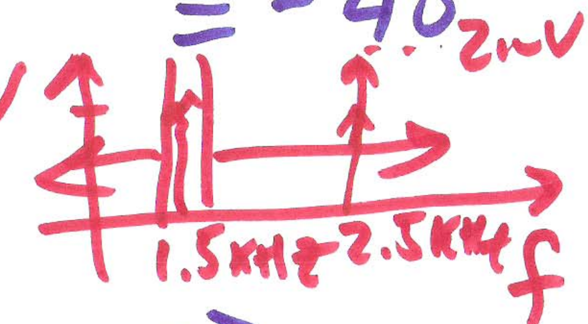
$\angle \frac{v_o}{v_i} = \angle v_o - \angle v_i$

$-45^\circ - 0^\circ$

$= -45^\circ$

$BW = \frac{20MHz}{100}$





$= GAIN \cdot BW$

$20MHz = 100 \cdot BW$

valence electrons Ch. 2 semiconductor physics

Al → 2) conductors

Cu → 1)

SiO_2 → Silion dioxide, SiO_2

(glass)

→ 8) insulator

Si → 4 valence semiconductor

P → 5 valence electrons

B → 3 valence electrons

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2)

Drift current due to an $\mathcal{E}$ field

$$J = Q \cdot V$$

Velocity, cm/s due to Electric

charge density

C/cm^3

current density

$A/cm^3 \rightarrow \dfrac{A}{cm \cdot cm \cdot cm}$

$(cm)^3 = cm \cdot cm \cdot cm$

$\mu m^2 = \mu m \cdot \mu m = 10^{-6} m \cdot 10^{-6} m = 10^{-12} m^2$

$$\frac{A}{10^{-6}\, m} = \frac{A \cdot 10^{6}}{m}$$

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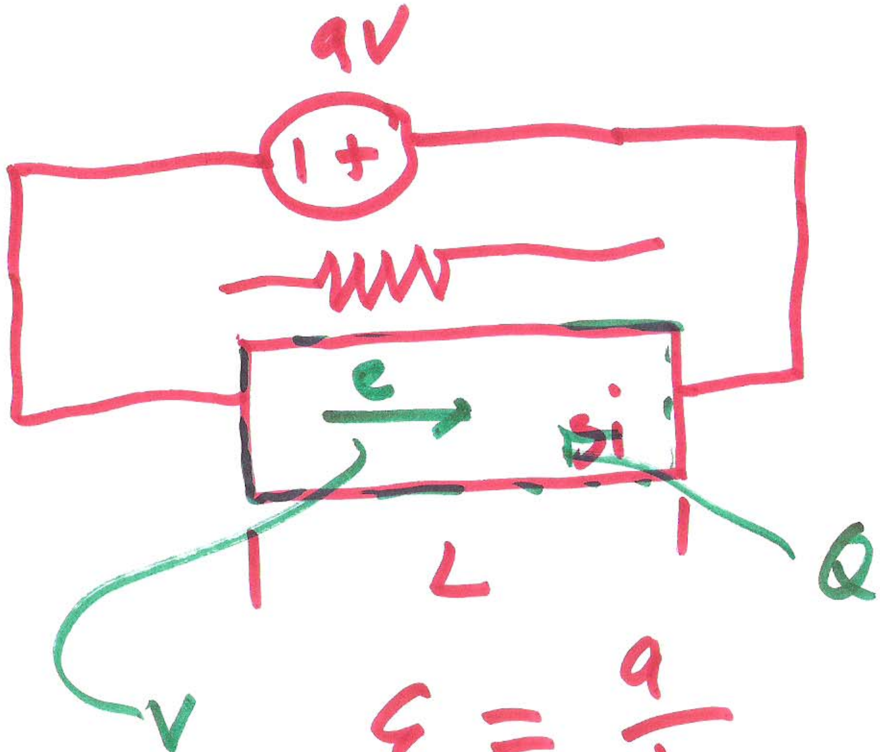

$$\mathcal{E} = \frac{9}{L}$$

cm/s

$$\frac{C}{cm^3} \cdot \frac{cm}{s} = \frac{C}{s} \cdot \frac{1}{cm^2}$$

$$= \frac{A}{cm^2}$$

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4)

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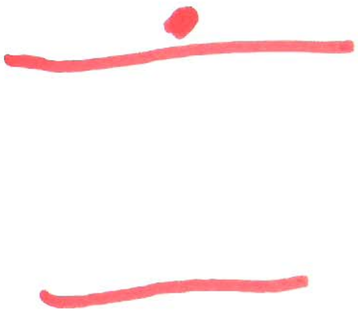
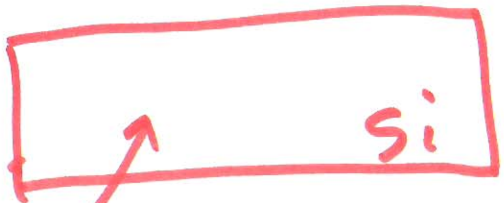
Mobility { electrons / holes



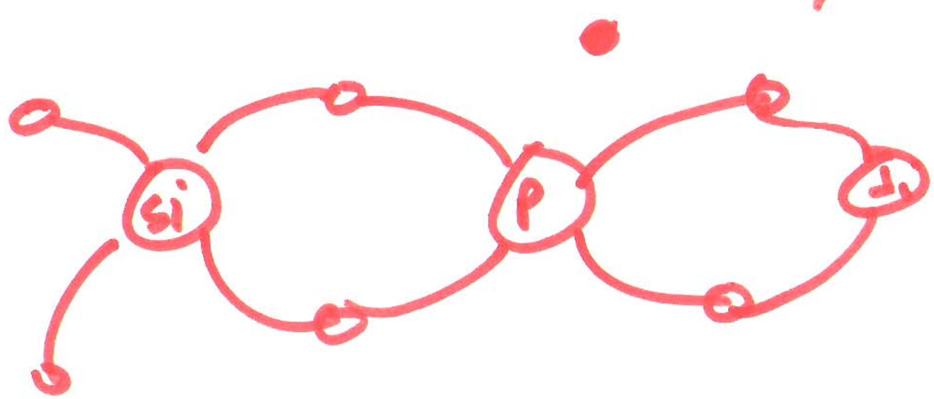


Si → 4

density Atoms $\sim \frac{10^{22}}{cm^3}$

N_D = P → 5 valence electrons

10^{16} P Atoms/cm^3



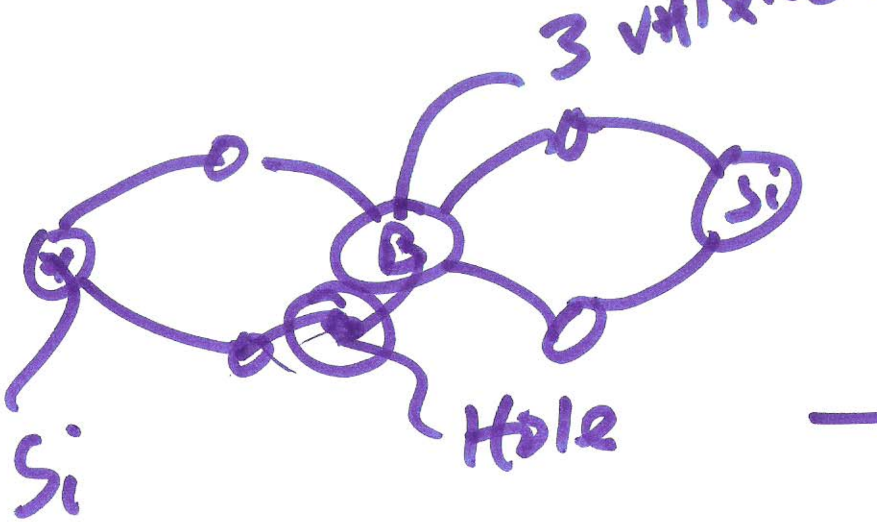
Si

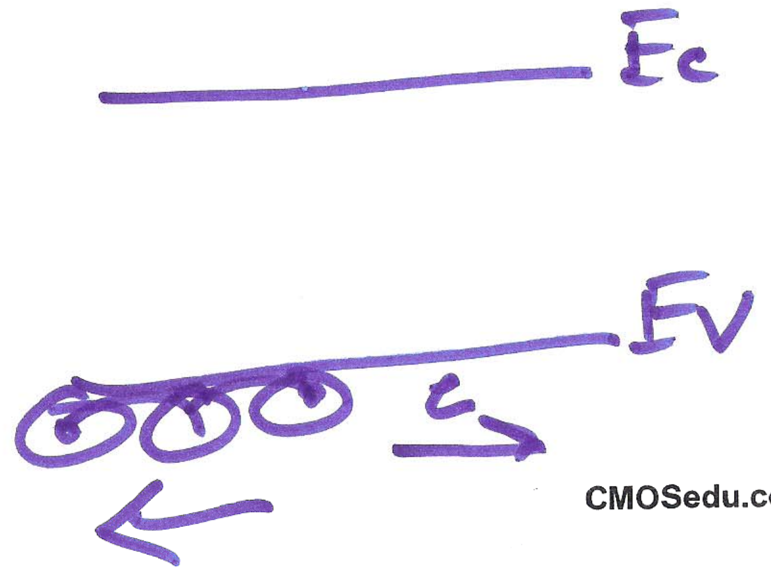
$10^{22}\ \frac{\text{Atoms}}{\text{cm}^3} = N_{si}$

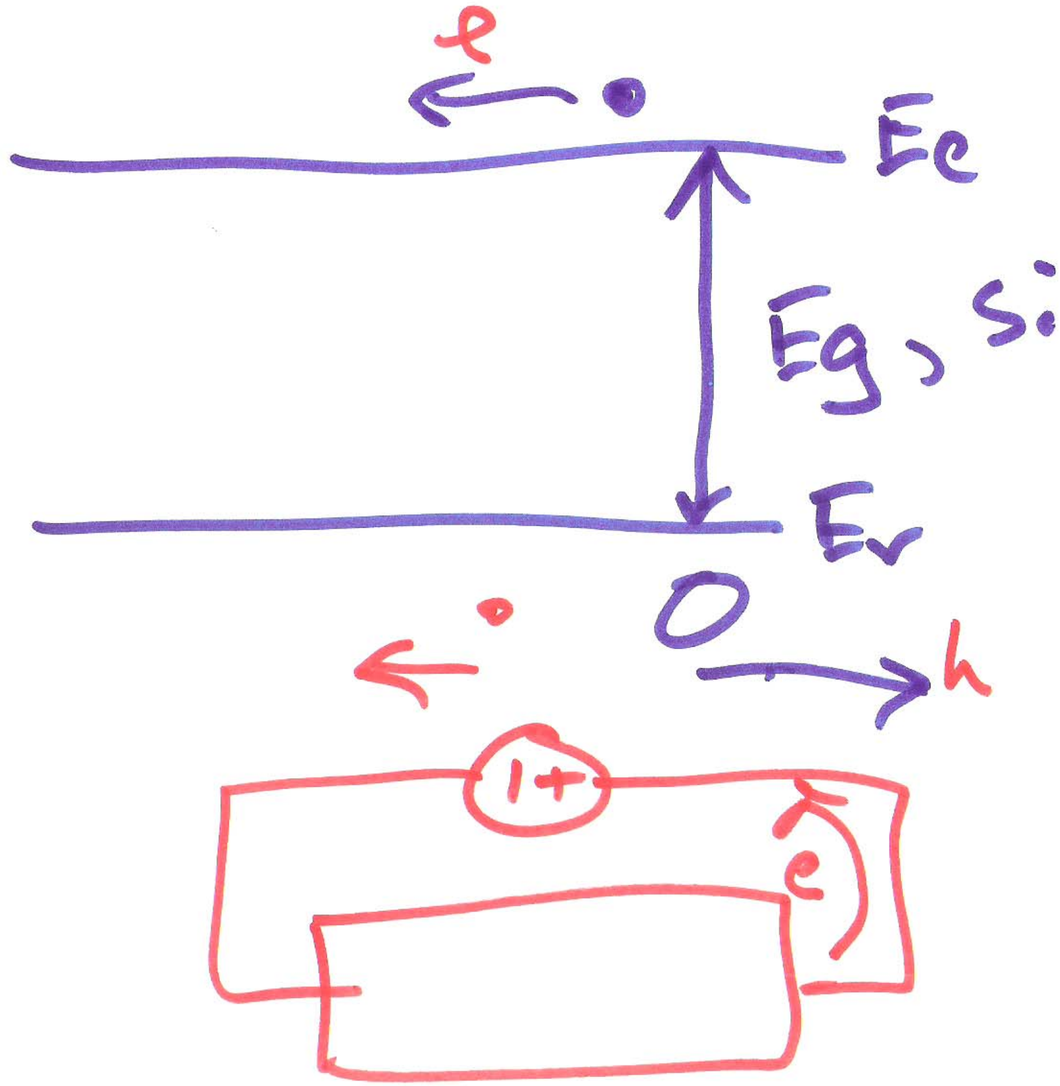
density of Si Atoms/cm^3

$B \Rightarrow 10^{17}\ \frac{\text{Atoms}}{\text{Cm}^3}$

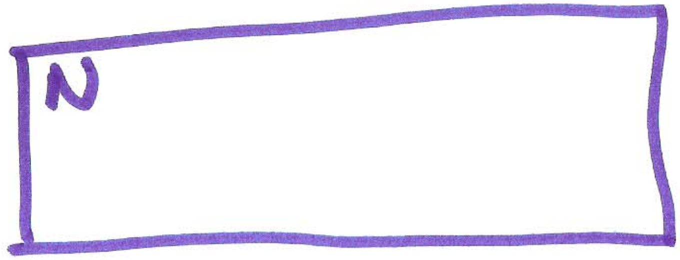
NA







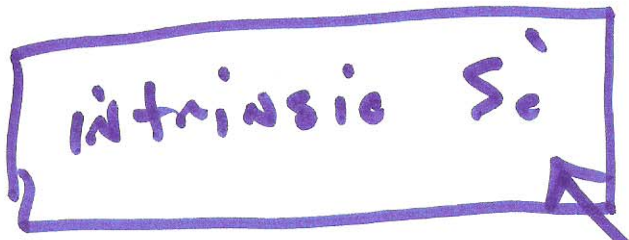
$J =$



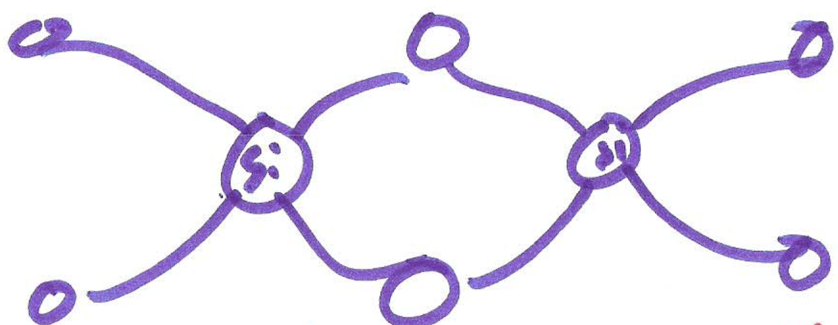
N_i = # of intrinsic CARRIERS under equilibrium

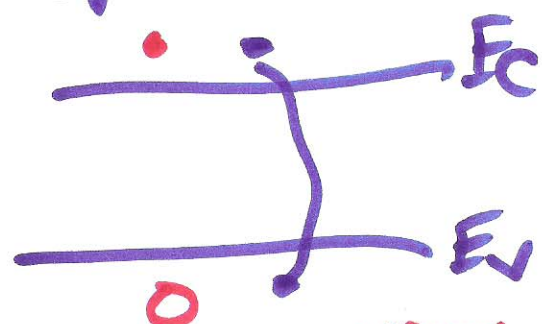
$$\boxed{n \cdot p = n_i^2}$$

MASS-Action law



undoped Si





$\frac{\text{electrons}}{cm^3} = n$ = # of electrons, $\frac{\text{carriers}}{cm^3}$

$\frac{\text{holes}}{cm^3} = p$ = # of holes, $\frac{\text{carriers}}{cm^3}$

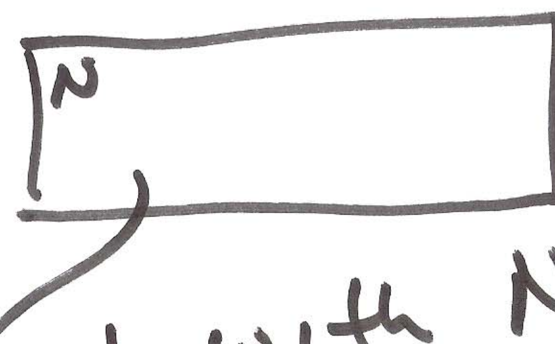
$p = n = n_i$ in intrinsic Si

N_D = # of donor Atoms (extra electron)

doping atoms / cm^3

N_A = # of Acceptor Atoms (extra hole)

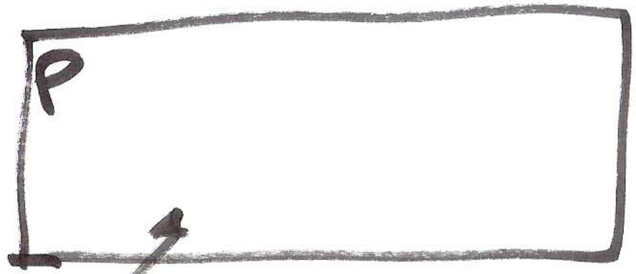
doping density, $\frac{Atoms}{cm^3}$



doped with N_D $\frac{Atoms}{cm^3}$

$$n = \frac{electrons}{cm^3} \approx N_D, \ \frac{Atoms}{cm^3}$$

$$p = \frac{n_i^2}{n} = \frac{n_i^2}{N_D}$$



N_A = Acceptor, $\frac{\text{Atoms}}{\text{Cm}^3}$

P = # of holes, $\frac{\text{Carriers}}{\text{Cm}^3}$

$$P \simeq N_A$$

$$N = \frac{N_i^2}{P} = \frac{N_i^2}{N_A}$$

Mobility

μ_N = mobility of electrons

$$= \frac{\text{velocity, cm/s}}{\mathcal{E}\text{ field, V/cm}}$$

μ_P = mobility of holes

$$= \frac{\text{Velocity, cm/s}}{\mathcal{E}\text{ field, V/cm}}$$

$$\boxed{\mu_{N,P},\ \frac{cm^2}{V \cdot s}}$$

Read 2.1 → 2.7