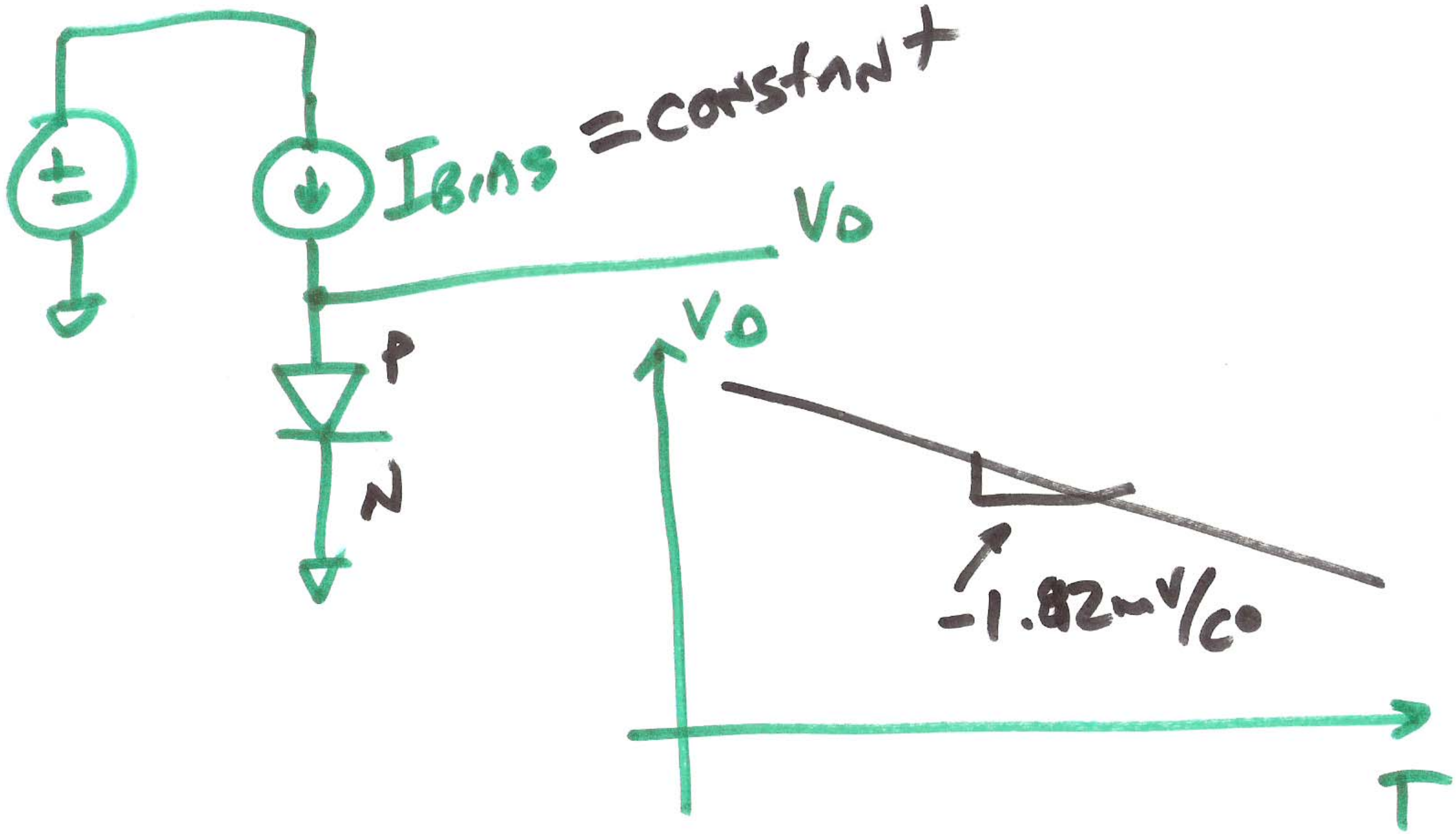
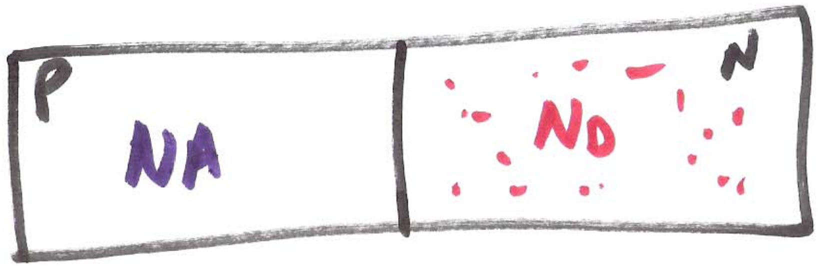
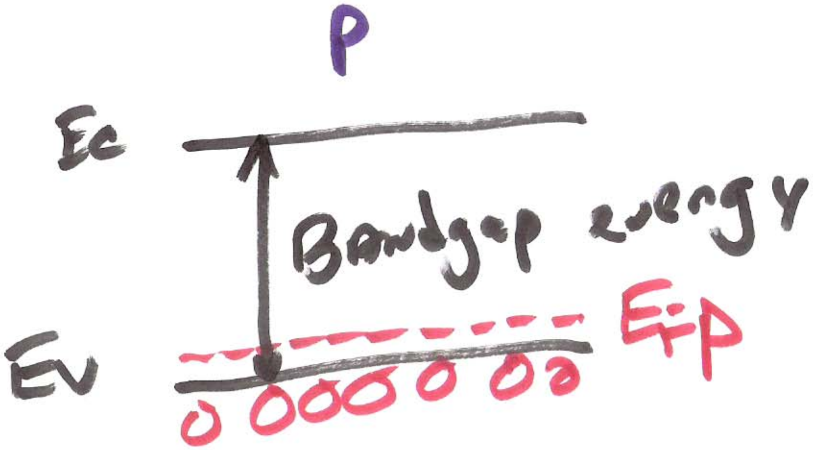
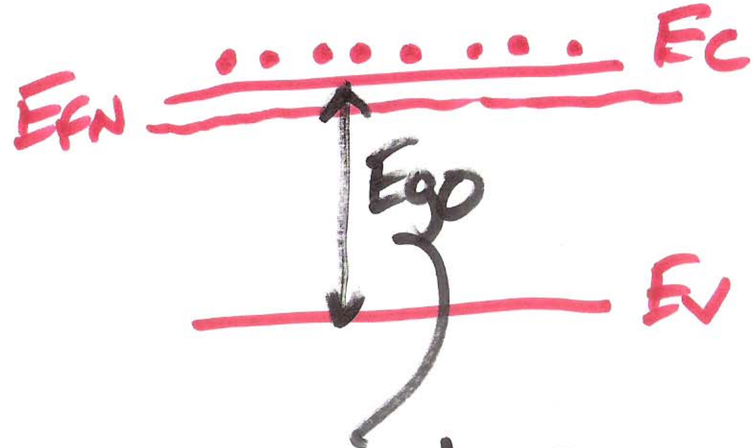
Lecture 8 EE 320

Feb. 15, 2013





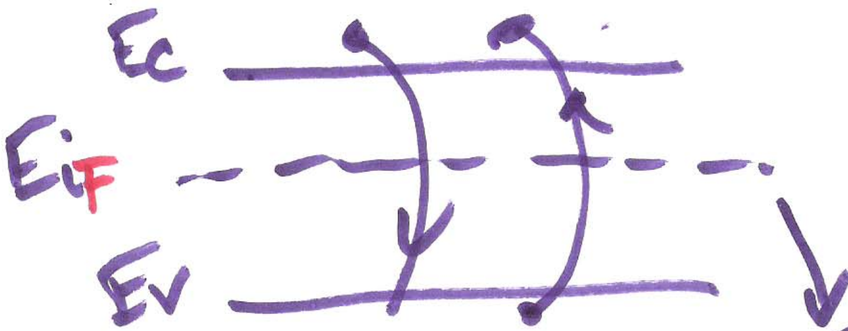




Bandgap energy

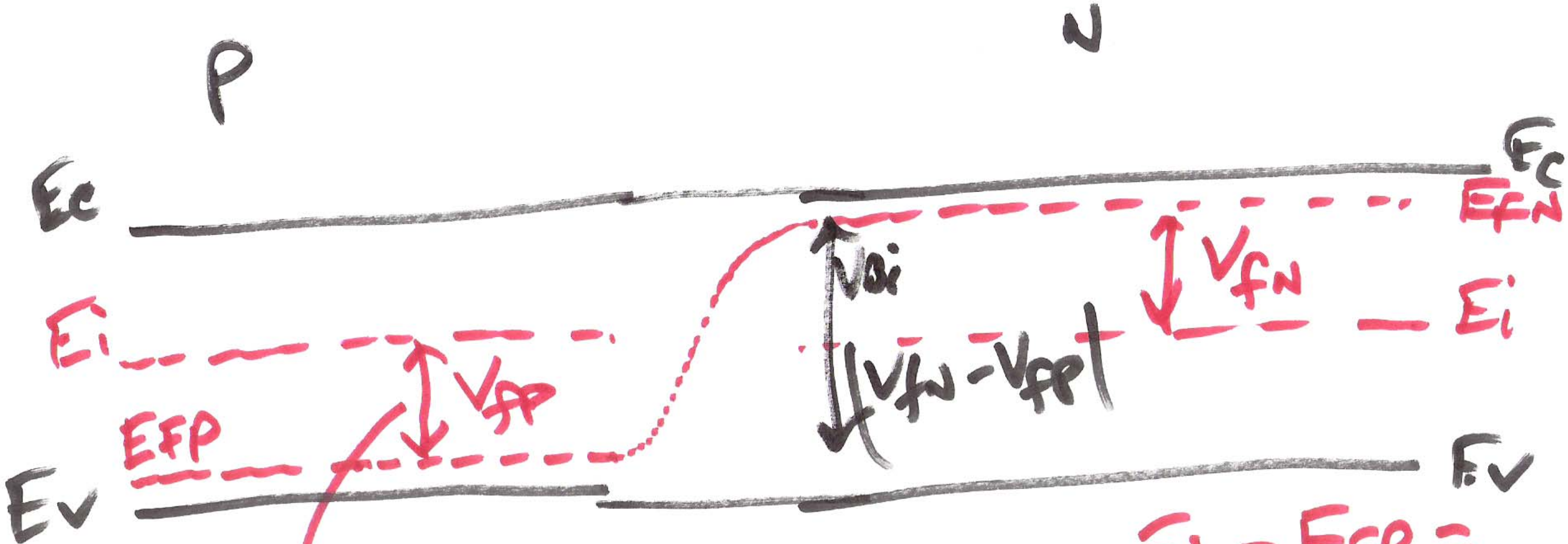
Ego ↓ T ↑

intrinsic Si



Ei → intrinsic Fermi Energy level

probability than an electron is above this level



$$E_i - E_{FP} = -KT \ln \frac{N_D}{N_i}$$

$$E_i - E_{FP} = KT \ln \frac{N_A}{N_i}$$

$$E = V \cdot q$$

$$V_{fP} = \frac{E_i - E_{FP}}{q}$$

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

$$\boxed{V_{fN} = -\frac{KT}{q} \ln \frac{N_D}{N_i}}$$

$$V_{Bi} = V_{fN} - V_{fP} = \frac{KT}{q}\left(\ln \frac{N_D}{N_i} + \ln \frac{N_A}{N_i}\right)$$

$$\ln a + \ln b = \ln ab$$

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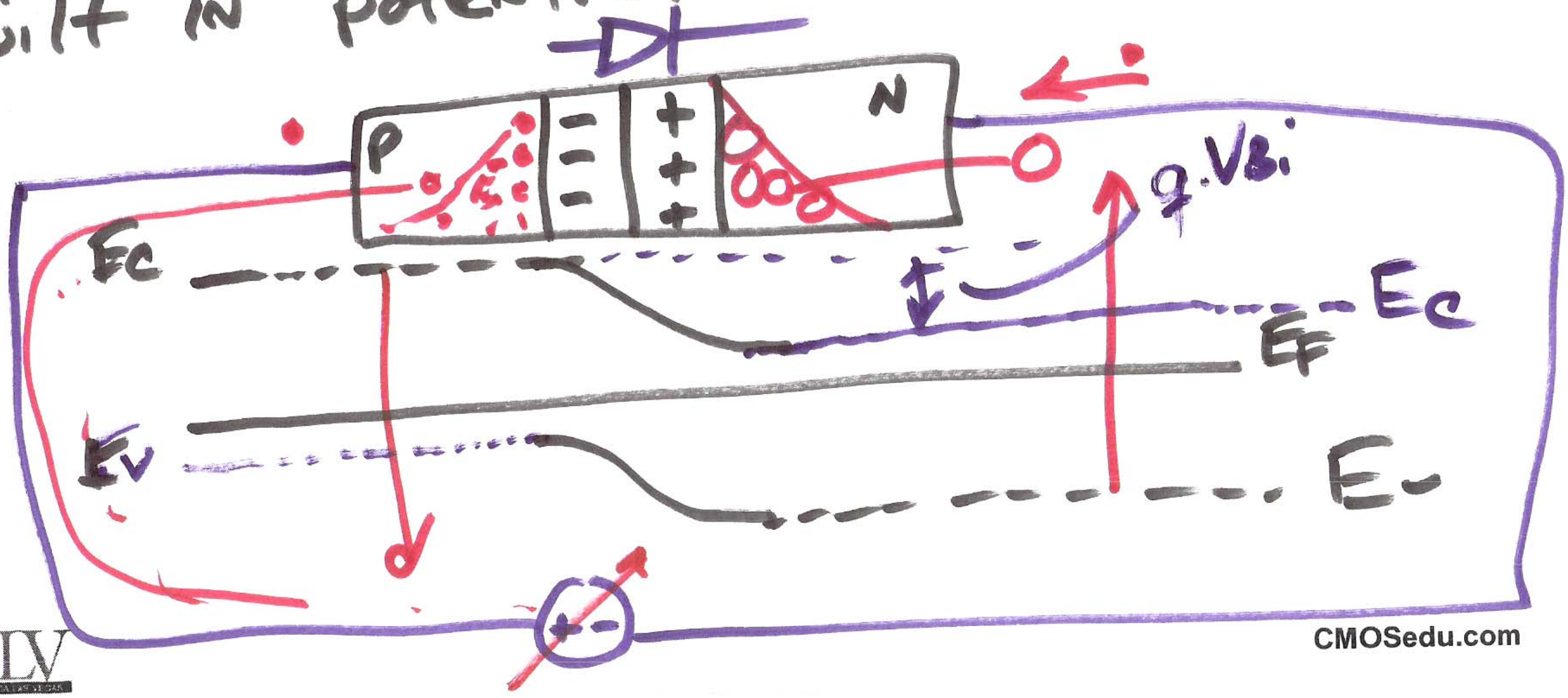
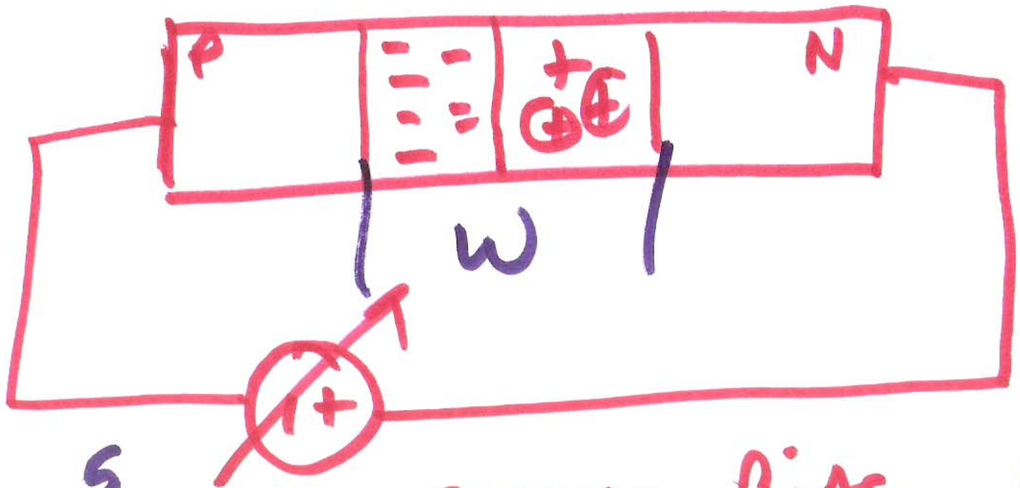
$$V_{Bi} = \frac{KT}{q}\left(\ln \frac{N_D}{N_i} + \ln \frac{N_A}{N_i}\right)$$

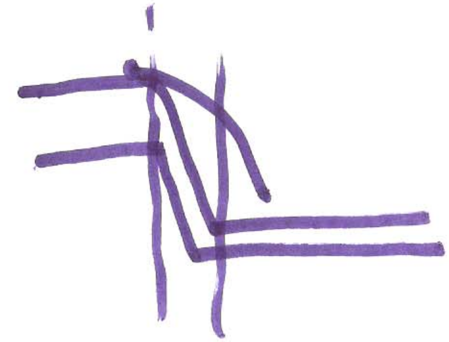
$$V_{Bi} = \frac{KT}{q}\left(\ln \frac{N_D N_A}{N_i^2}\right)$$

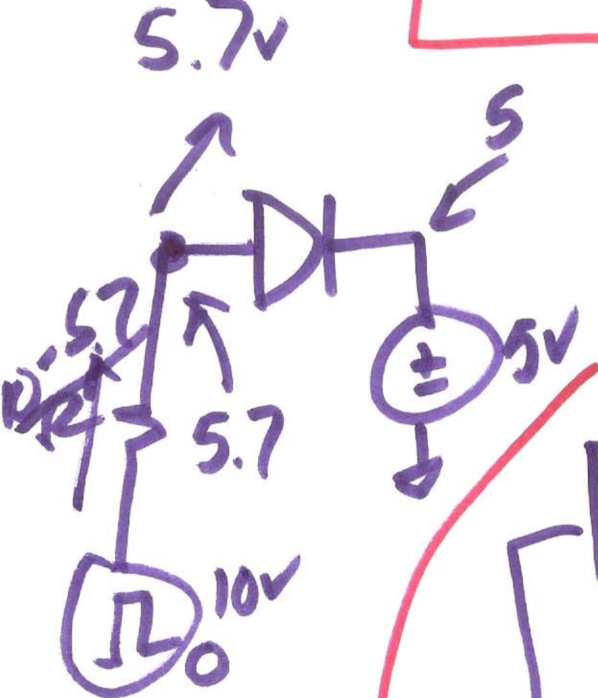
Built in potential



Reverse Bias





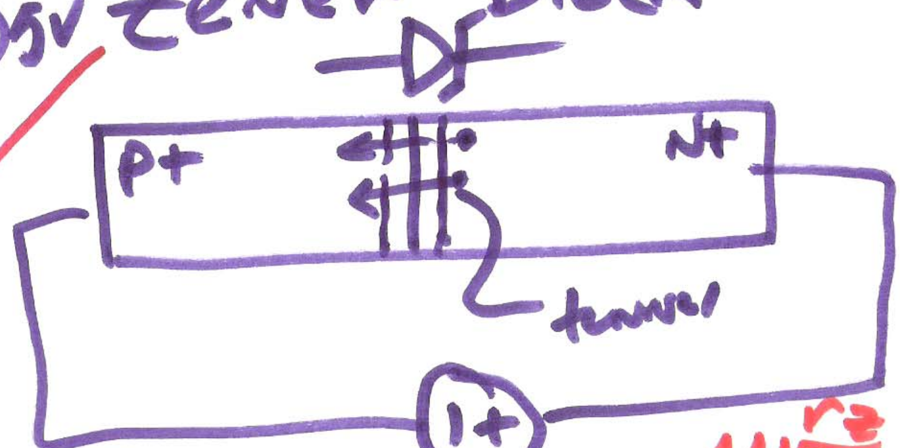


Reverse Bias

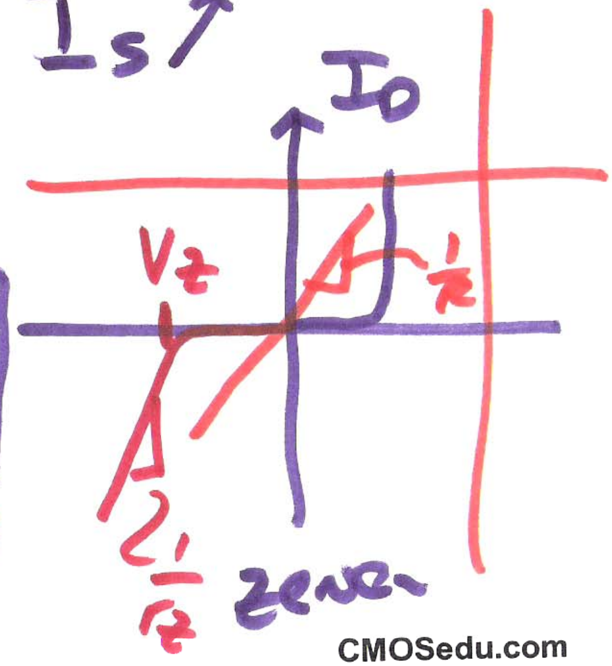
$W \uparrow \quad C_j \downarrow$

$I_S \uparrow$

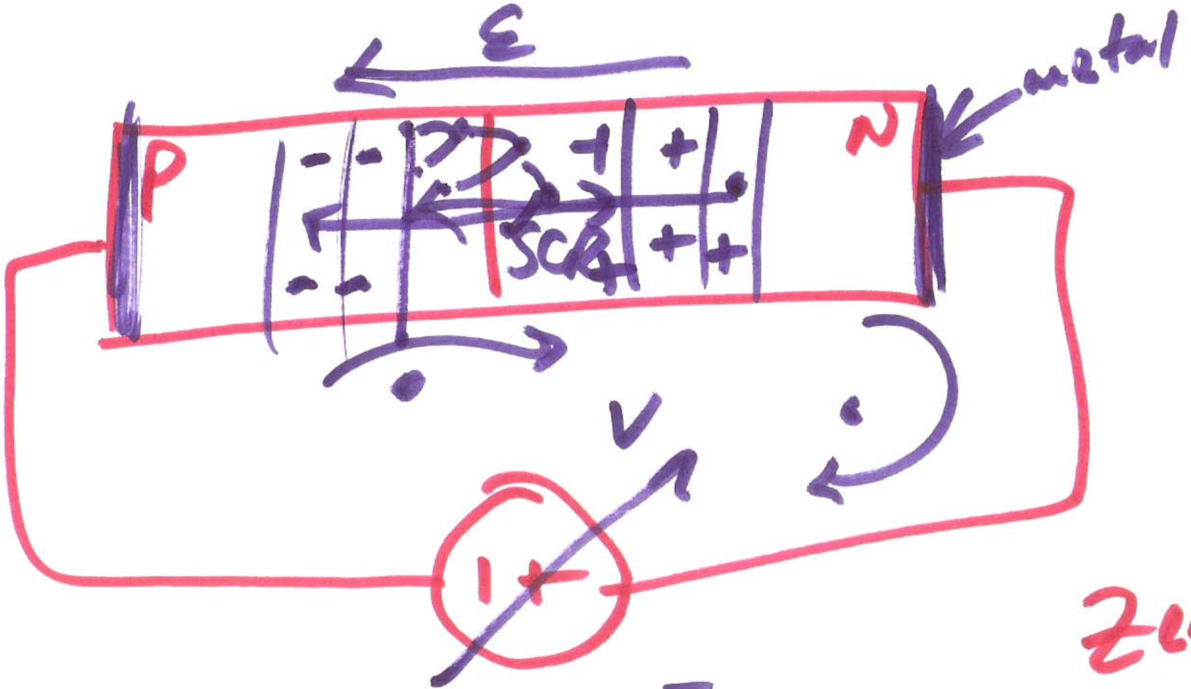
Zener Diode



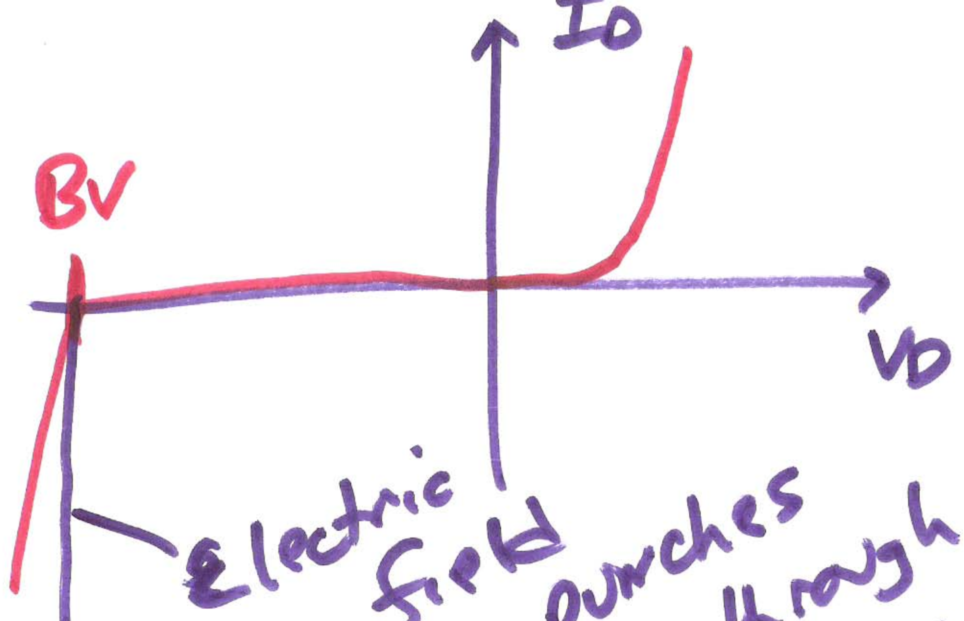
Lower voltage tunneling



AVALANCHE Multiplicatin



Zeners < 6V
Avalanche > 6V



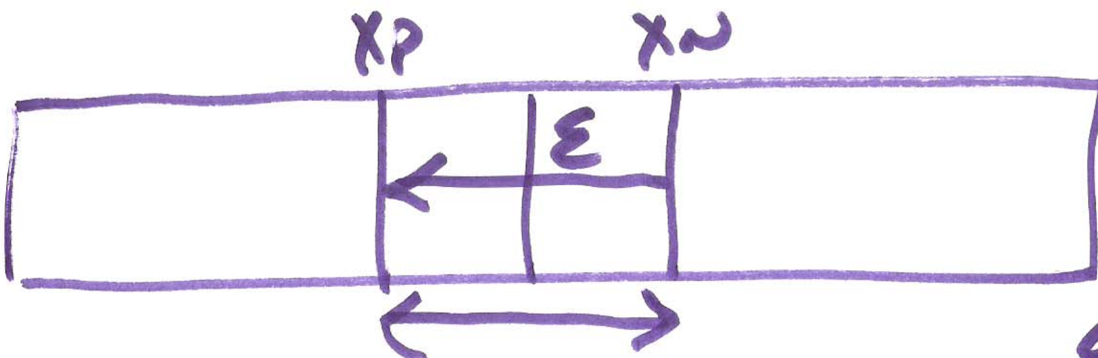
Electric field punches through to metal contacts

3.42 $V_Z = ?$ $R_Z = ?$

$V_Z = 4$ $R_Z = 0$

3.40* $W_{d0} = 1\mu m$, $\phi_j = 0.6V$ = Built-in potential

Breaks down when $\mathcal{E} = 300 kV/cm$



$\underline{\underline{BV}} = \dfrac{300kV}{cm} \cdot W_{BV}$

width at B.d.

$W_{d0} = X_p + X_n$

0-bias depletion width

$\mathcal{E}_{bi} = \dfrac{0.6}{1\mu m}$

$= \dfrac{0.6}{10^{-4} cm}$

$= 6 kV/cm$

$$BV = \frac{300KV}{C_m} \cdot W_{BV}$$

$$W_{BV} = W_{d0}\sqrt{1 + \frac{BV}{\phi_j}}$$

3.33 $I_S = 2.5 \times 10^{-16}$ @ $30°C$

$I_D = 1mA$

$V_D = ?$ $T = 303°K$ $I_D = I_S e^{V_D/NV_T}$

forward biased

$T - T_0$

$$V_D = \cancel{N}^{1} V_T \ln \frac{I_D}{I_S}$$

$$\rightarrow V_D = \frac{KT}{q} \ln \frac{10^{-3}}{2.5 \times 10^{-16}} \leftarrow$$

3.26 $i_D = 300\mu A$ $v_D = 0.75V$

(a) $I_S = ?$ $N = 1$

$$I_S = \frac{i_D}{e^{V_D/NV_T}}$$ (forward Bias)

solve for I_S

$$I_D = I_S\left(e^{V_D/NV_T} - 1\right) \simeq I_D \simeq I_S e^{V_D/NV_T}$$

(B) $I_D = ?$ for $V_D = -3V$

$$I_D \simeq -I_S$$

$$I_D = I_S\left(\underbrace{e^{\overbrace{V_D/NV_T}^{-\text{Big}}}}_{\simeq 0} - 1\right)$$

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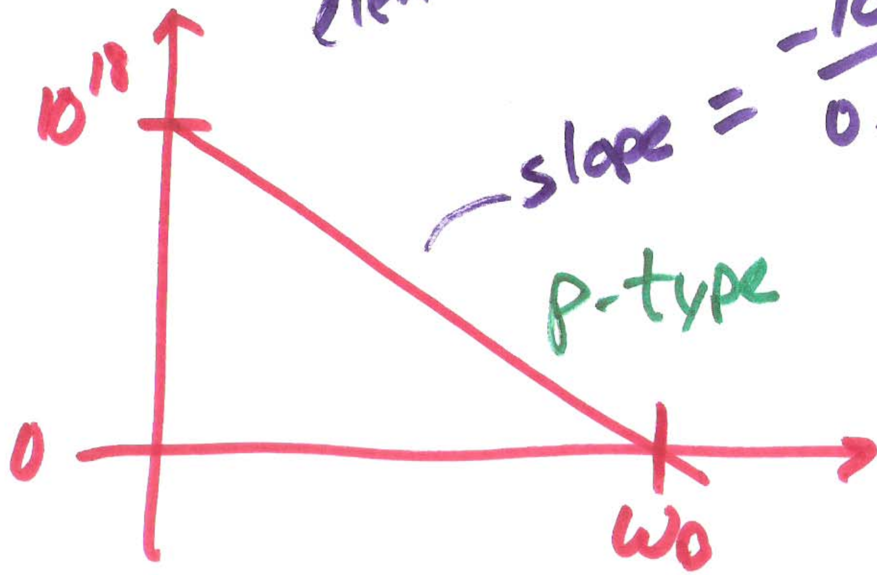
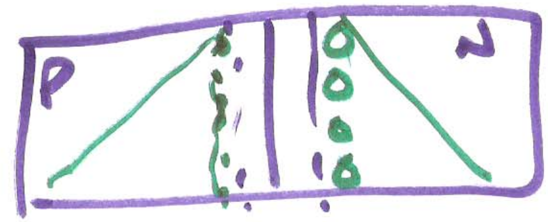


electrons

slope = $\frac{-10^{18}/cm^3}{0.5\cdot 10^{-6}} = \frac{\delta N}{\delta x}$

p-type



$\mu_N = 350\ cm^2/V\cdot s$

$W_B = 0.5\ \mu m$

$J_{Diff} = ? = -q D_N \frac{\delta N}{\delta x}$

$D_N = \frac{KT}{q}\cdot \mu_N$