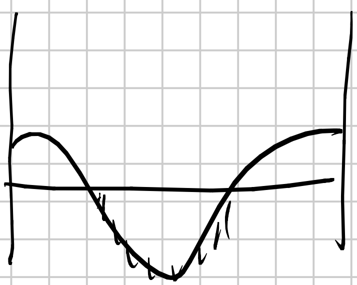
LECTURE #37

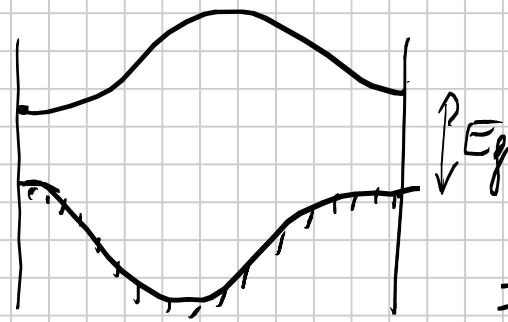
Note Title 4/19/2010

SEMICONDUCTORS

INSULATOR



METAL



FILLED BAND

$\Rightarrow$ NO CURRENT

$J = 0$

$T \neq 0 \Rightarrow$ THERMAL EXCITATIONS

$\sigma \neq 0$ AT ROOM TEMPERATURE

$\rho = \frac{1}{\sigma}$ $\rho_{METALS} \sim 10^{-6}\ \Omega\ cm$

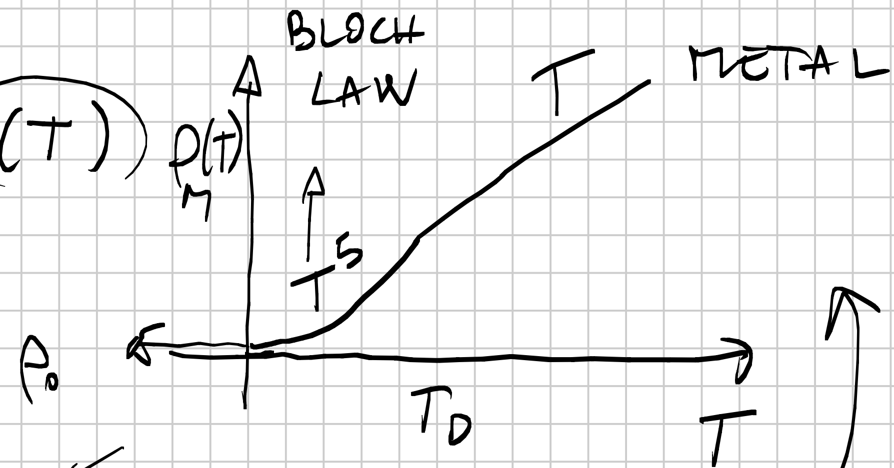
$\rho_{SEMICONDUCTOR} \sim 10^{-3} \sim 10^{9}\ \Omega\, cm$ AT ROOM T

$\rho > 10^{9} \sim 10^{22}\ \Omega\, cm \rightarrow$ INSULATORS

$\rho(T)$ DIFFERENT FOR METALS AND SEMICONDUCTORS

METALS

$$\frac{1}{\rho_M(T)} = \sigma(T) = \frac{n e^2 \tau(T)}{m}$$



SEMCONDUCTORS

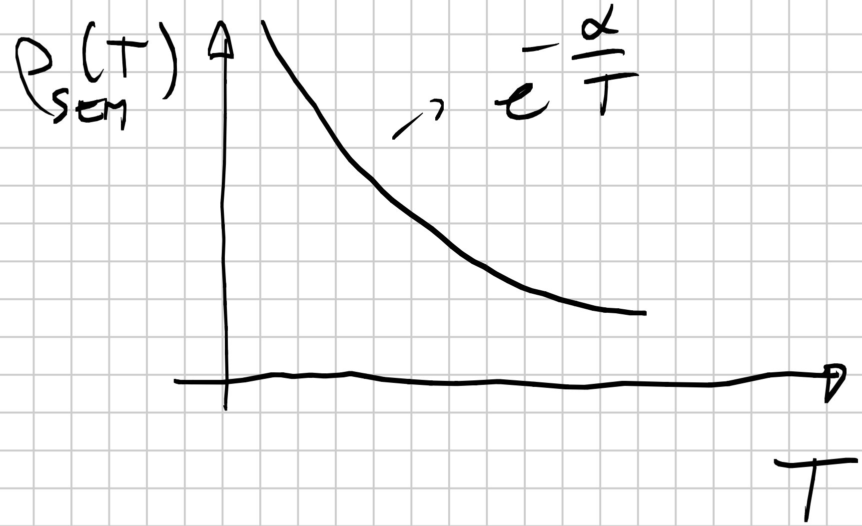
$$\frac{1}{\rho_{SEM}(T)} = \sigma(T) = \frac{n_0 e^{-\frac{E_g}{2k_BT}} e^2 \tau(T)}{m}$$

$n(T)$

$$\frac{d\rho}{dT} > 0$$

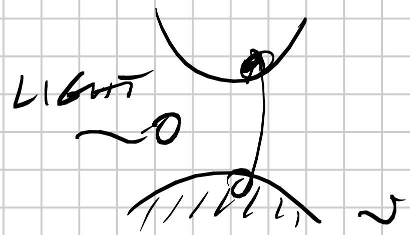
$$\frac{d\rho}{dT} < 0$$

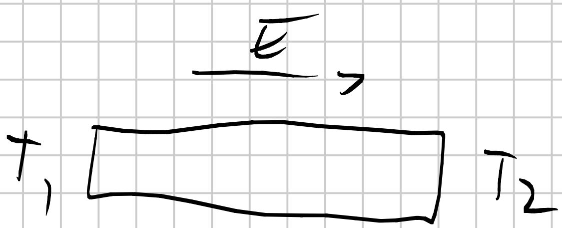
NEGATIVE DIFFERENTIAL RESISTIVITY



FINITE E_g

$\Rightarrow$ PHOTO CONDUCTIVE PROPERTIES





$$\vec{E} = -Q \nabla T$$

$Q \to$ THERMOPOWER

DRUDE $\to$ $Q \sim -\frac{C_V}{3ne}$

$C_V \to$ BOLTZMANN

$$C_V \sim \frac{3}{2} k_B n$$

Q ~ 100 BIGGER THAN IN REAL METALS

ELECTRONS ARE WELL DESCRIBED BY BOLTZMANN

Q SEMICONDUCTORS ~ 100 Q METALS

INTRINSIC PROPERTIES

EXTRINSIC " (<u>DOPING</u> WITH IMPURITIES)

GROUP <u>IV</u>

FCC

2 ATOMS / BASIS

(000 / $\frac{a}{4}$(1,1,1))

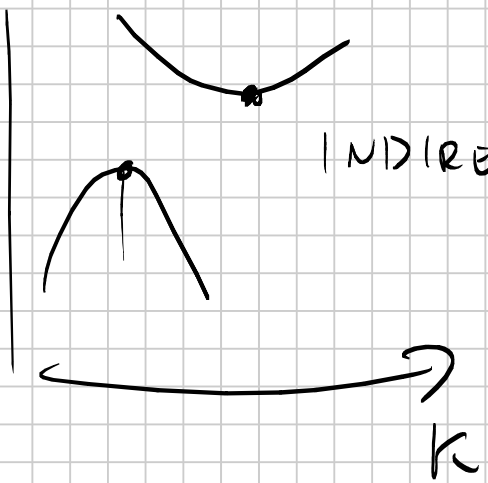
	E_{gap} (eV)	
C	4	→ (INSULATOR)
Si	1.1	
Ge	0.7	
Sn	0.2	→ NARROW GAP SEMICONDUCTOR
Pb		——→ METAL

FCC ZINC BLENDE

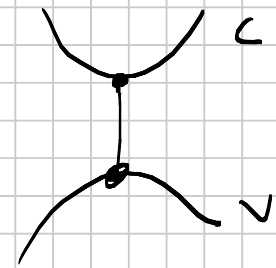
III	- V
B	N
Al	P
Ga	As
In	Sb
Tl	

II	VI
Zn	S
Cd	Se
	Te

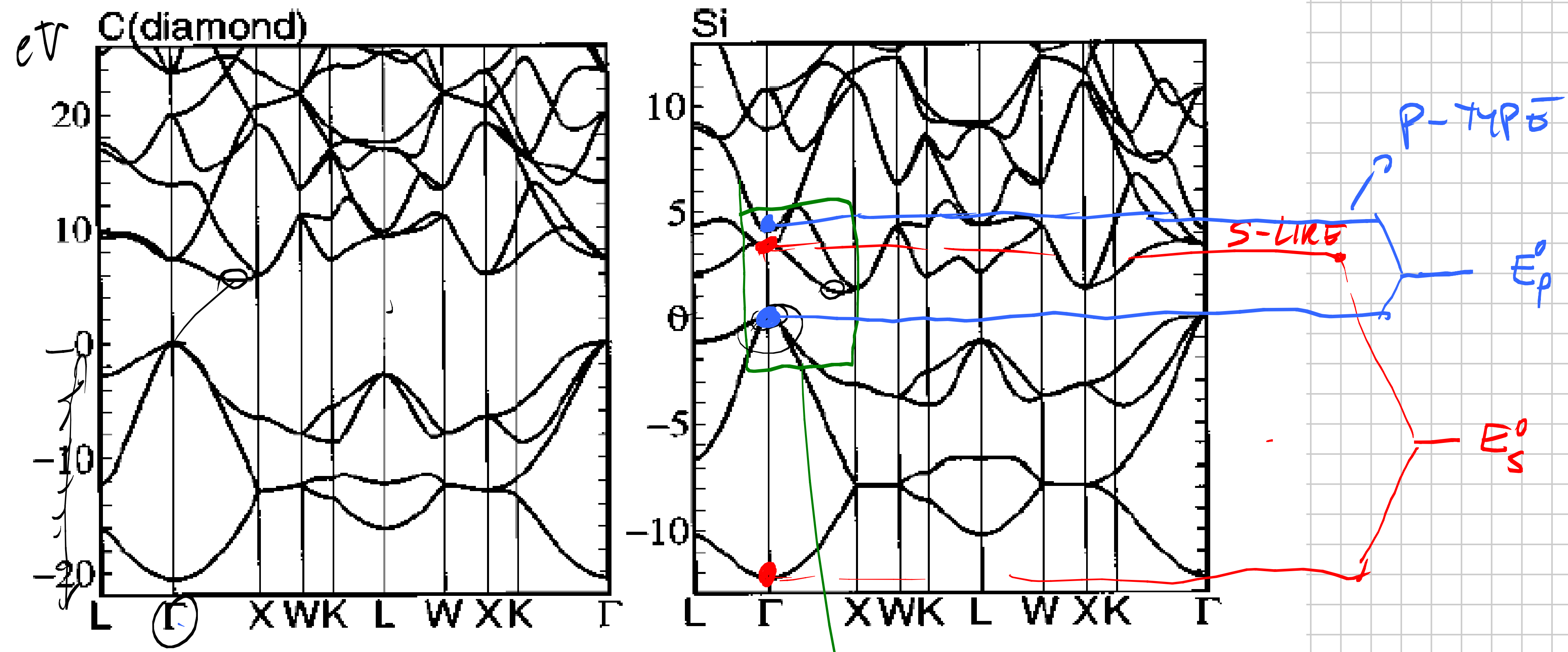
→ ALSO HEXAGONAL



INDIRECT

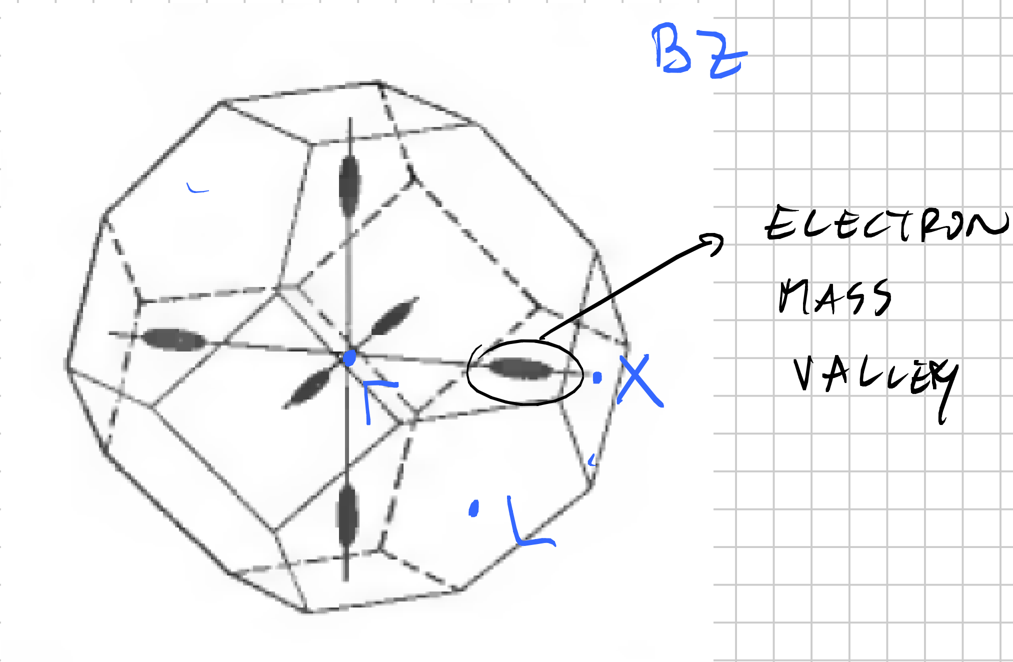


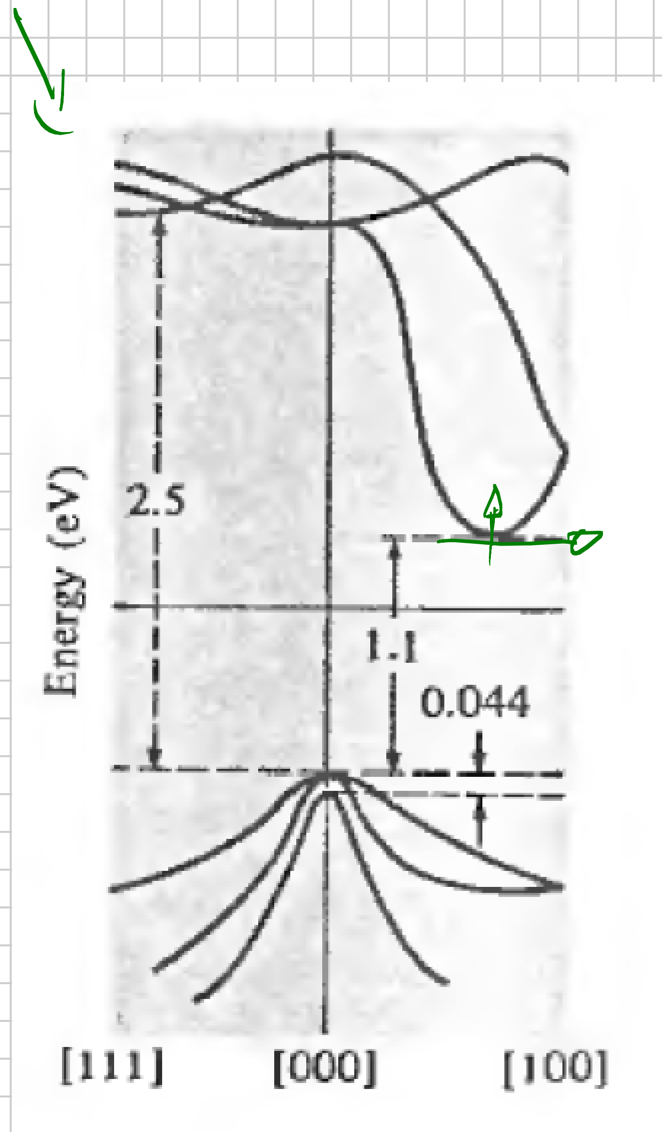
DIRECT



$C = ~~(1s)^2~~ (2s)^2 (2p)^2$

$[Ne] (3s)^2 (3p)^2$

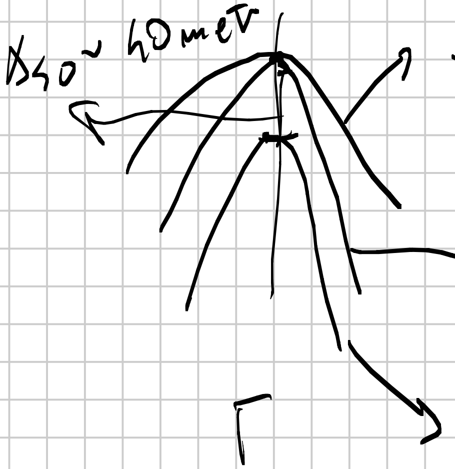




$m_{e\parallel} = 1. m_0$

$m_{e\perp} \sim 0.2\, m_0$

SPIN ORBIT EFFECTS



HEAVY HOLE BAND ~ $m_{HH} \sim 0.44\, m_0$

LIGHT HOLE $m_{LH} \sim 0.16\, m_0$

SPLIT OFF BAND

$\vec{L} = 1$

$\vec{S} = \frac{1}{2}$

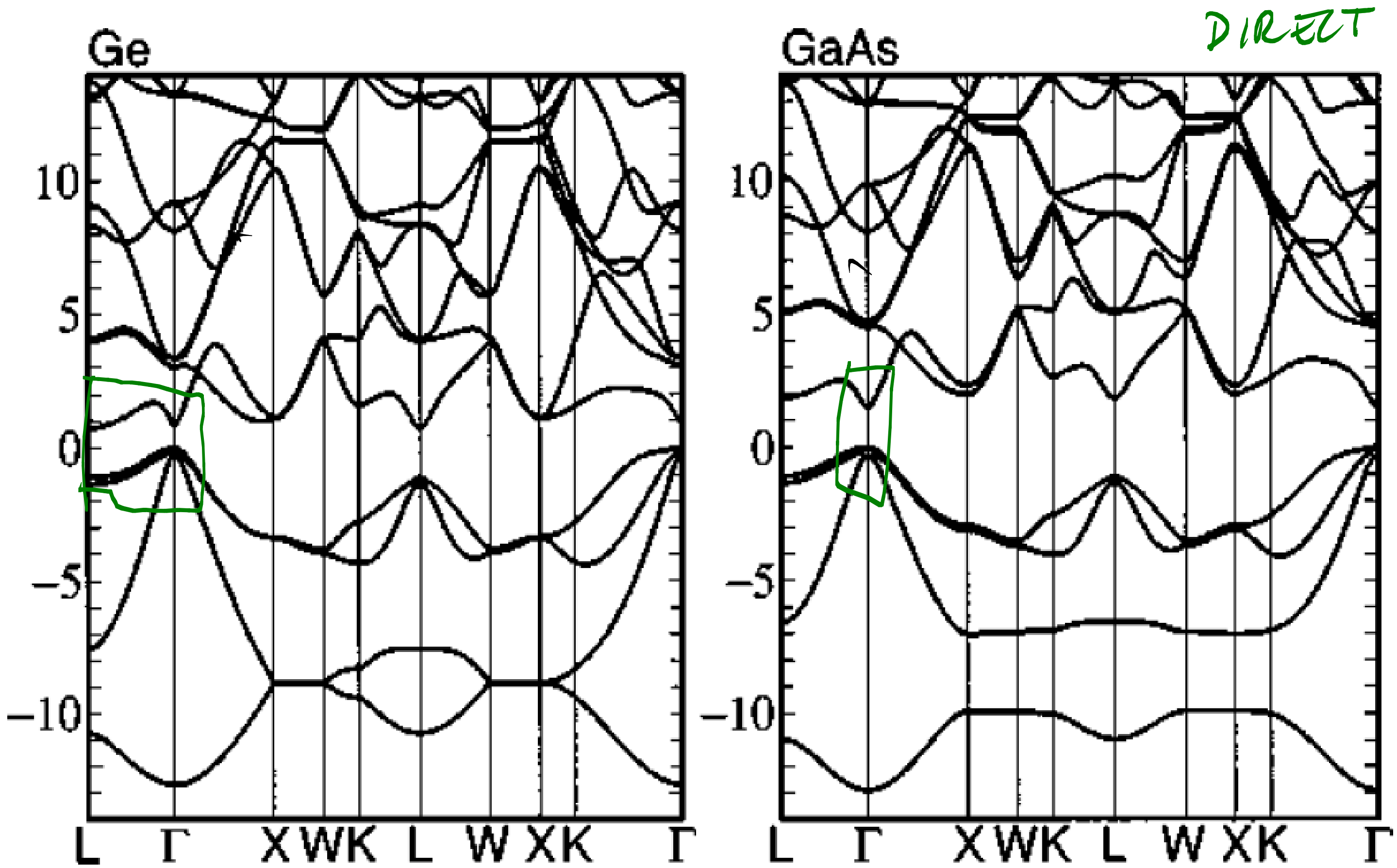
$\vec{J} = \vec{L} + \vec{S}$ → $\vec{J} = \frac{3}{2}$ → $+\frac{3}{2}$, $+\frac{1}{2}$, $-\frac{3}{2}$, $-\frac{1}{2}$

$+\frac{3}{2}, -\frac{3}{2}$ → HH

$+\frac{1}{2}, -\frac{1}{2}$ → LH

$\vec{J} = \frac{3}{2}$ ↕ Δ_{SO} ↕ $\vec{J} = \frac{1}{2}$

$\vec{J} = \vec{L} + \vec{S}$ → $\vec{J} = \frac{1}{2}$



+ STRONG
SPIN
ORBIT

Ge