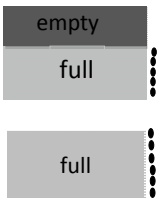
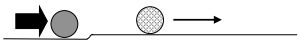
4.3 Semiconductors
4.4 Electron effective mass

Conductor (metal):



The electron is like a ball rolling on almost flat ground:

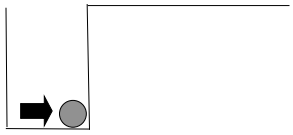


Electron can move easily

Insulator:

ENERGY gap- no ALLOWED levels

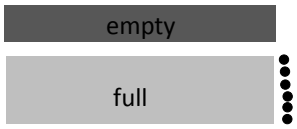
Electron is in a pit,



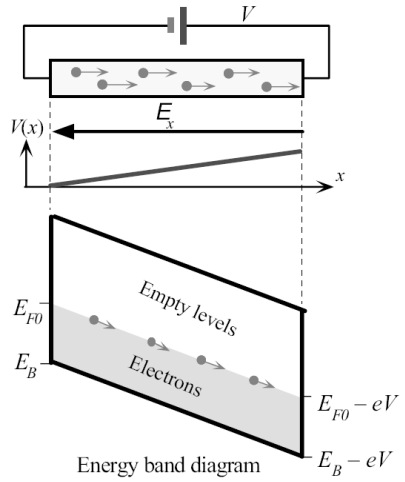
It can't move without a big boost.

Semiconductor:

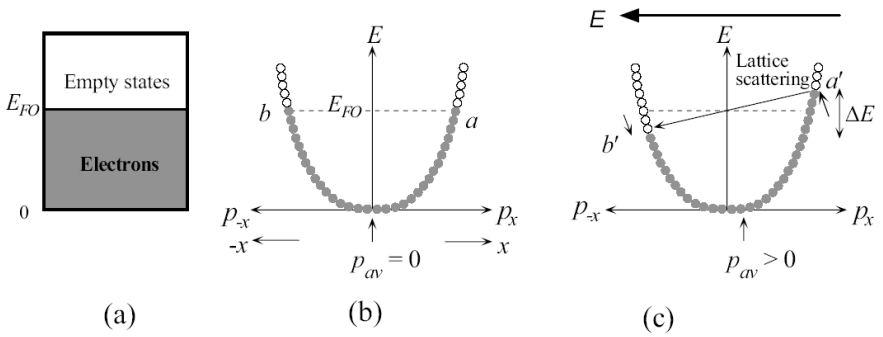
Half way in between a conductor and an insulator.



Little gap to empty levels, shallow pit.


V
E_x
V(x)
x
E_F0
E_B
Empty levels
Electrons
E_F0 − eV
E_B − eV
Energy band diagram

$E = KE = p^2/2m$


Empty states
E_FO
Electrons
0
E
b
E_FO
a
p_-x
p_x
-x
x
p_av = 0
E
E
Lattice scattering
a′
ΔE
b′
p_-x
p_x
p_av > 0

(a) (b) (c)

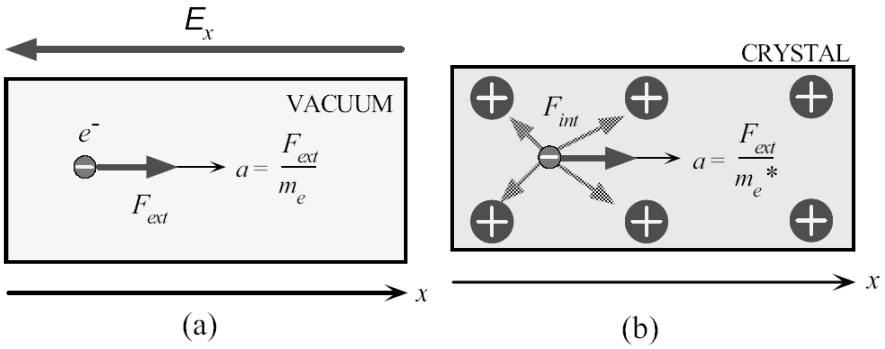
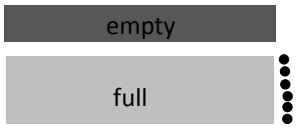


Table 4.2 Effective mass m_e^* of electrons in some metals

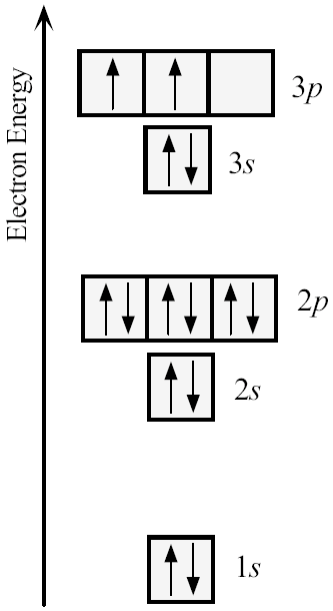
Metal	Ag	Au	Bi	Cu	K	Li	Na	Ni	Pt	Zn
$\frac{m_e^*}{m_e}$	0.99	1.10	0.047	1.01	1.12	1.28	1.2	28	13	0.85

Semiconductor:

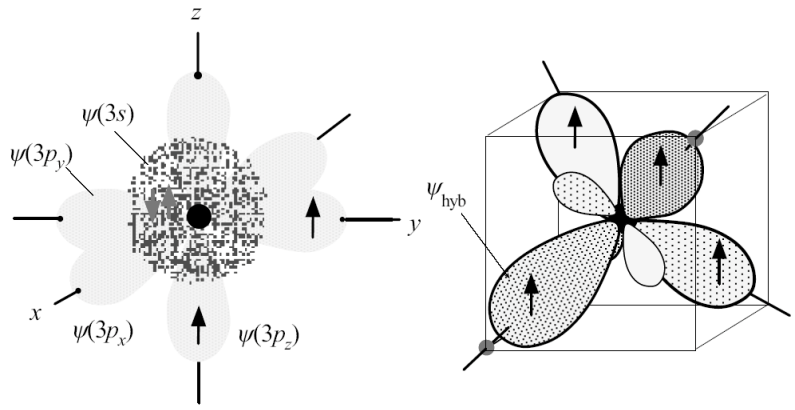
Half way in between a conductor and an insulator.



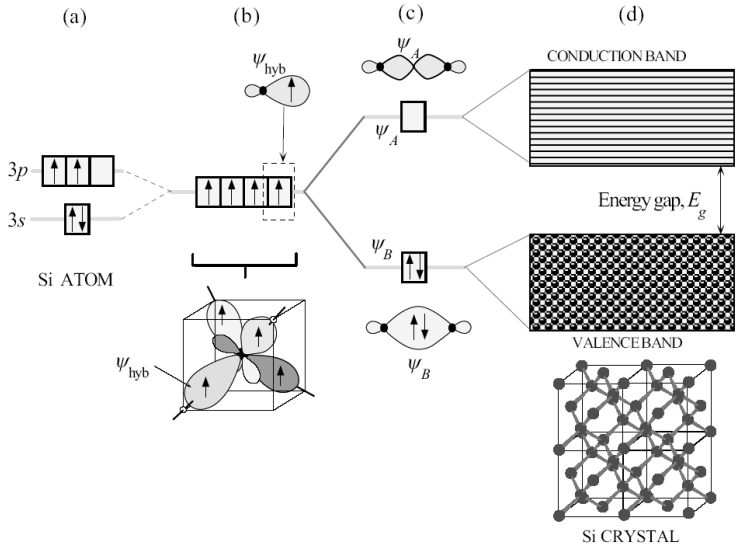
Little gap to empty levels, shallow pit.

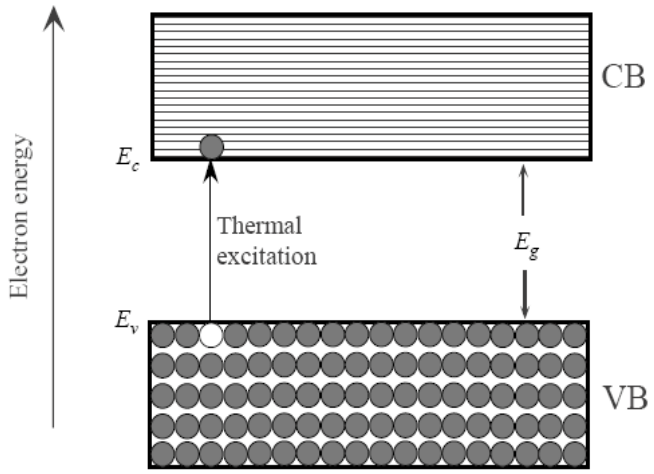


The electronic structure of Si



(a) Isolated Si (b) Si preparing to bond



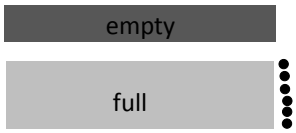


Semiconductors:

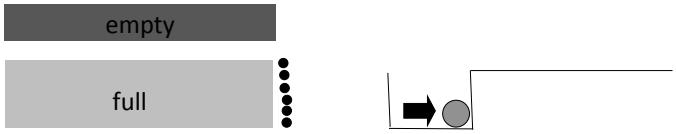
		IIIA	IVA	VA	VIA	VIIA	VIIIA
							2 He 4.003
		5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
IB	IIB	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)

Material	Band gap [ev] (T = 0K)	Band gap [ev] (T = 300K)
Si	1.17	1.11
Ge	0.74	0.66
InSb	0.23	0.17
InAs	0.43	0.36
InP	1.42	1.27
GaP	2.32	2.25
GaAs	1.52	1.43
GaSb	0.81	0.68
CdSe	1.84	1.74
CdTe	1.61	1.44
ZnO	3.44	3.2
ZnS	3.91	3.6
C (diamond)		5.5

Semiconductors:.



What are possible ways could get electron to higher empty level (out of pit), so could move to conduct electricity?



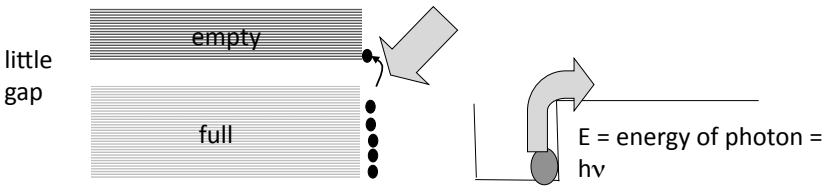
Ways to get electrons up to where they can move:

1. light-- photoconductors (copying machines, laser printers)

2. heat

3. designer impurities- tinker slightly with energy levels.

1. Photoconductors:



Physics of copying machines and laser printers.