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CSE, IUB

Lecture notes - 3
CSE 310

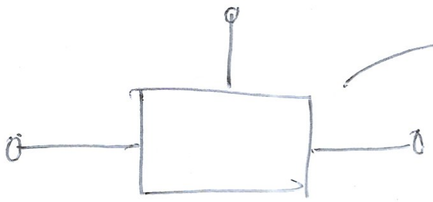
0) Recap
1) Transistor → basic action
2) FET → Field Effect Transistor
3) FET & BJT comparison
4) Review → Semiconductor basics & Pn junction

0) Recap

i) Course information
ii) Industrial Revolution
iii) MOSFET
iv) Nanotechnology & nanoelectronics

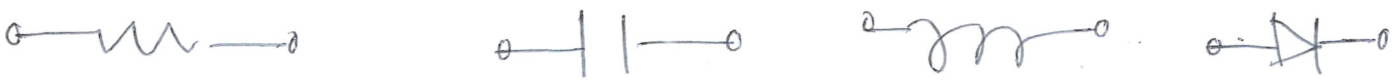
1) Transistor

Passive
2 terminal



active device

3 terminal
device



Basic action of a transistor

i) Amplification of a Signal → BJT
ii) switching action → logic gates → FET
iii) Current source (saturation of current)

2) FET

Field **E**ffect **T**ransister

electric field

→ current is controlled inside the device by creating an electric field with external bias

FET

JFET — Junction

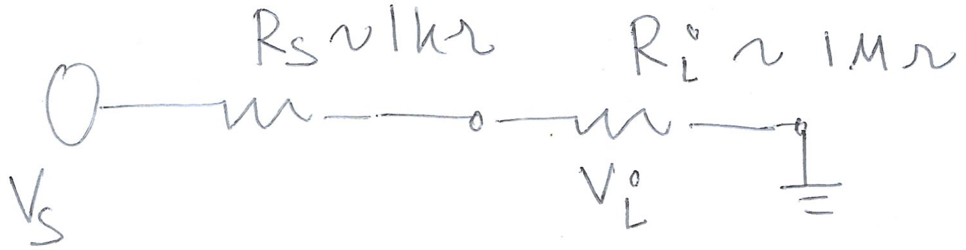
MOSFET — metal-oxide-semiconductor

depletion, enhancement

3) FET & BJT Comparison

FET	BJT
i) Unipolar	i) Bipoler
ii) Voltage controlled	ii) Current controlled
iii) Moderate gain	iii) High gain
iv) High input impedance [~ 1 MΩ to ~~100 MΩ~~ several hundreds MΩ]	iv) low input impedance
v) temperature stable, smaller in size	v) sensitive to temperature, bigger in size, not ideal for chips

* High input impedance (R_i) is good for voltage source →

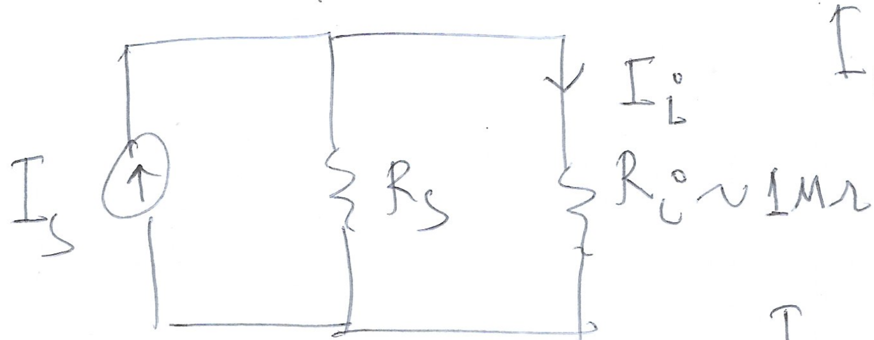


$$V_i = V_s \frac{R_i}{R_s + R_i} \approx \frac{V_s R_i}{R_i} \simeq V_s$$

Input voltage $\simeq$ source voltage

* But high input impedance (R_i) is bad for current source

→



$$I_i = I_s \frac{R_s}{R_i + R_s}$$

$$\simeq I_s \frac{R_s}{R_i}$$

$$I_i << I_s$$

input current is much less than source current

1) Review – Semiconductor basics & pn j^n ^{c}

(band gap $\rightarrow E_g$)

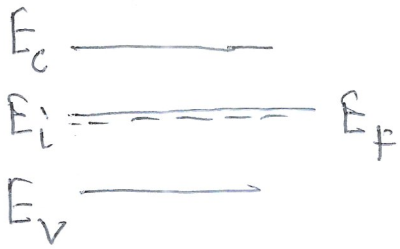
Energy bands, Fermi Energy (E_F)

Carriers $\rightarrow$ electron (e^-) & hole (e^+)

Doping $\rightarrow$ p type & n type

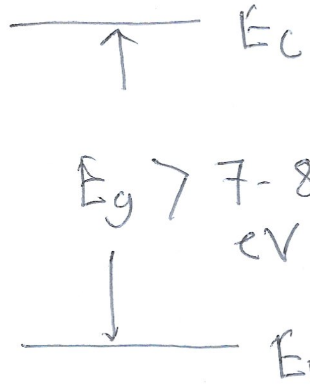
$E_g = 0$

(conductors)

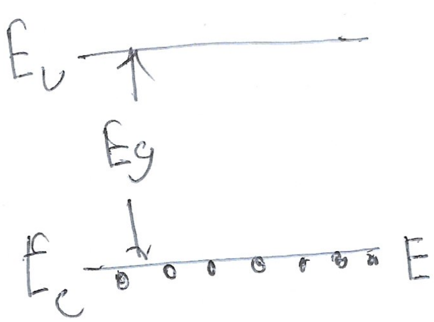


$E_g \rightarrow 0$ to 3-4 eV

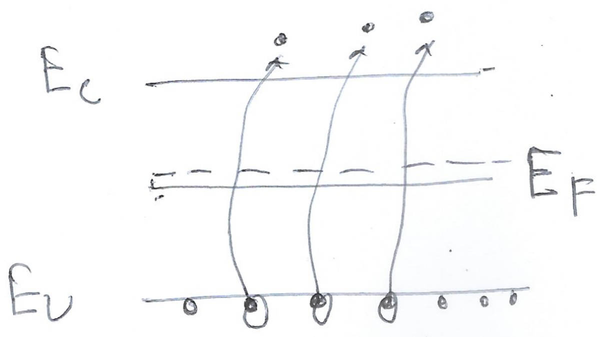
(semiconductors)



(insulators)



$T = 0$



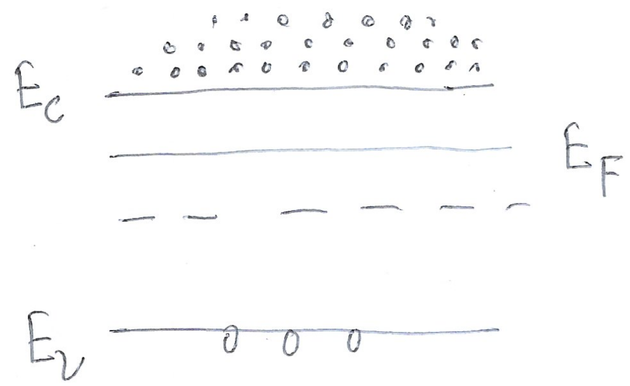
$T = 300^\circ K$

<u>intrinsic</u> semiconductor (say Si)

Doping

n type

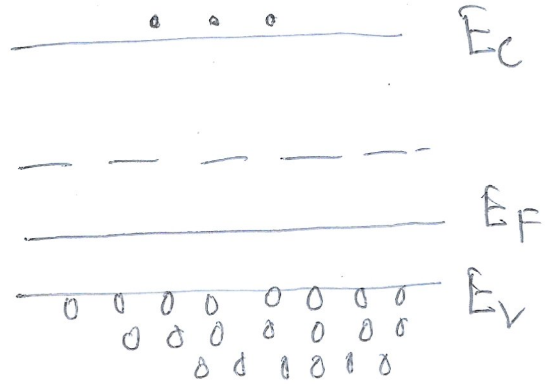
5 valence electrons → (Sb, As, P)



e^- → majority
e^+ → minority

p type

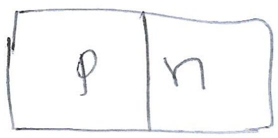
3 valence electrons → (B, Ga, In)



e^+ → majority
e^- → minority

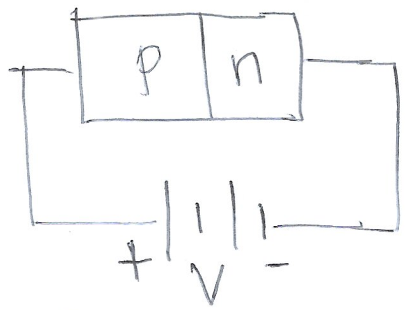
* more n type doping → E_F moves up towards E_c

* more p type doping → E_F moves down towards ~~Va~~ E_v

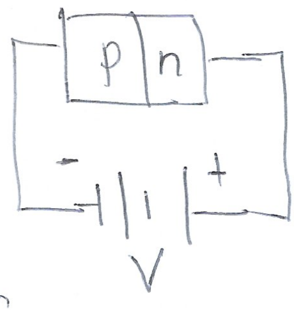


$V = 0$
(equilibrium)

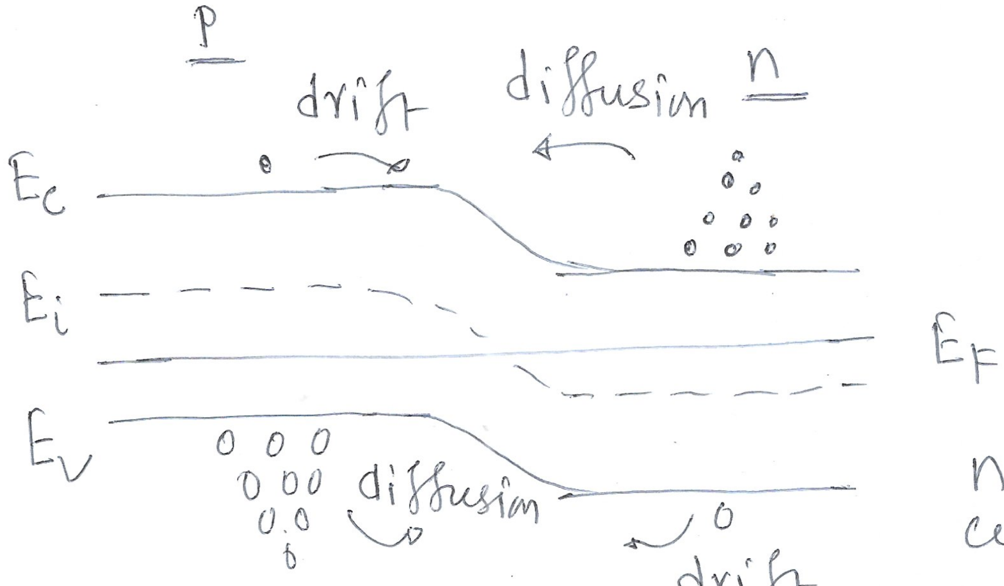
⊛ E_F is flat & constant



(Forward bias)
(quasi fermi level)



(reverse bias)

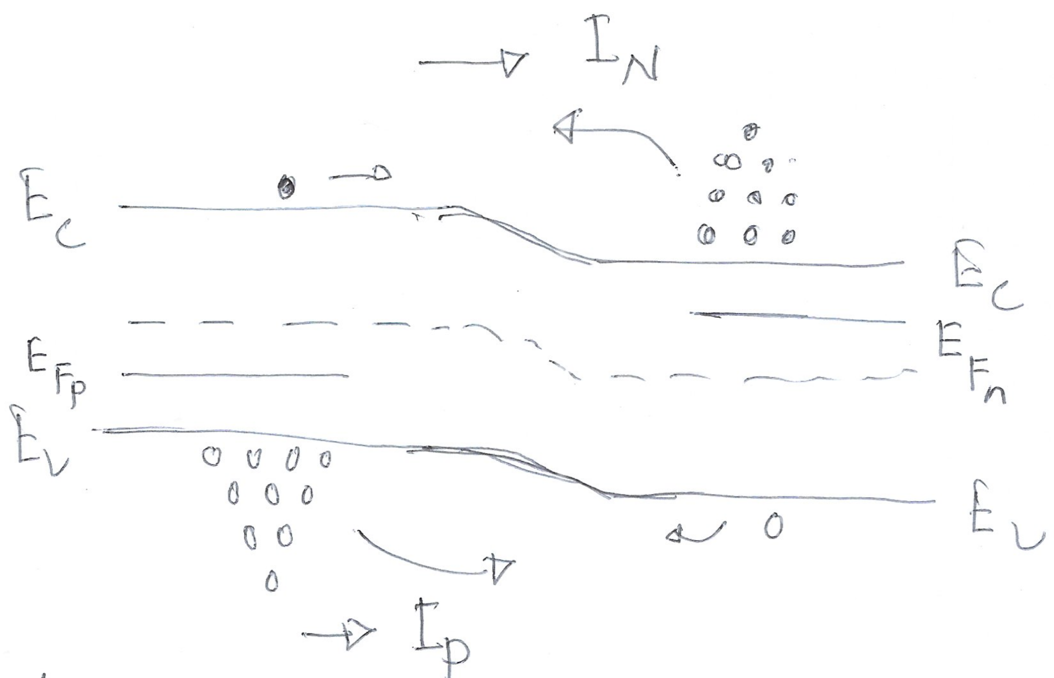


net current $I = 0$

$(V=0)$

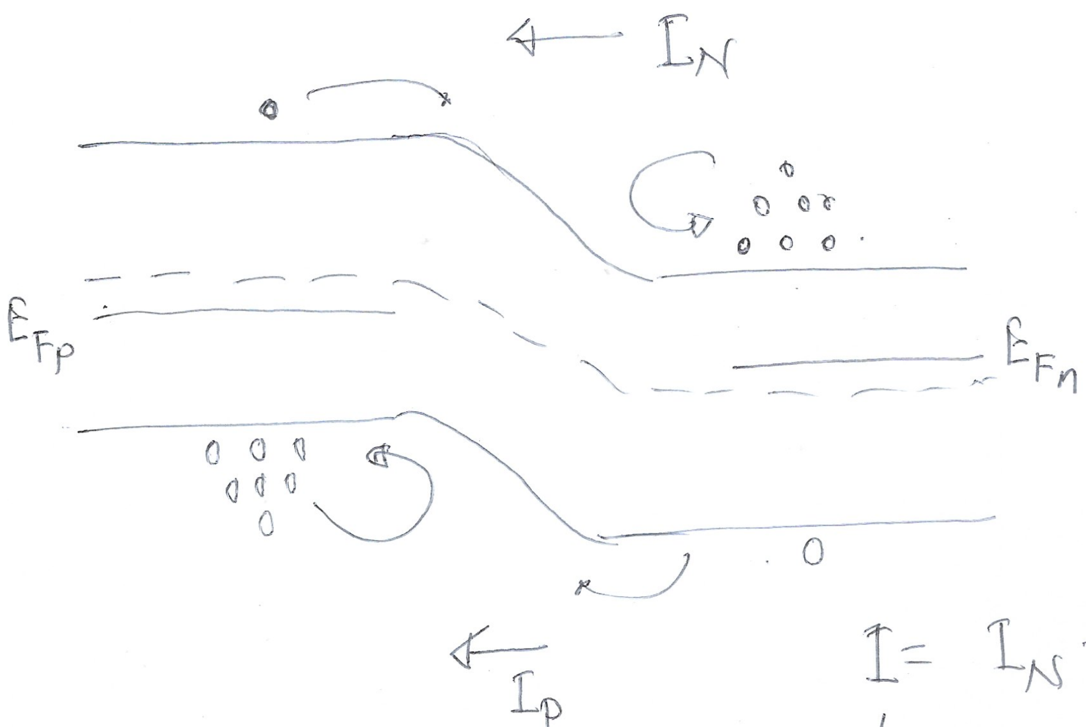
diffusion → due to concentration gradient

drift → due to presence of an electric field



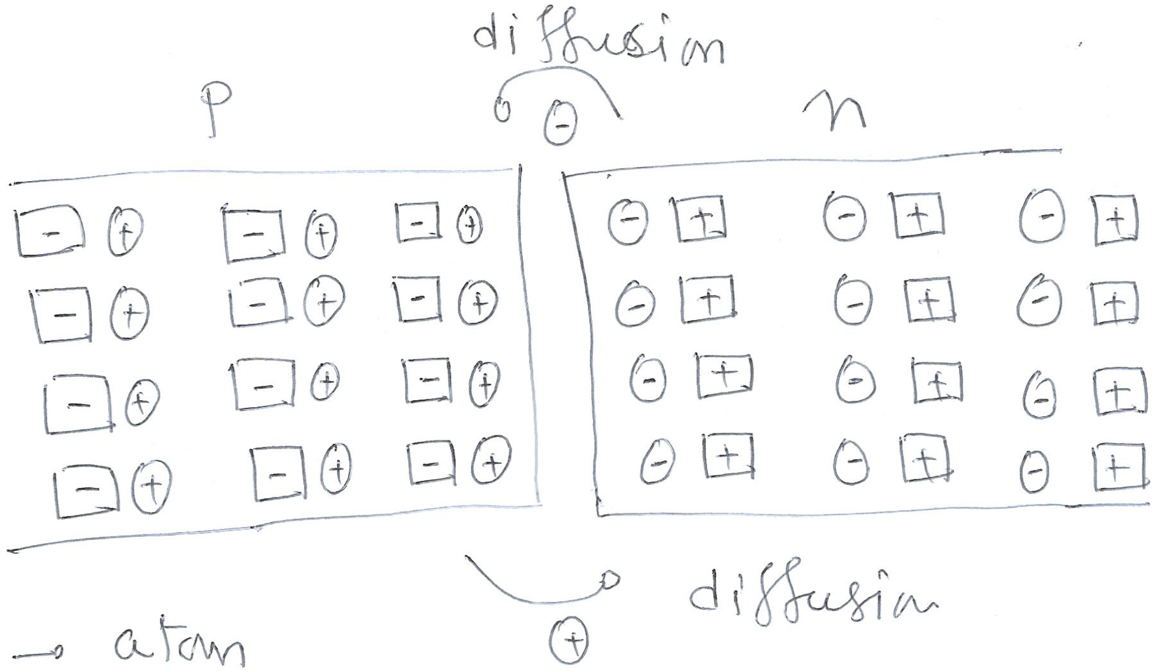
(V > 0 forward bias)

net current $I = I_N + I_p$
↳ mA



(V < 0 reverse bias)

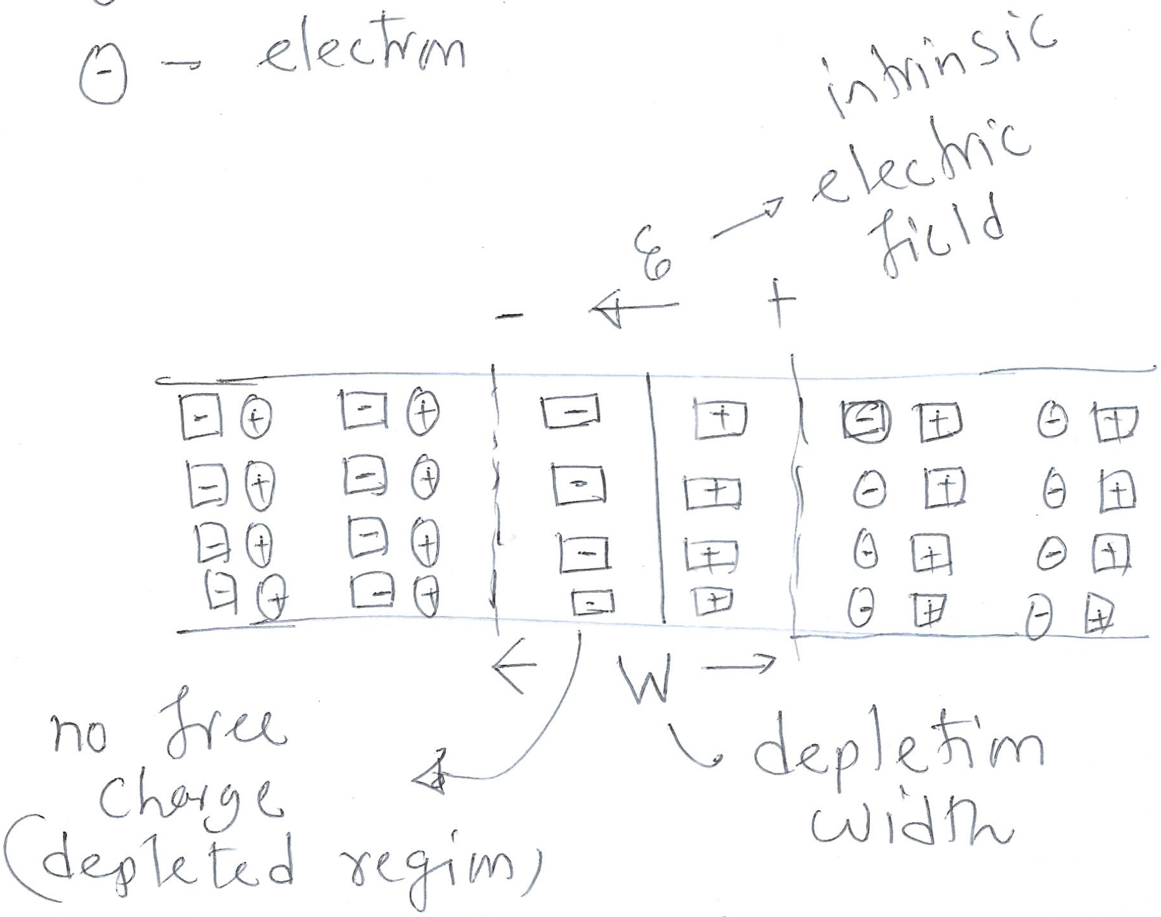
$I = I_N + I_p$
↳ very small
~ nA



□ → atom

⊕ → hole

⊖ → electron



* more forward bias → W ↓

* more reverse bias → W ↑