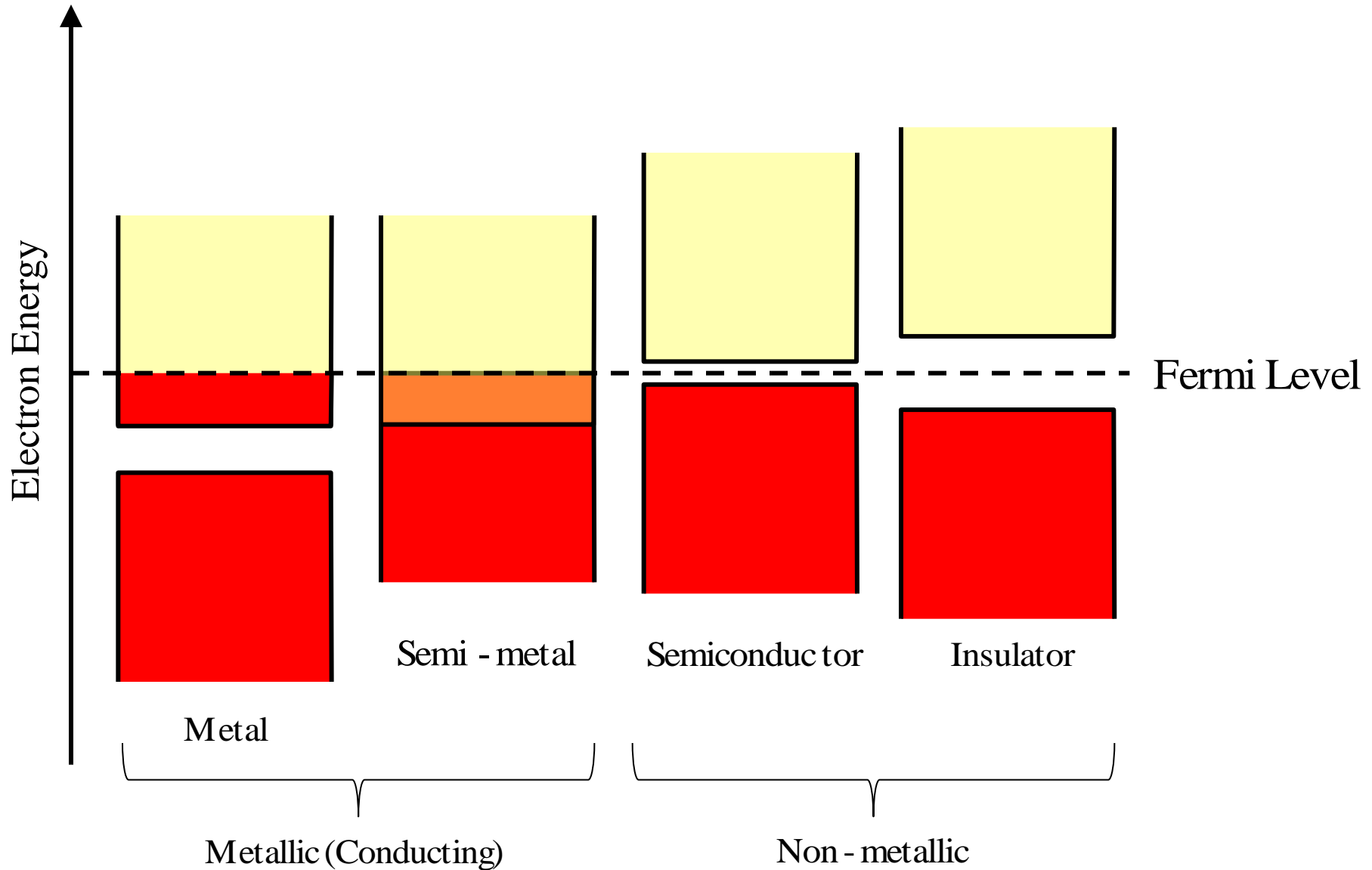
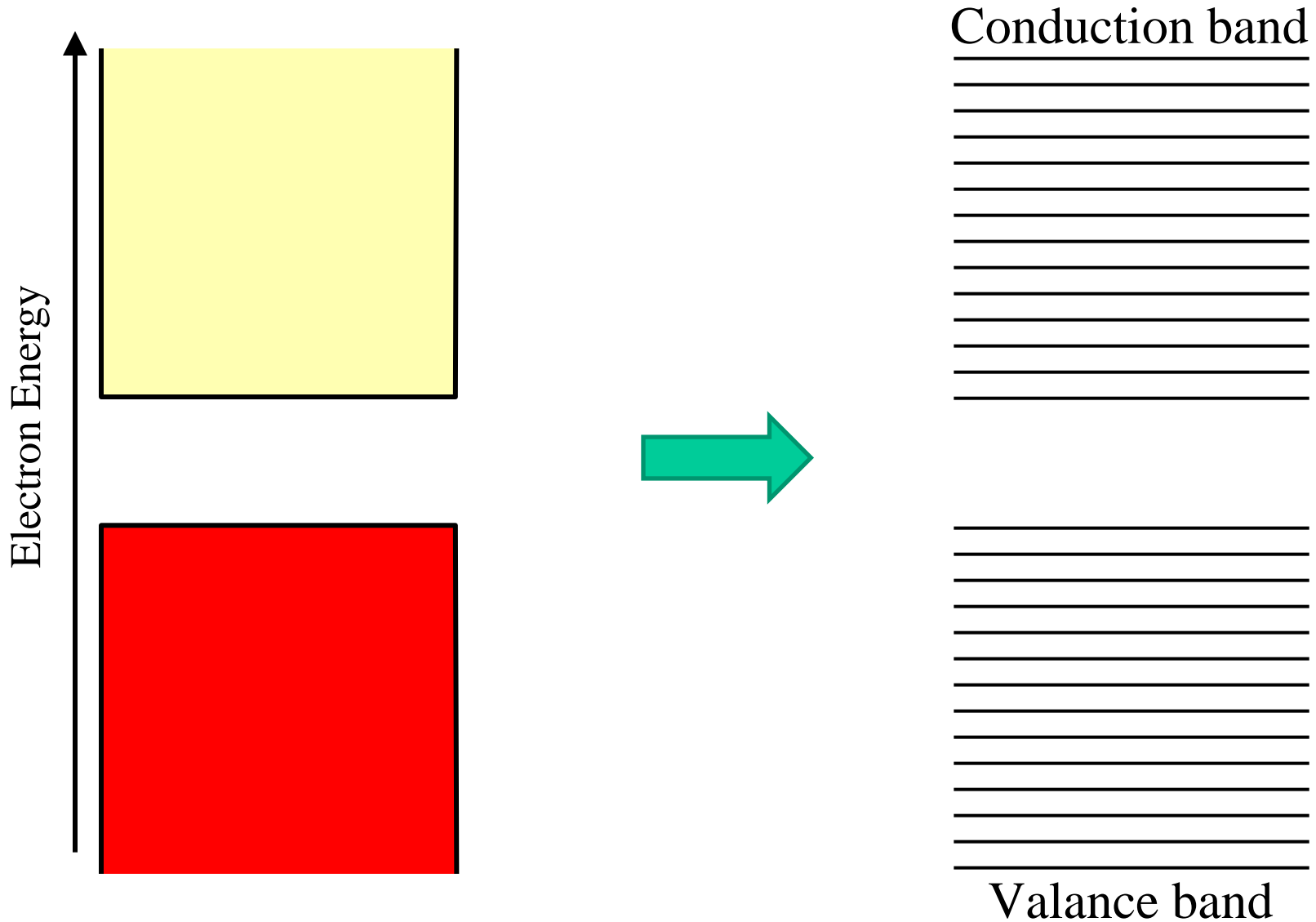


1. 能源需求
2. 太陽光
 1. 太陽能
 2. 單位換算
 3. 太陽光譜
 4. 空氣質量
3. 太陽能電池
 1. 能隙
 2. p-n 接面
 3. 二極體方程式
 4. 光二極體
 5. 太陽能電池等效電路
4. 聚光型太陽能電池

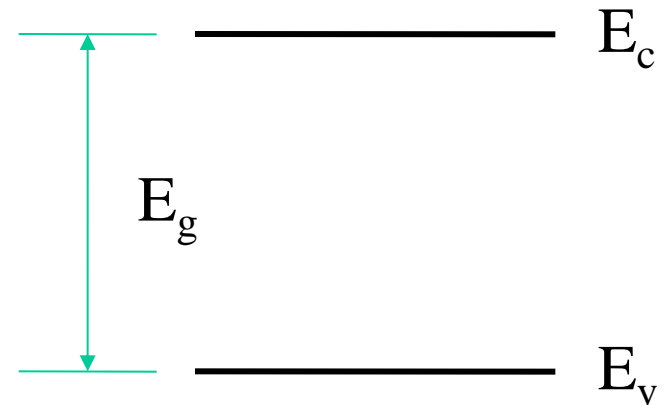
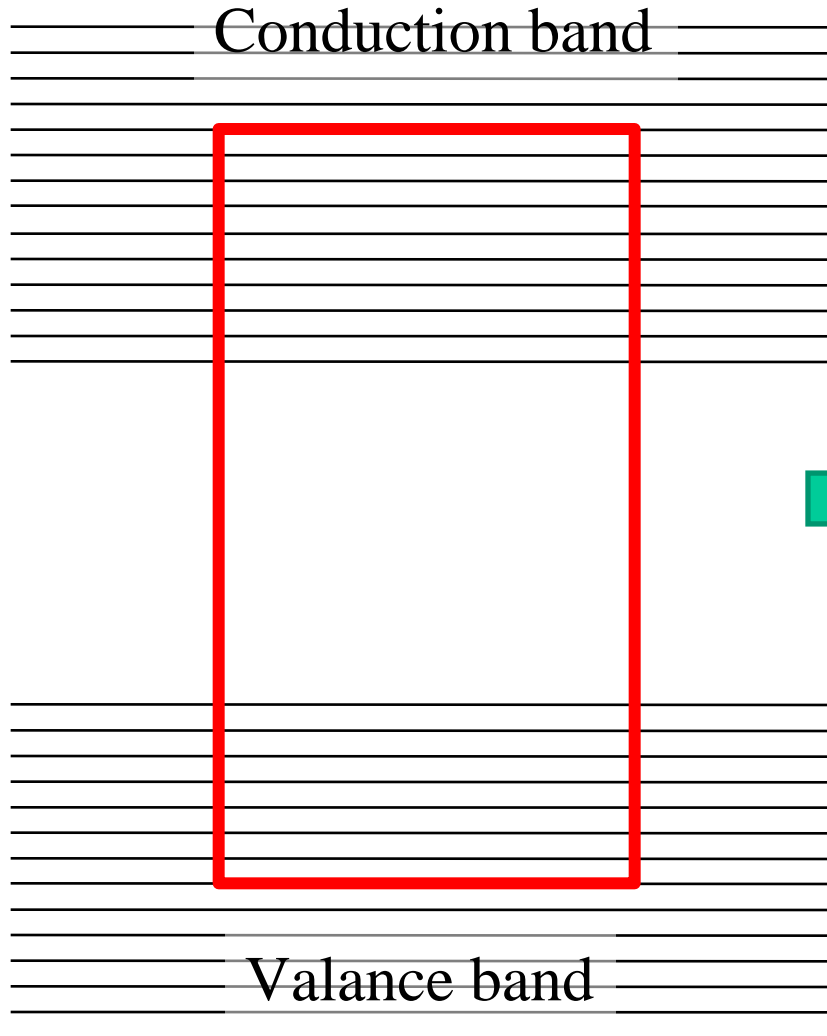
Band Diagram of Materials



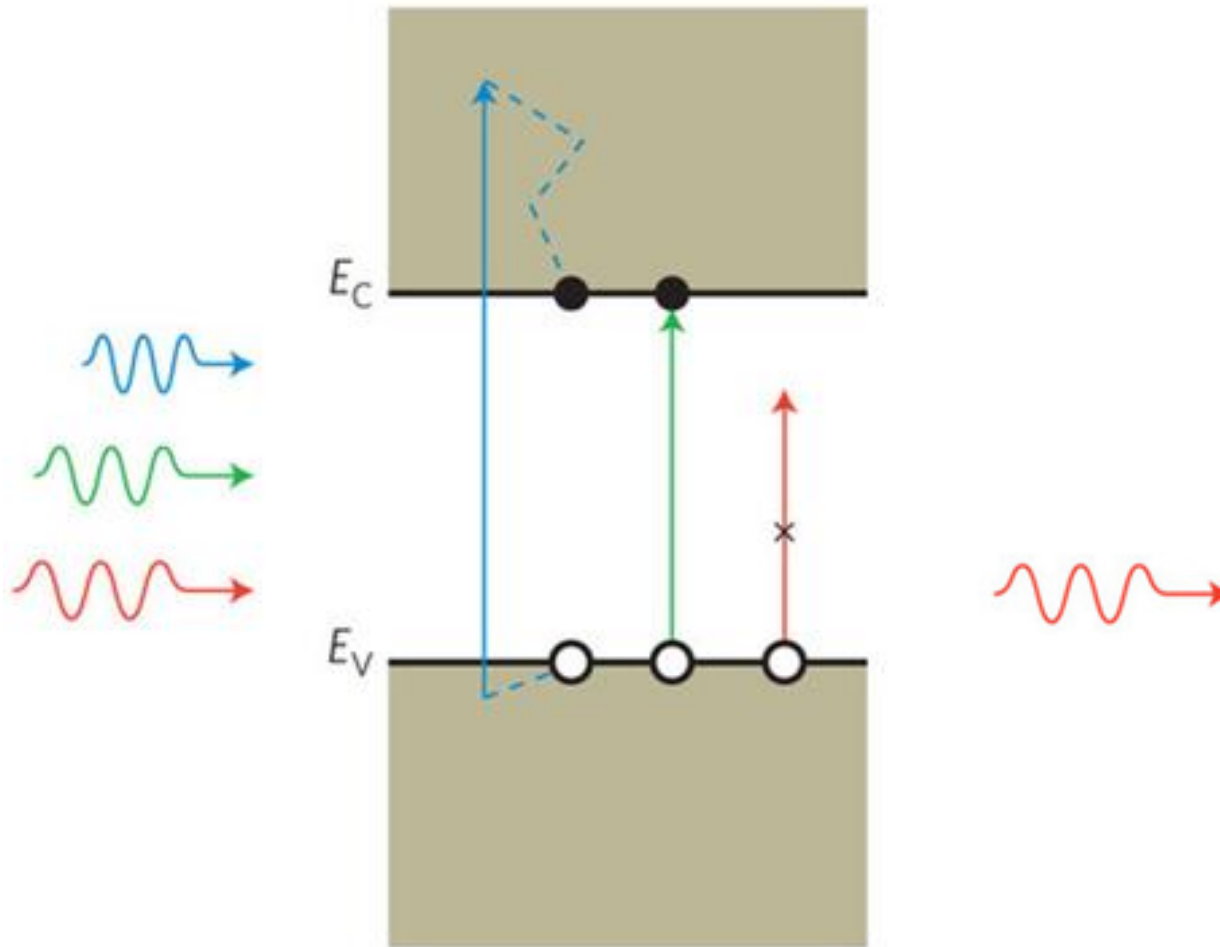
Schematic of Semiconductor Band Diagram



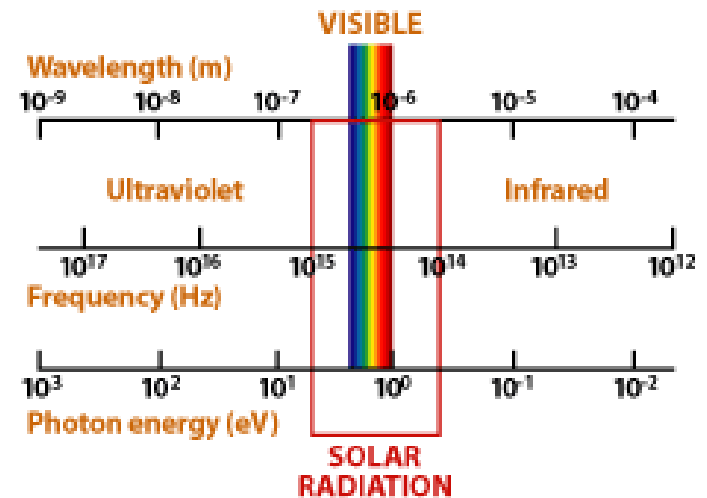
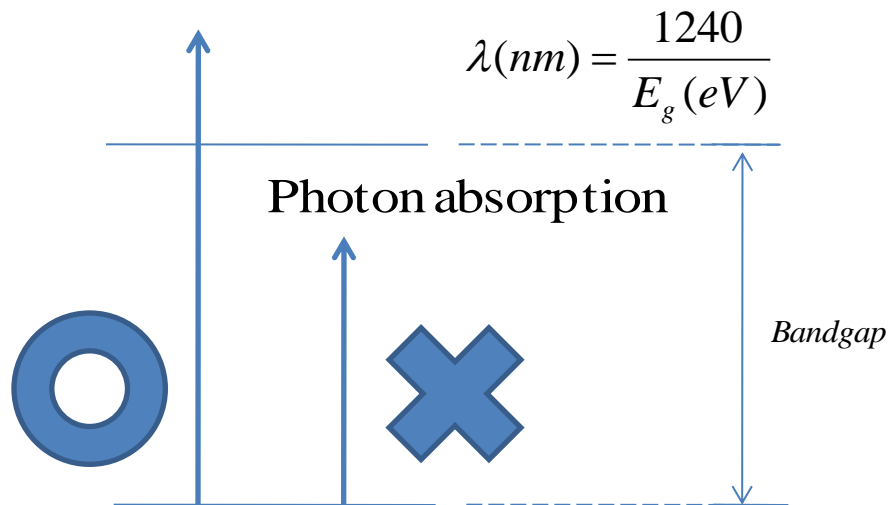
Schematic of Semiconductor Band Diagram



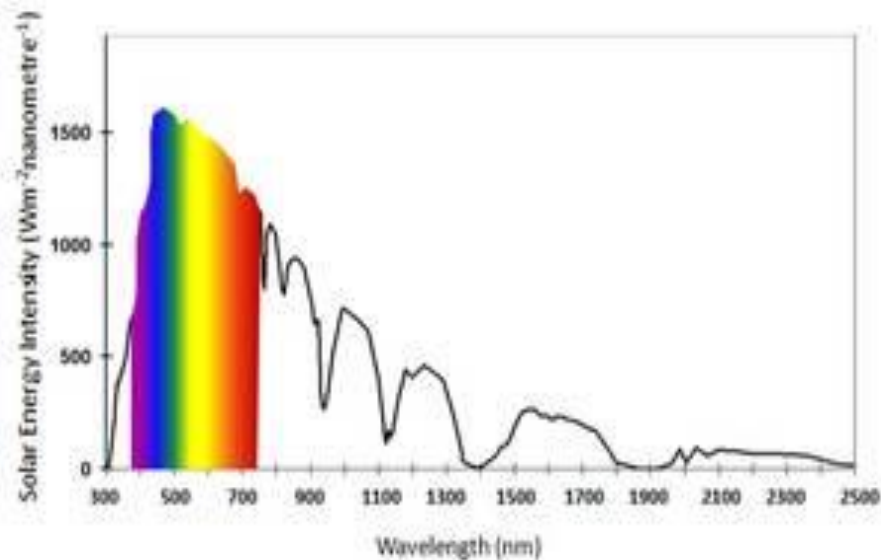
Bandgap and Light Absorption



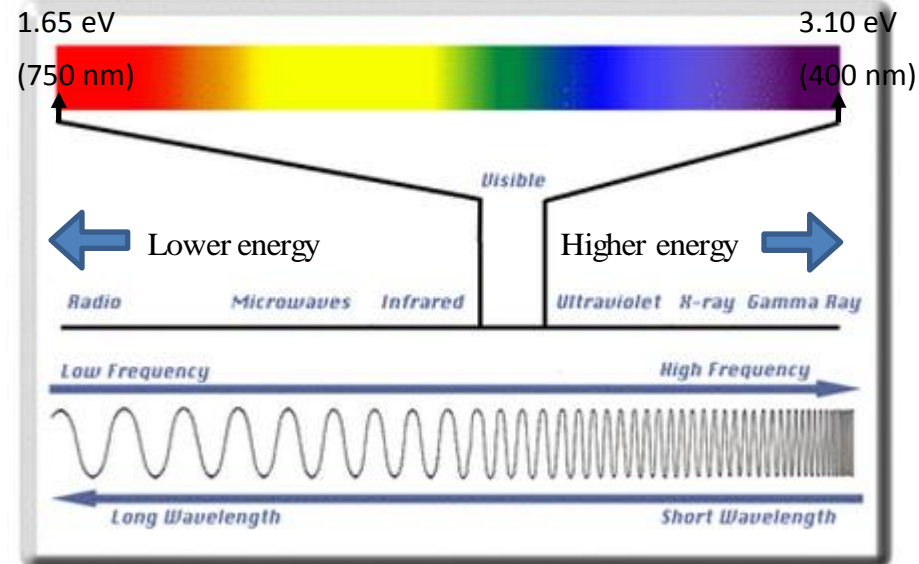
Band gap (E_g)



<http://www.greenenergybuild.com/pv%20basics%20a.htm>

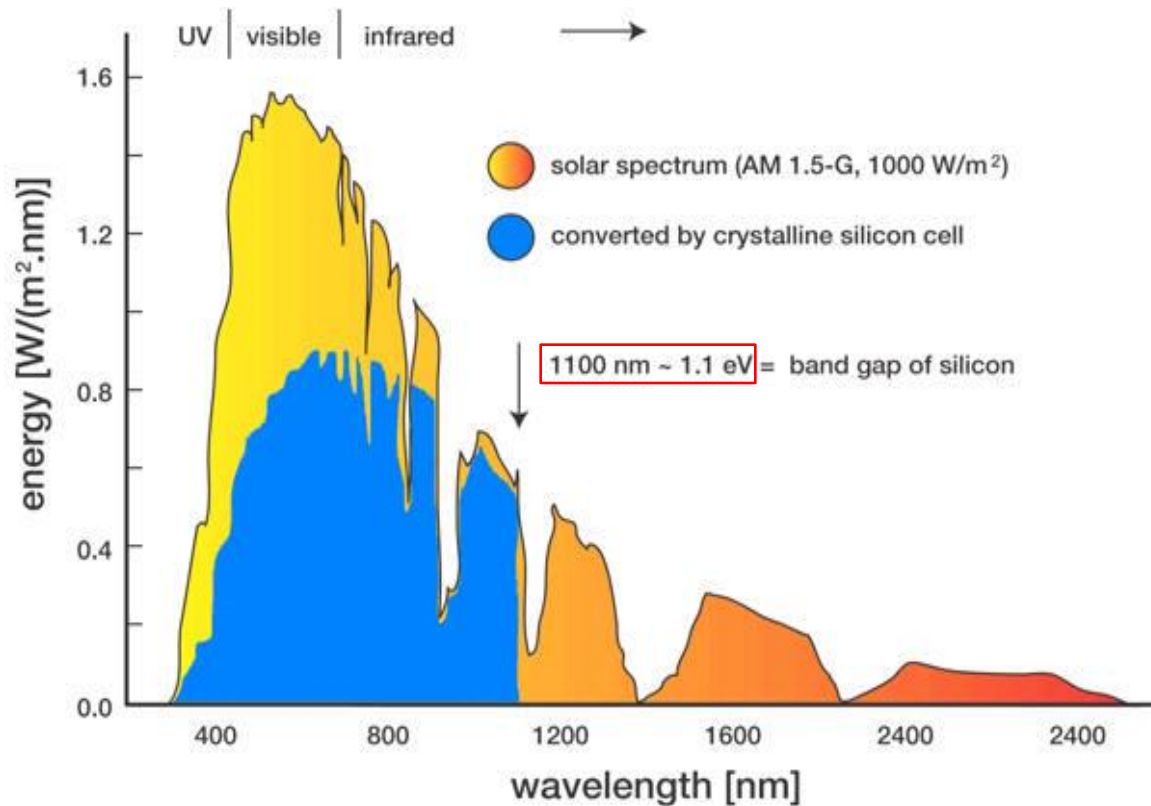


<http://www.thenakedscientists.com/HTML/articles/article/catching-energy-from-the-sun/>



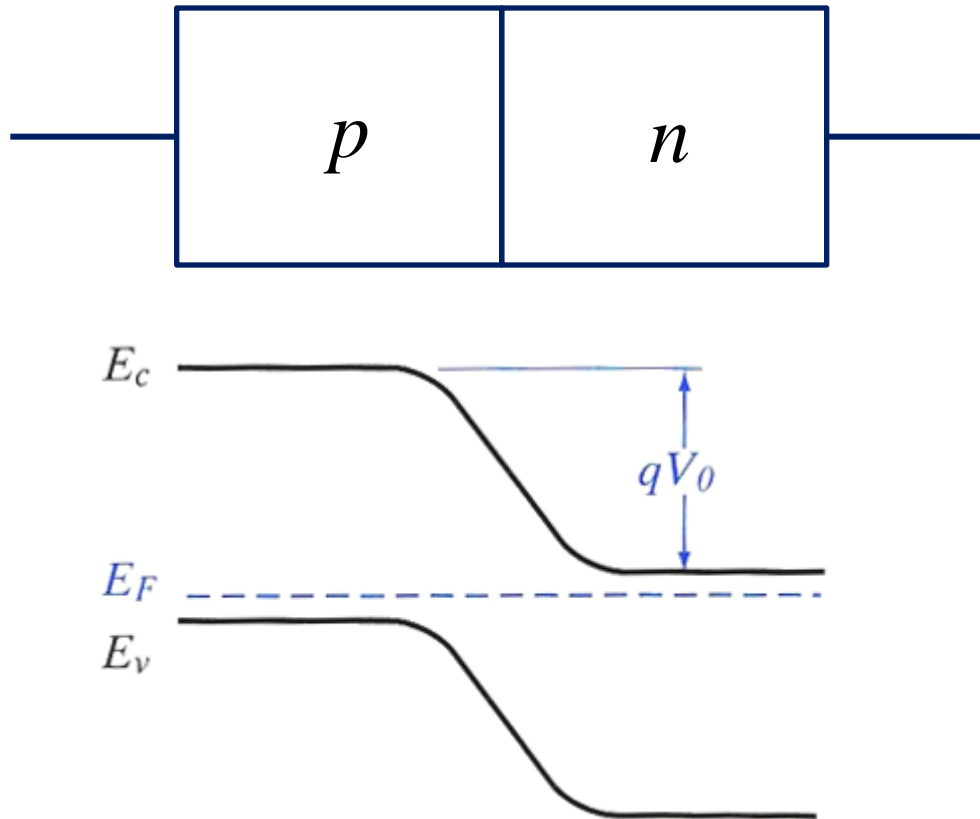
<http://solar1.org/2008/09/>

Photon Absorption by Silicon Bandgap



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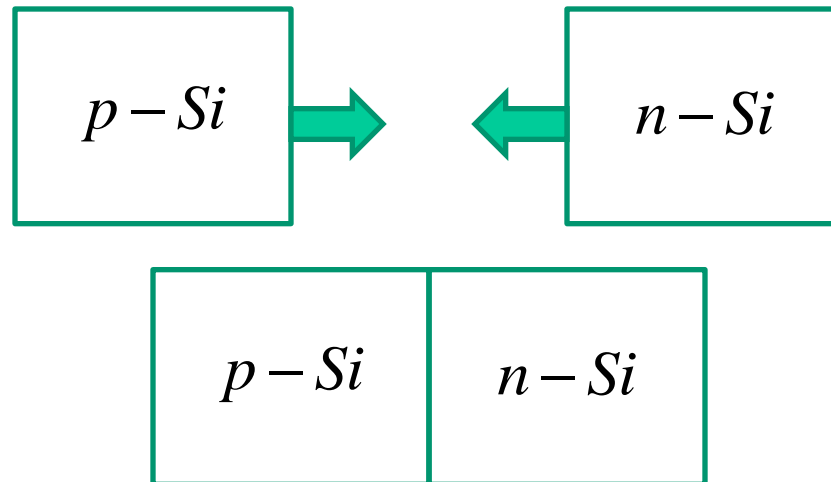
p-n Junction



The band diagram bands at the p-n junction. *Why and how?*

Place in Contact of the p-n Junction

Equilibrium will be reached shortly after when the p and n semiconductors are made in contact with each other.



Q & A

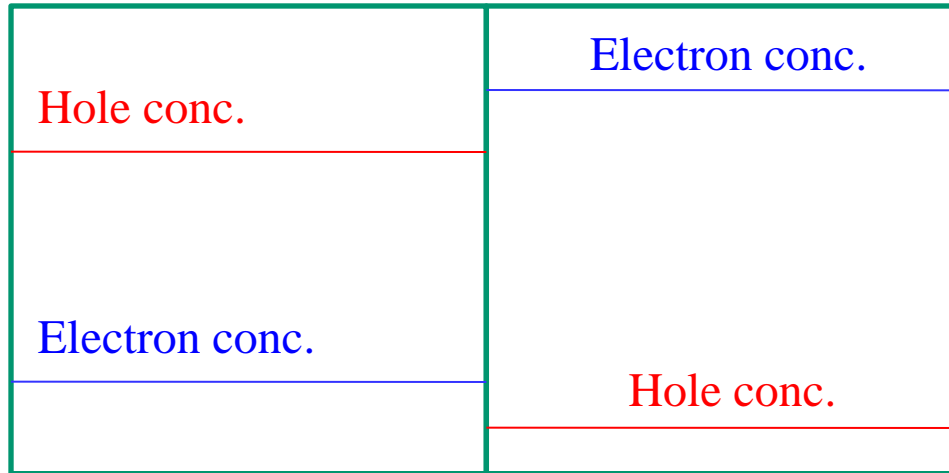
1. What is the difference between n-type semiconductor and p-type semiconductor? (Answer: carrier type)
2. What do you expect to happen when the two are placed in contact? (Answer: diffusion of carriers between two blocks)
3. Will this transient event proceed forever?
4. What may terminate the transient event? (What may terminate the net diffusion?)

Equilibrium of the p-n Junction

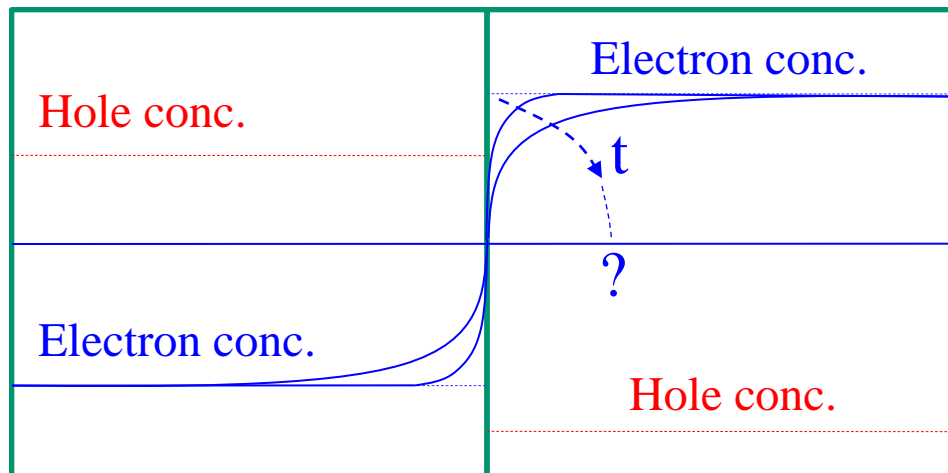
During the diffusion, the electric field also builds up as the result of carrier diffusion.

p – type

n – type



Immediately
after in contact

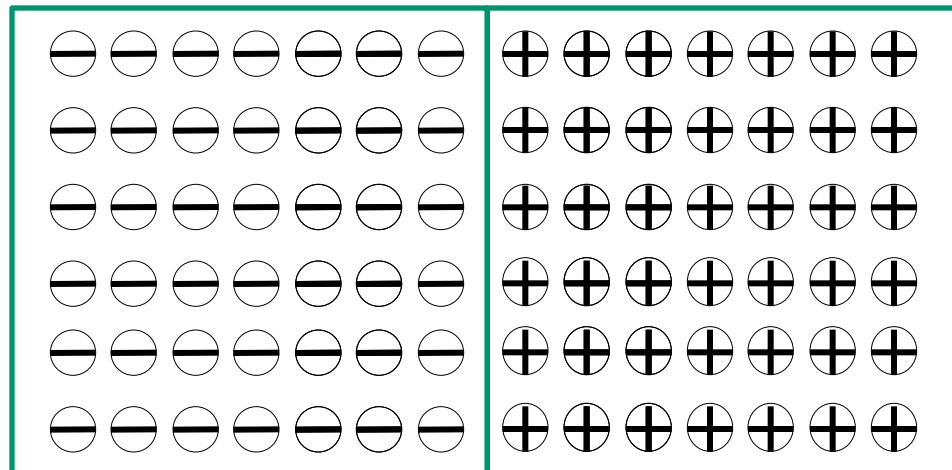
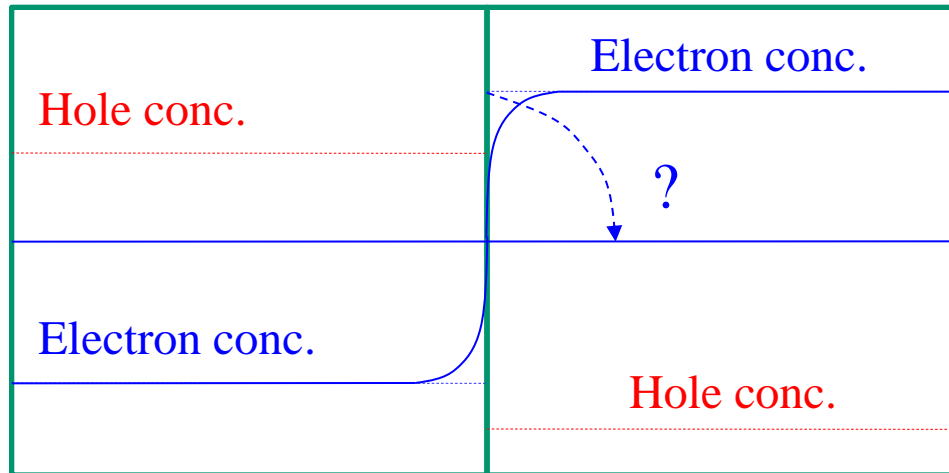


Shortly after in
contact

Diffusion of Electrical Carriers

p - type

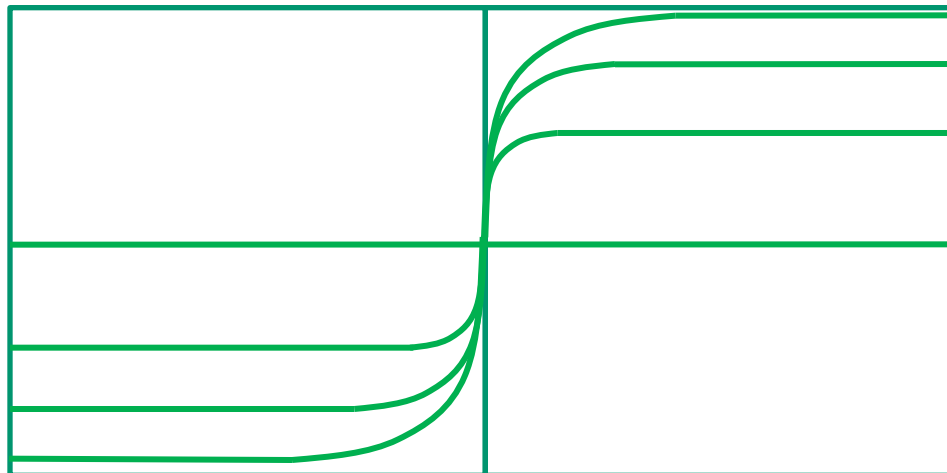
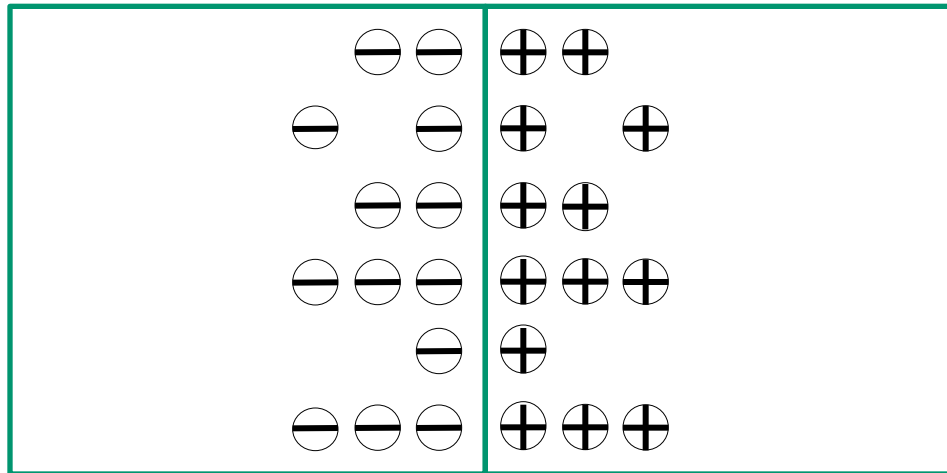
n - type



Development of Electric Potential Difference

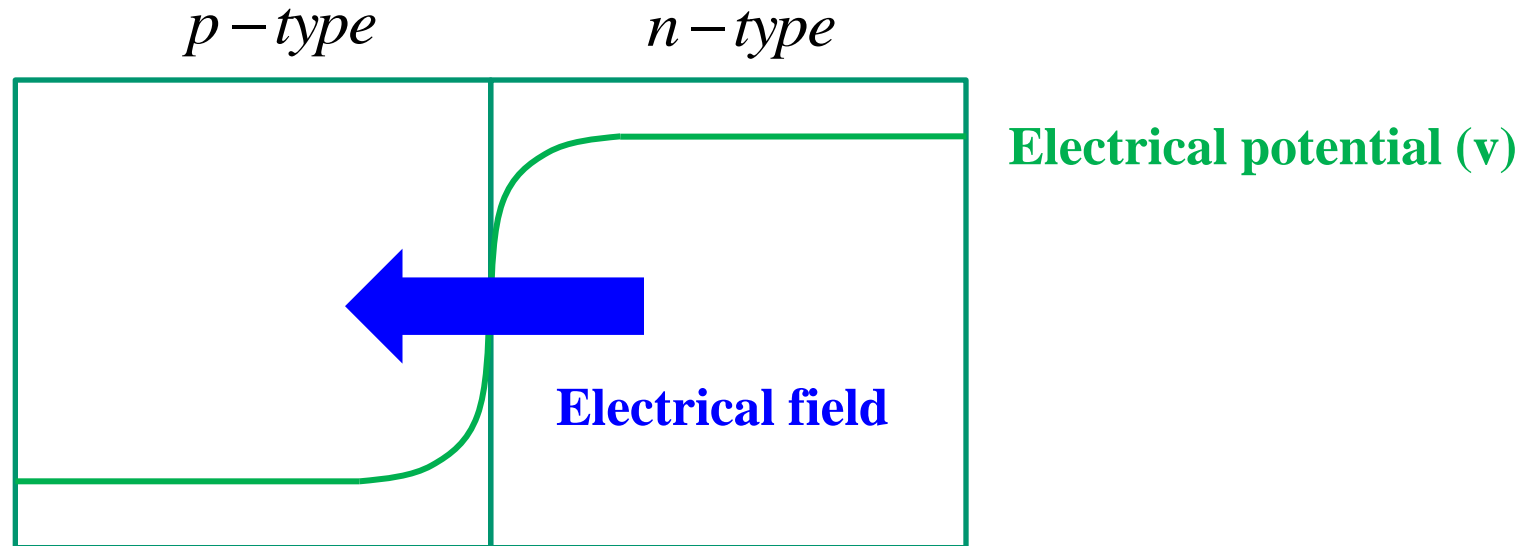
p - type

n - type



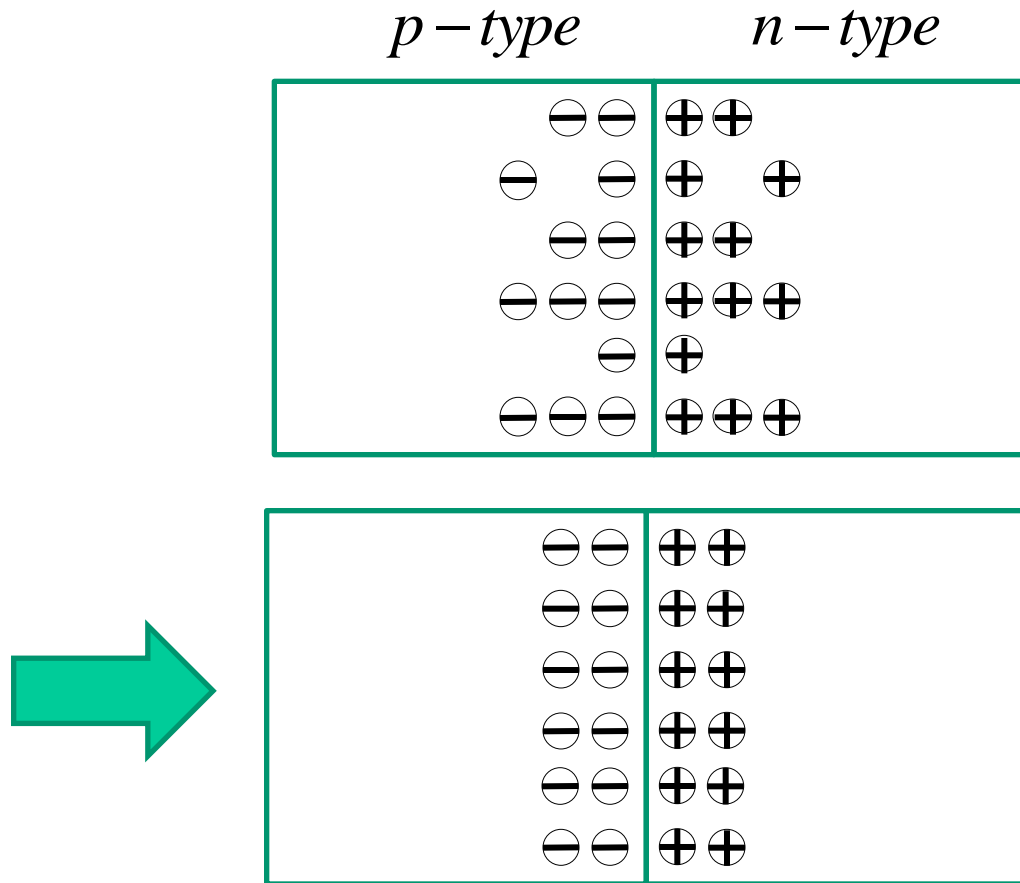
Electrical potential

Electric Field Build-up



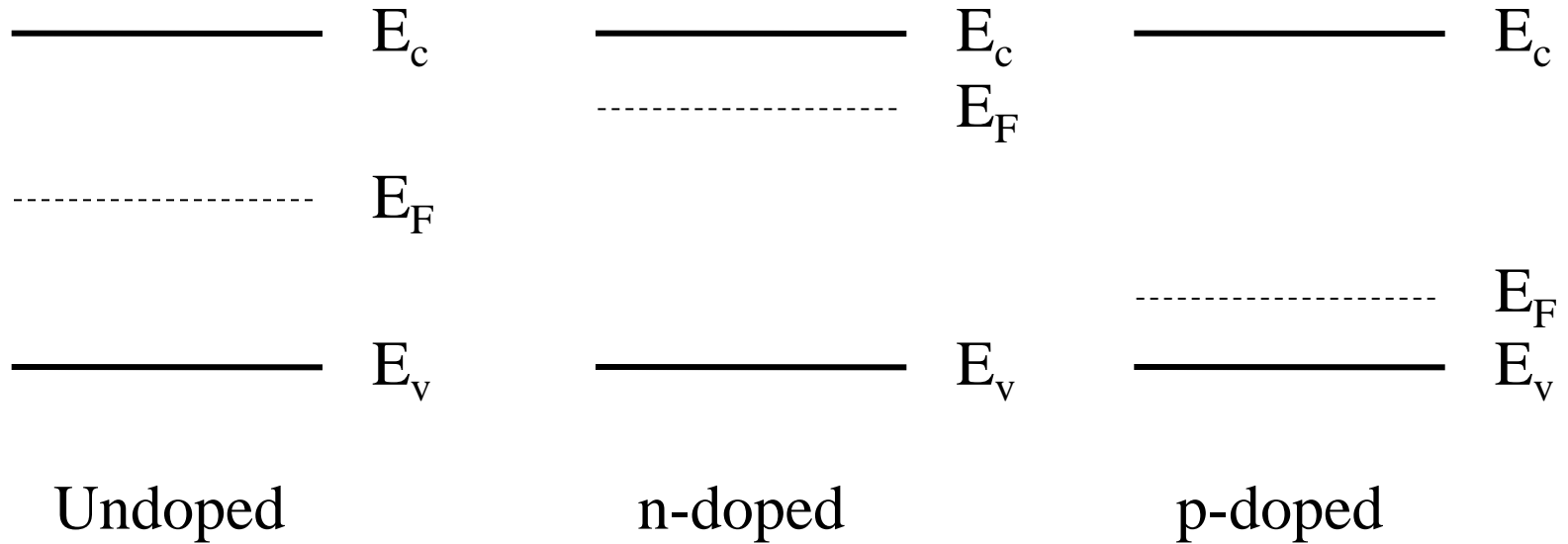
- Direction of Electrical field: Direction of force exerted on a positive unit charge.
- The built-up electrical field will exert a force that is against the movement of carriers that was driven by diffusion.
 - The electrical field exerts a force to move a hole from n to p.
 - The electrical field exerts a force to move an electron from p to n.
- The electrical field increases as the charge build-up proceeds.
- Eventually, the field will increase to a point that no more net charge build-up will occur, i.e., equilibrium condition is reached.

Depletion model of p-n Junction



- In equilibrium, the driving force of diffusion is balanced by that of electrical field, so the diffusion is no longer dominant.
- Since positive charge attracts negative charge, the charges of different sign tend to move close to each other. Thus charges will distribute as close to the interface.

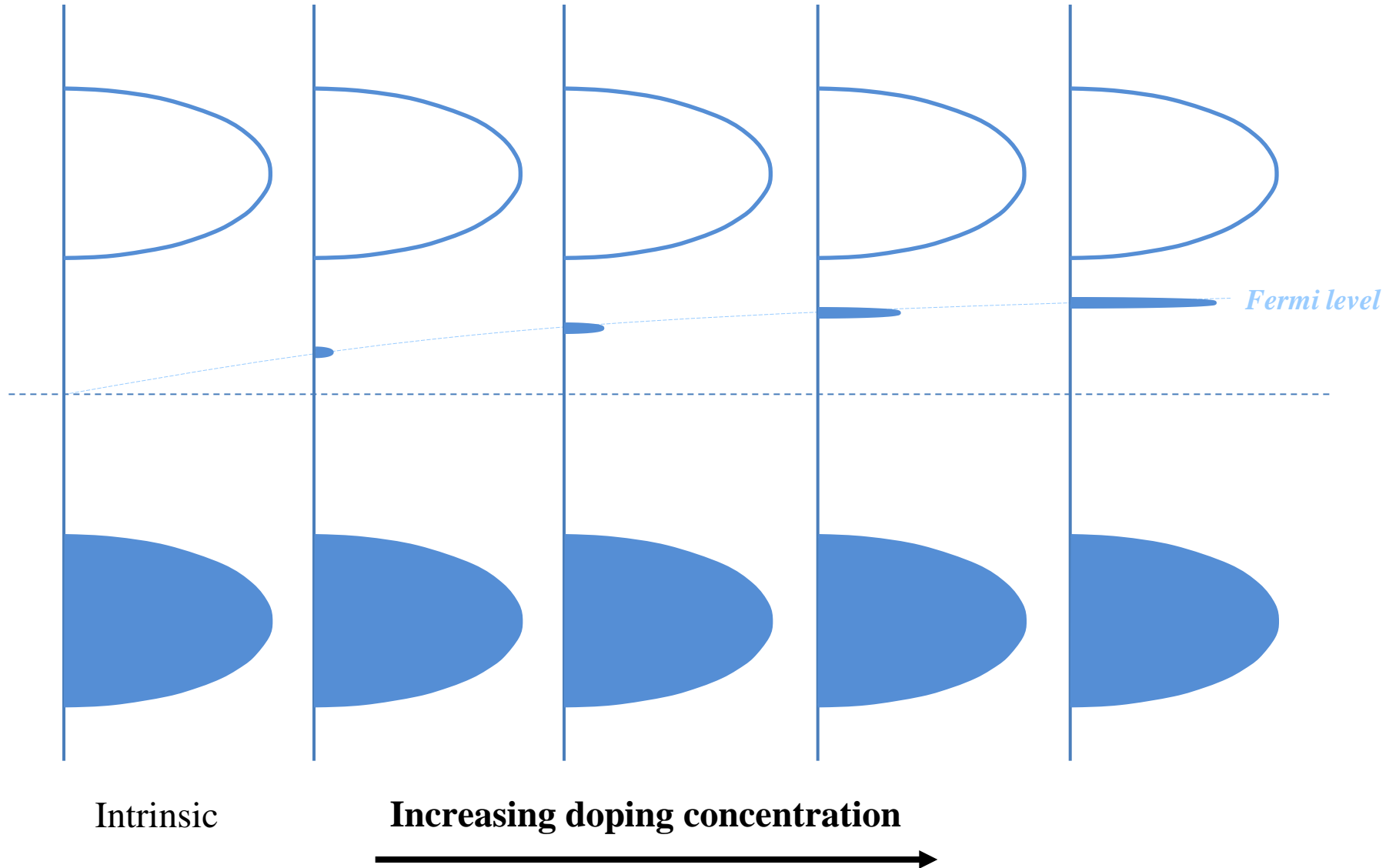
Doping of a Semiconductor



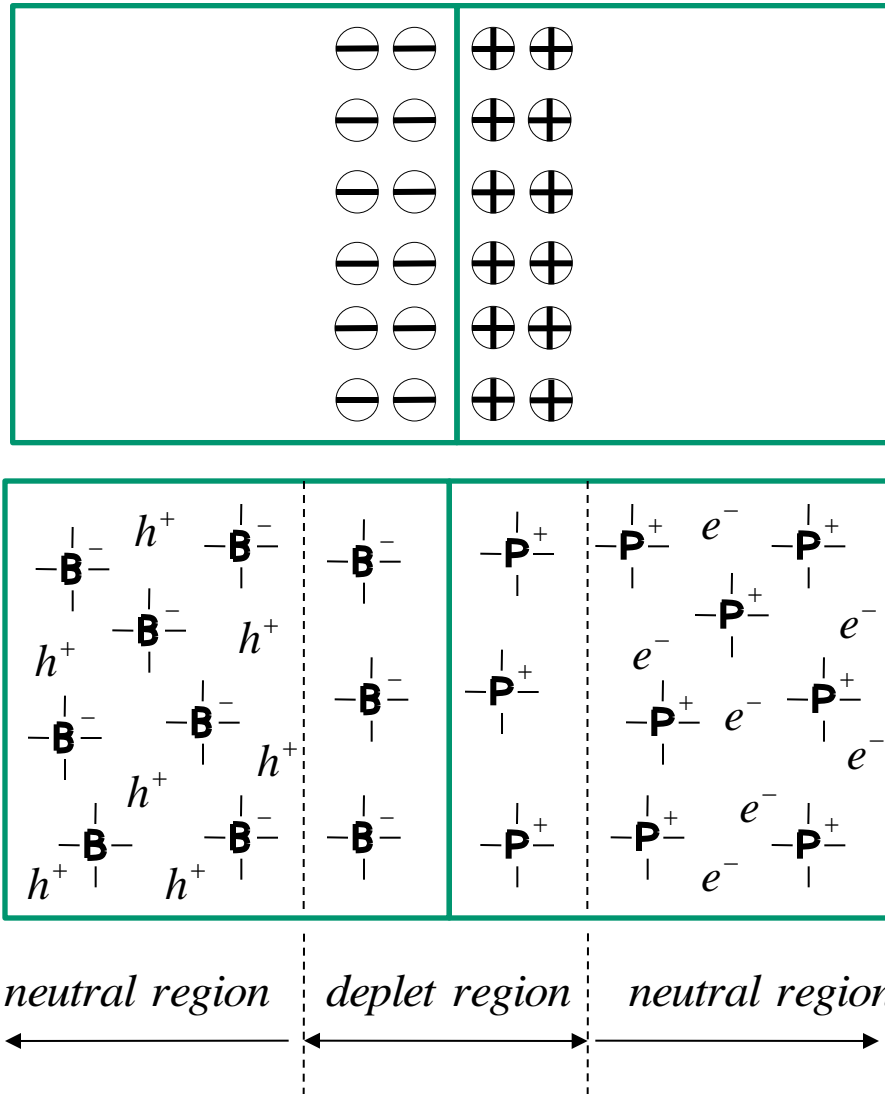
E_F : Fermi level (where electron occupation probability is 50%)

The location of Fermi level changes with doping. *Why?*

Fermi Level Change with Doping Concentration



Depletion model of p-n Junction



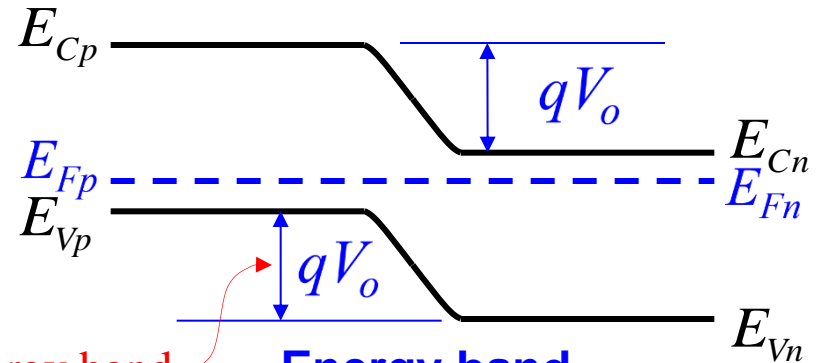
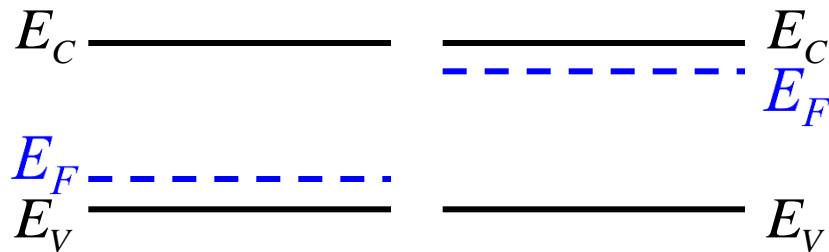
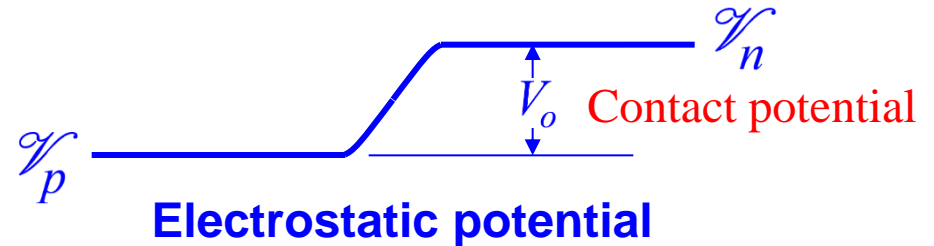
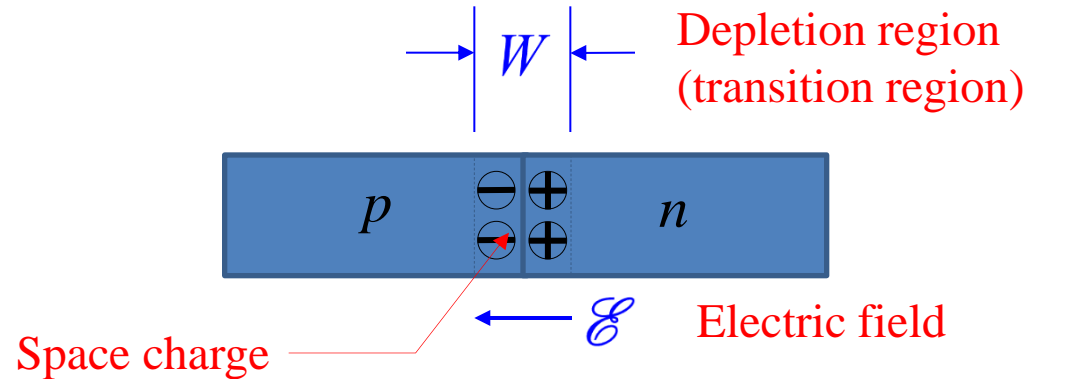
No free charges in depletion region, only immobile ions remain.

Equilibrium in p-n Junction

Isolated neutral regions of p and n



Junction formation of p and n



Separation of energy band

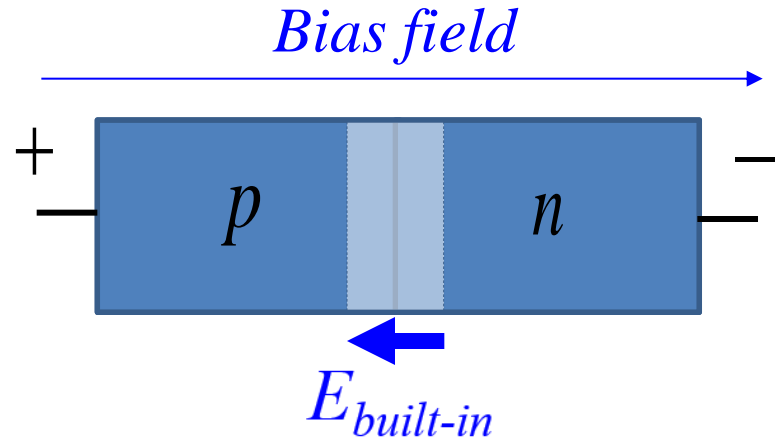
Energy band

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4. 聚光型太陽能電池

Forward- and Reverse-biased Junction

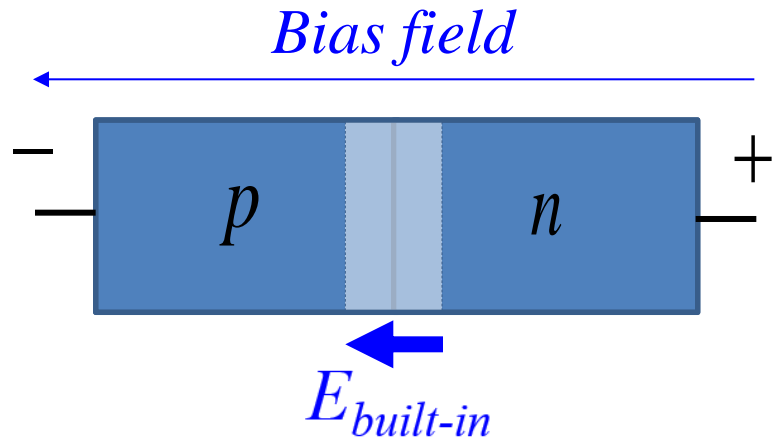
Forward bias:

The applied electric field is in the opposite direction of the built-in electric field



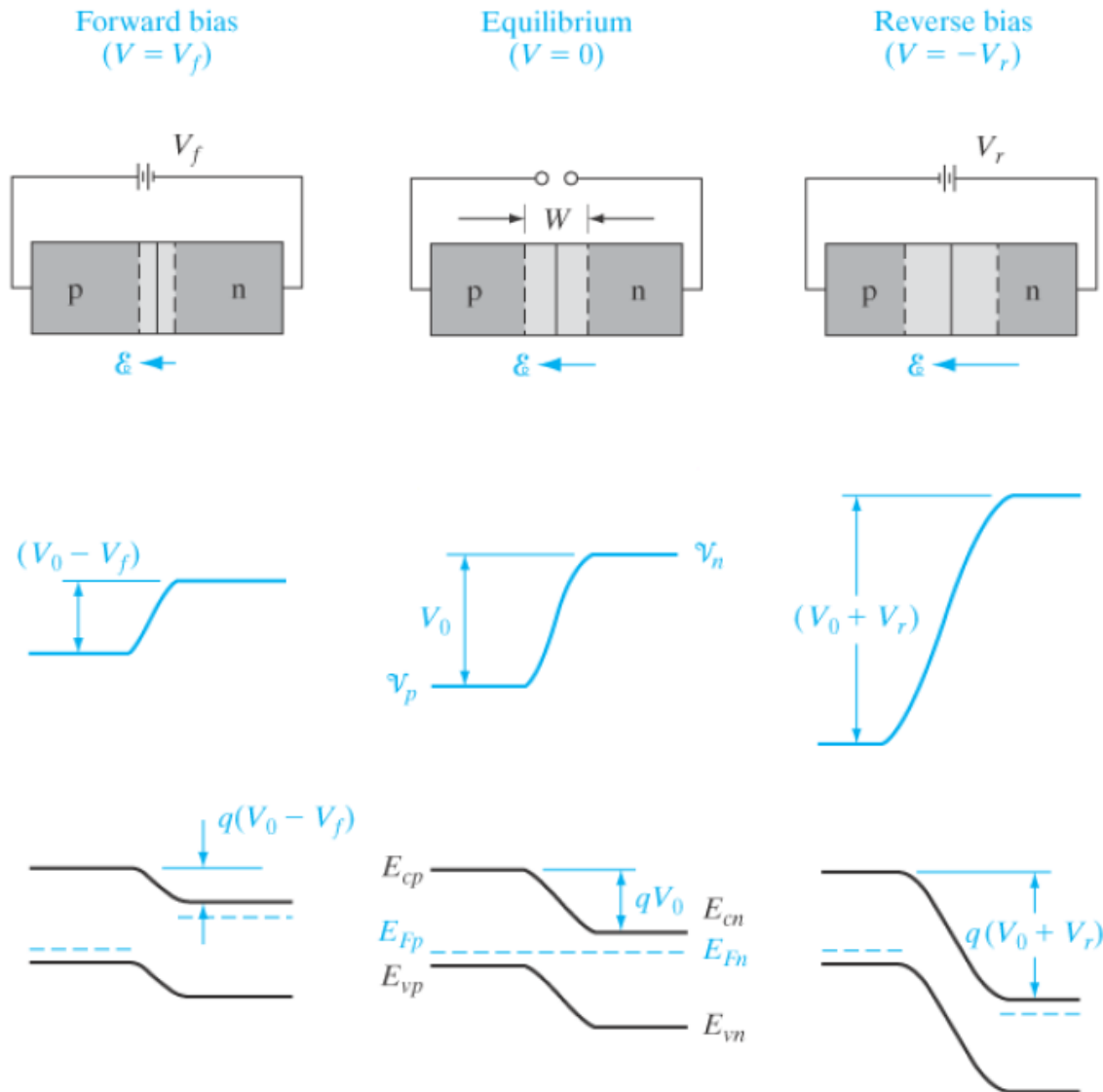
Reverse bias:

The applied electric field is in the same direction of the built-in electric field



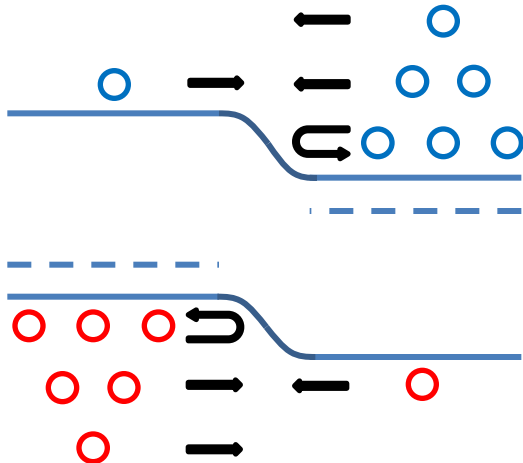
For almost all calculations it is valid to assume that an applied voltage appears entirely across the transition region and not in the neutral n and p regions.

Band Diagrams of Biased Junctions

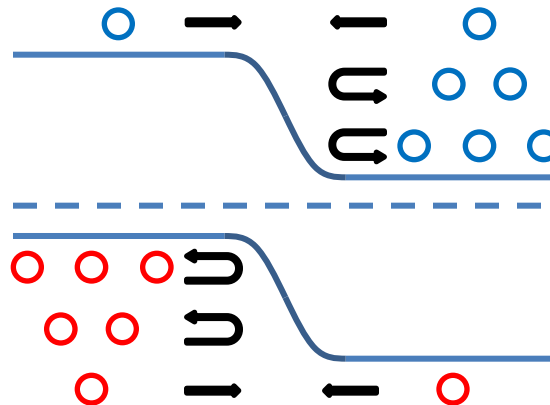


Particle Flow Schematics

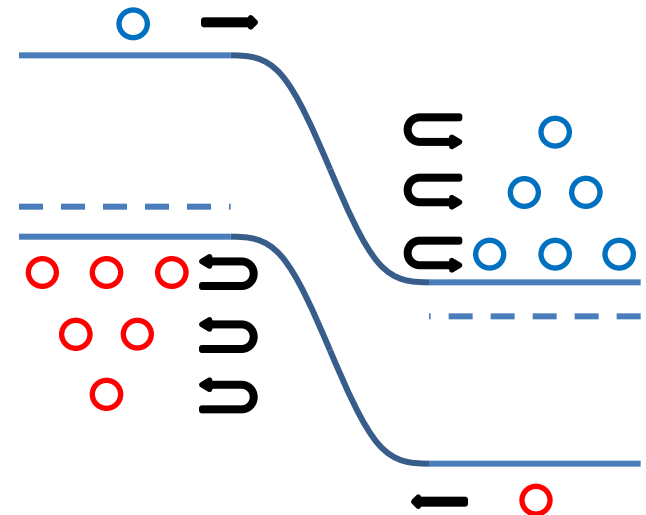
Forward bias ($V > 0$)

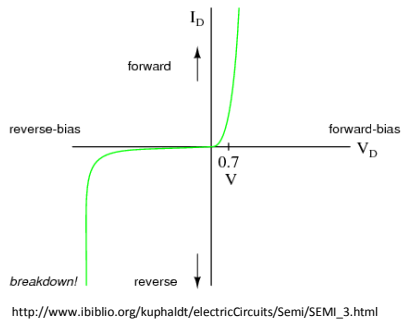


Equilibrium ($V = 0$)

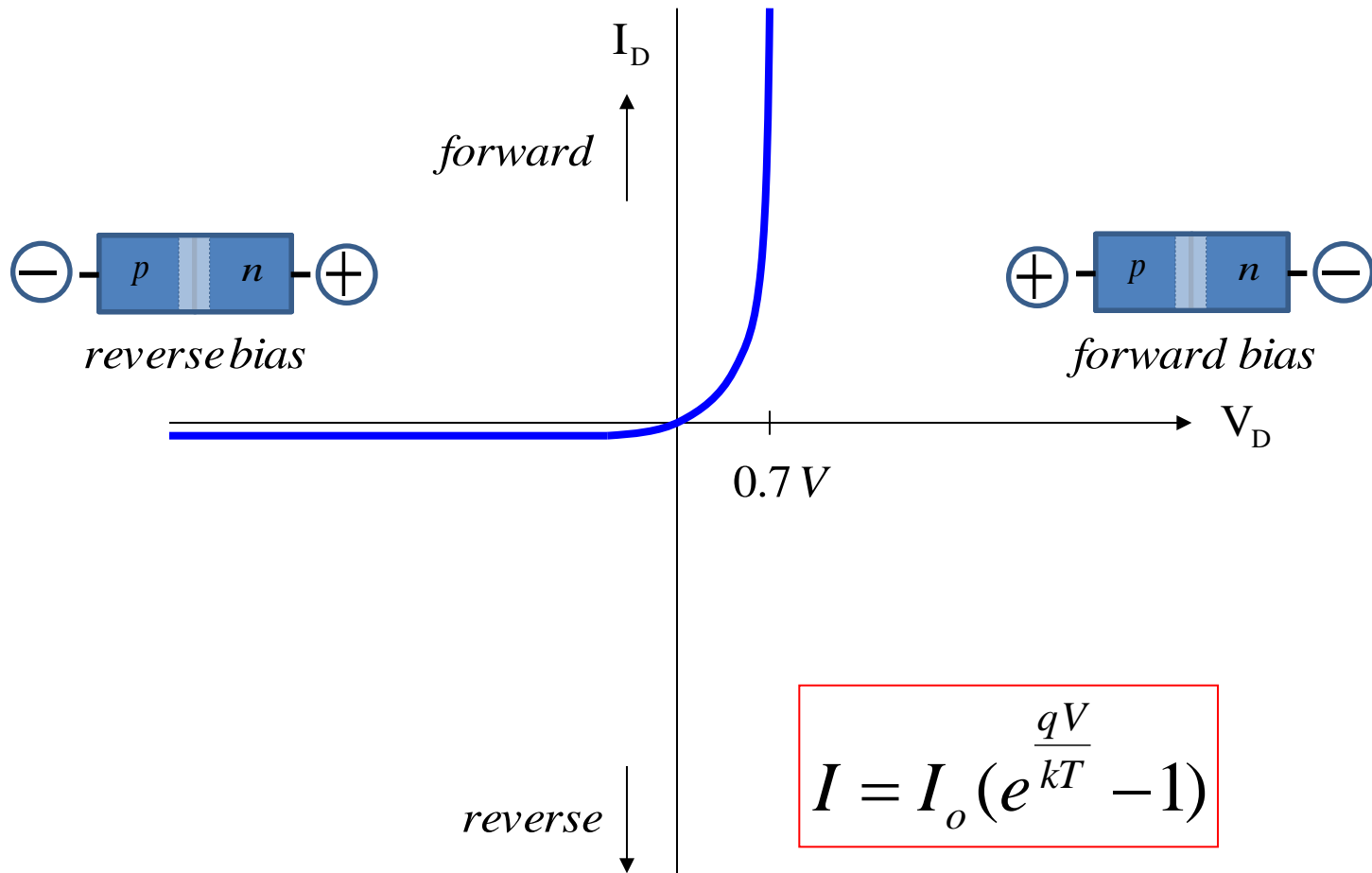


Reverse bias ($V < 0$)





Typical I-V curve of a Diode



$$I = I_o (e^{\frac{qV}{kT}} - 1)$$

Diode equation