유기소재물성실험

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수업계획

중간고사 40% + 보고서 40% + 출석 10% + 실험태도 10%

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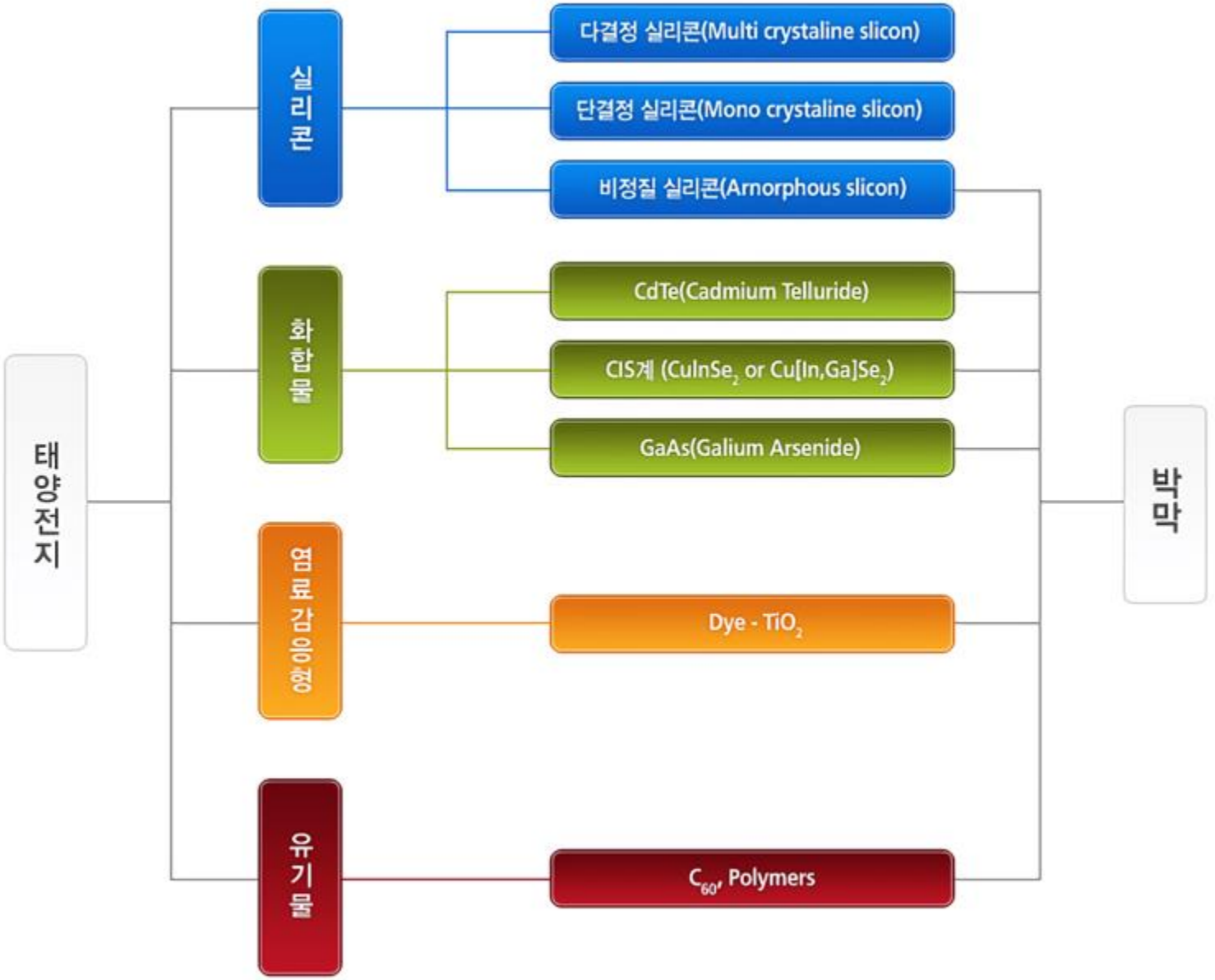
이성훈 010-4808-7805

T.A: 이성훈, 이아라, 홍승연, 이한빈

주별 강의계획		
주차	강의 및 실험 내용	과제 및 기타 참고사항
제1주 9/6	~~Introduction~~	
제2주 9/13	~~졸업여행 잘 갔다와요!~~	
제3주 9/20	이론 (Semiconductor)	
제4주 9/27	이론 (Device physics)	
제5주 10/4	이론 (OPV 개요 및 공정, measurement)	
제6주 10/11	이론 (Nano patterning)	
제7주 10/18	(휴강 or Q&A)	
제8주 10/25	중간고사 기간 -> 각 이론 파트에서 2~3문제	

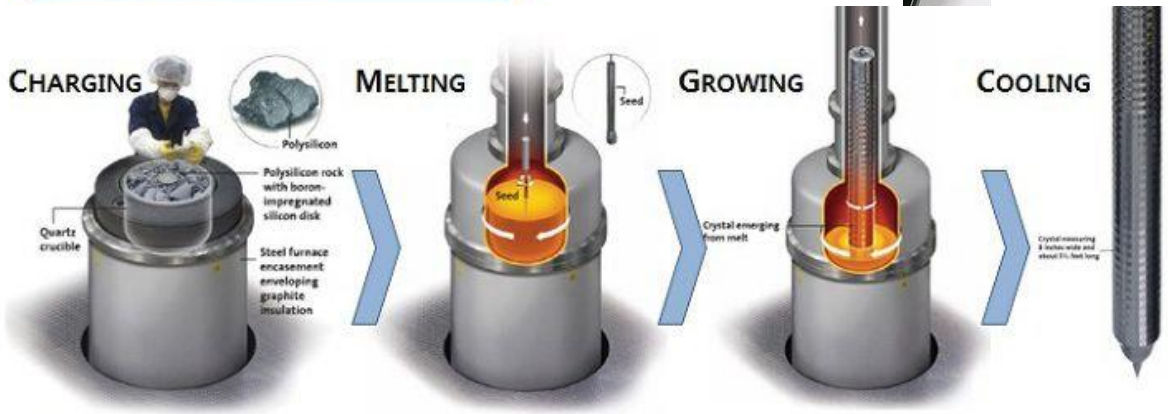
주별 강의계획		
주차	강의 및 실험 내용	과제 및 기타 참고사항
제9주 11/1	실험 Ⅰ	
제10주 11/8	실험 Ⅰ	
제11주 11/15	실험 Ⅰ	
제12주 11/22	실험 Ⅱ	
제13주 11/29	실험 Ⅱ	
제14주 12/6	실험 Ⅱ	
제15주 12/13	(휴강 or Q&A)	
제16주 12/20	기말고사 기간	최종 레포트

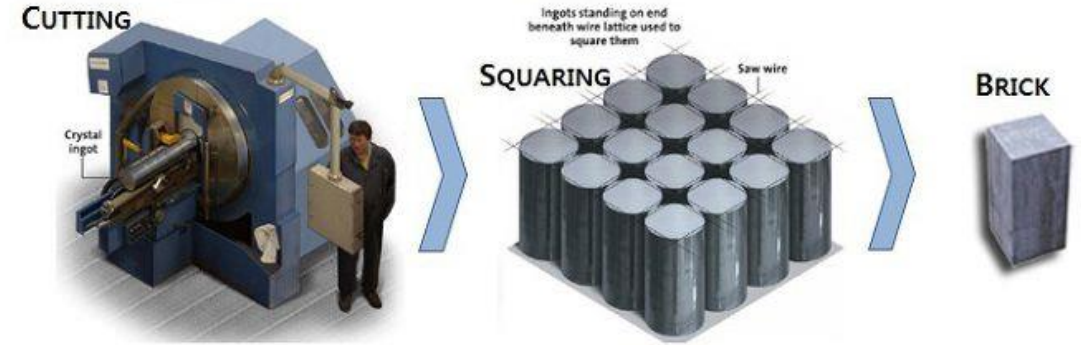
Solar cell

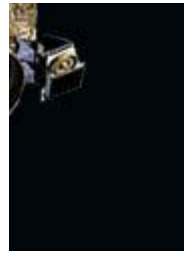

태양전지
실리콘
다결정 실리콘(Multi crystaline slicon)
단결정 실리콘(Mono crystaline slicon)
비정질 실리콘(Arnorphous slicon)
화합물
CdTe(Cadmium Telluride)
CIS계 (CuInSe2 or Cu[In,Ga]Se2)
GaAs(Galium Arsenide)
염료감응형
Dye - TiO2
유기물
C60, Polymers
박막

태양전지

- 실리콘
  - 다결정 실리콘(Multi crystaline slicon)
  - 단결정 실리콘(Mono crystaline slicon)
- 화합물
- 염료감응형
- 유기물
  - C_{60}, Polymers

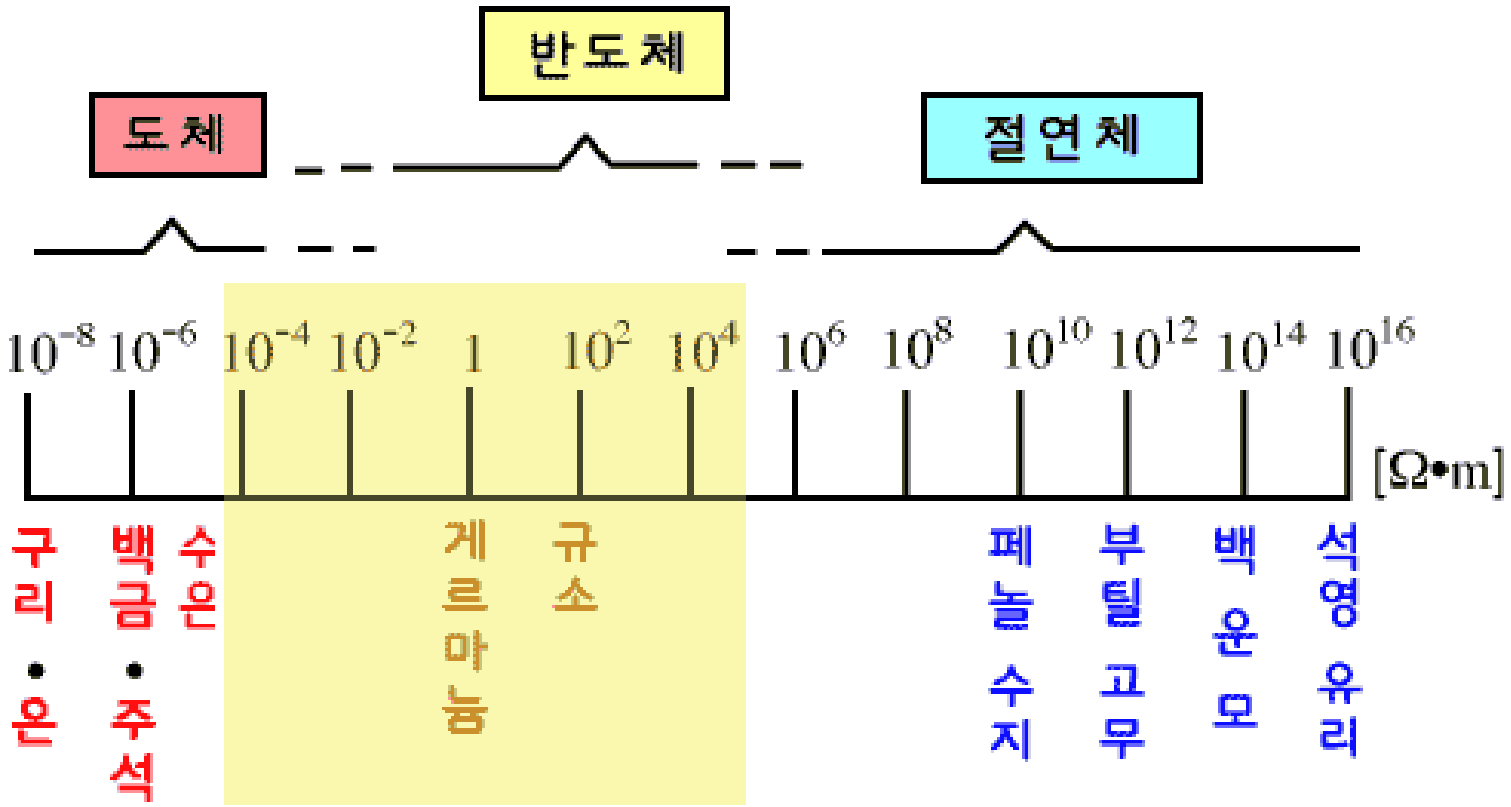


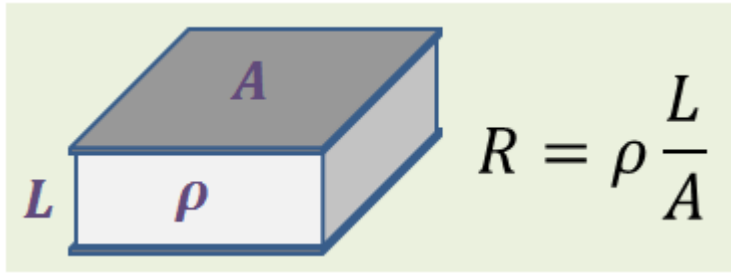




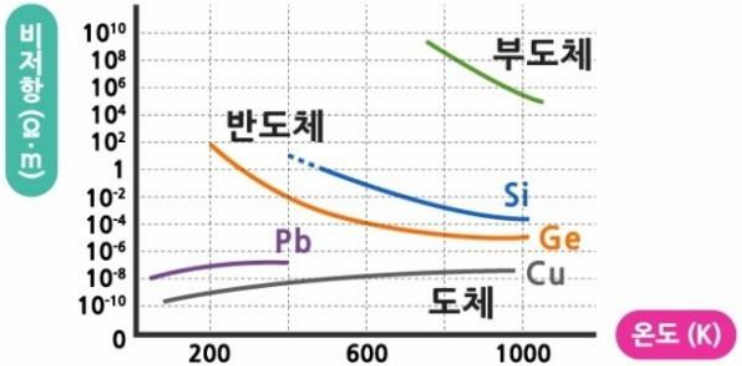
- Solar cell & Semiconductor
- Band gap(quantum mechanics)
- Carrier(Absorption & Recombination)
- Lifetime & Diffusion Length
- Doping(Fermi level)
- PN junction

Semiconductor

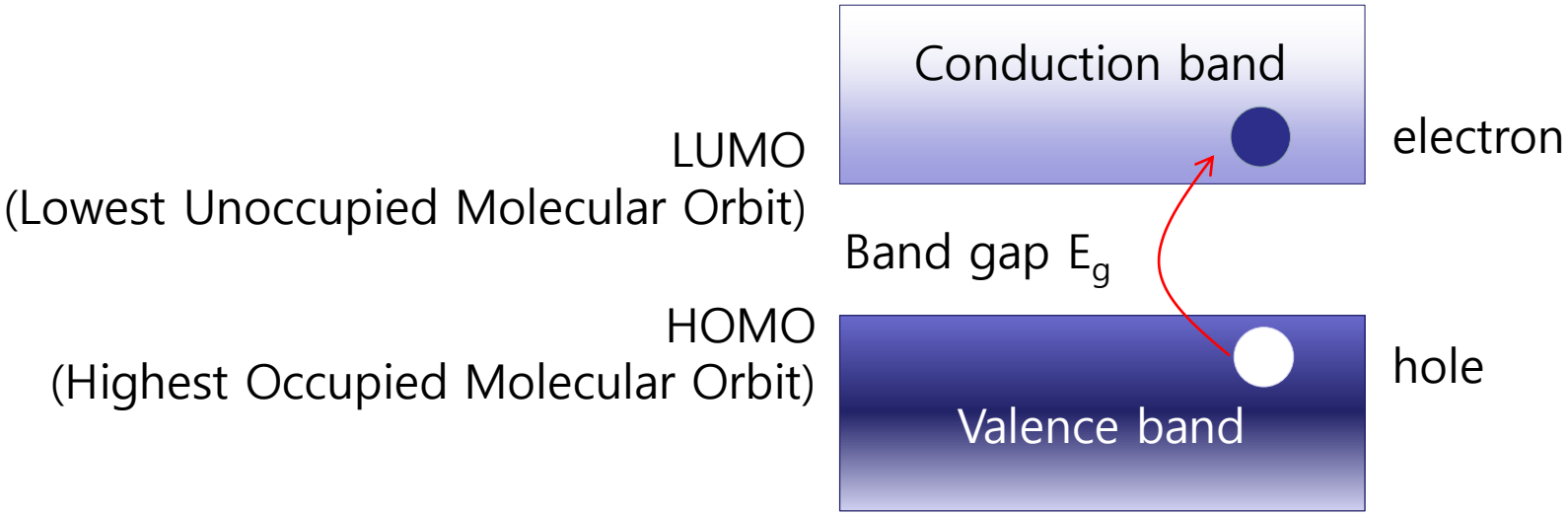




$$R[\Omega] = \rho \frac{L[m]}{A[m^2]}$$



Semiconductor - Band gap

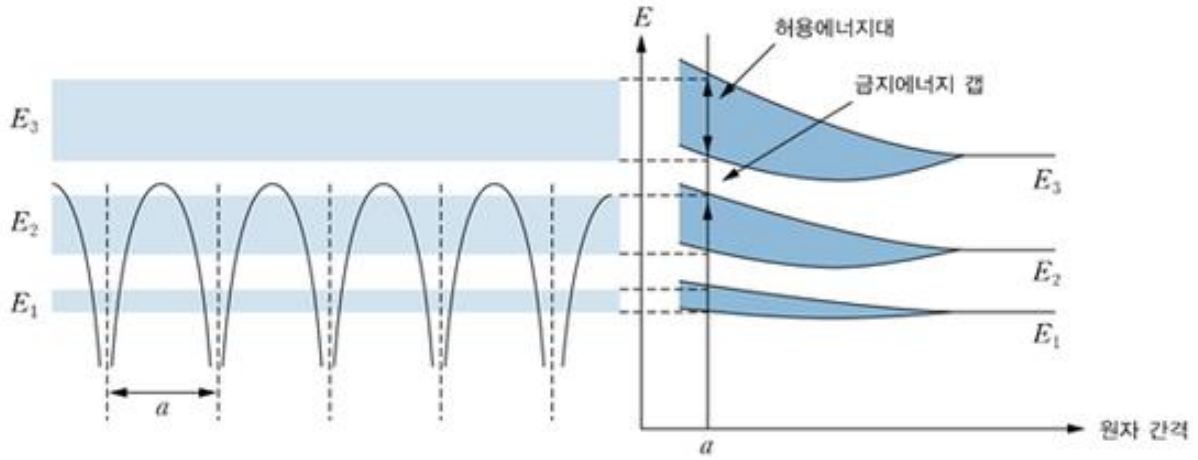


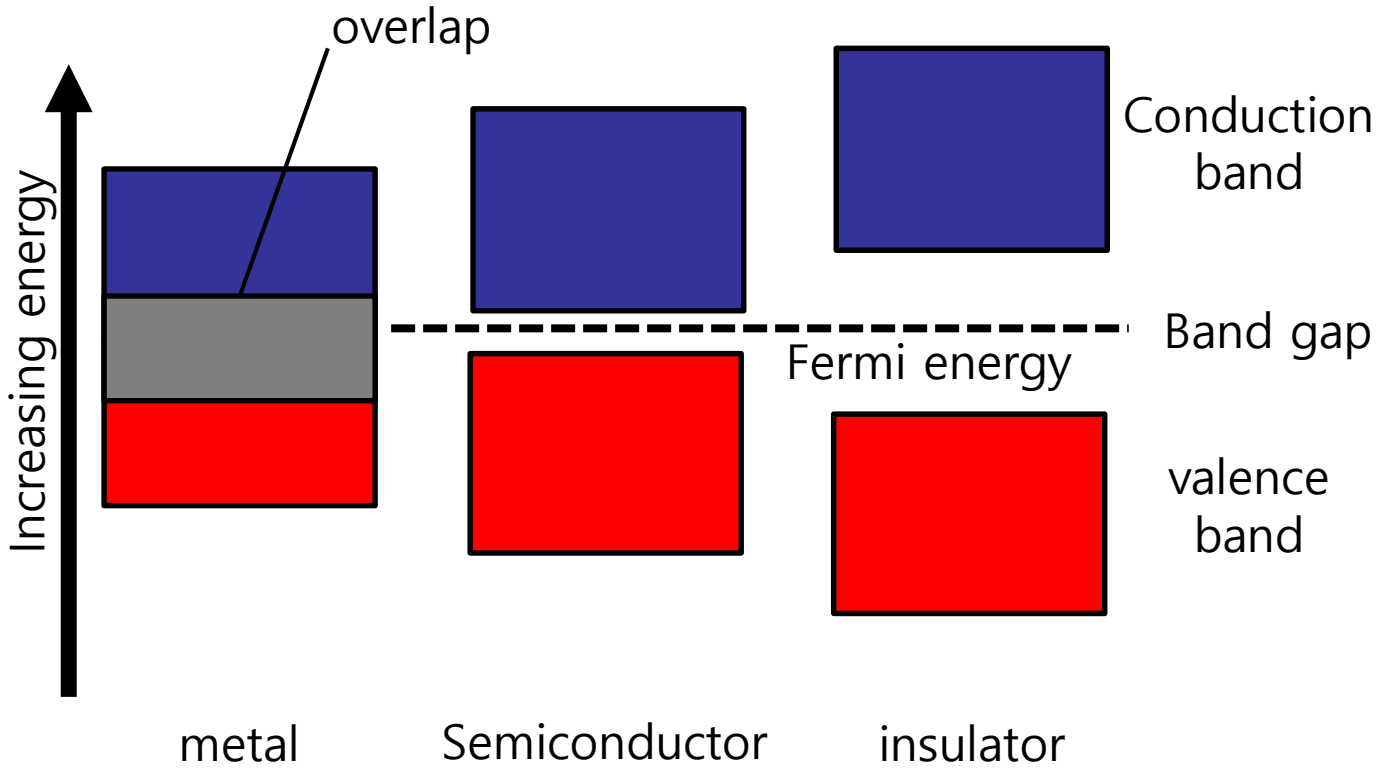
Inorganic semiconductors: 1 ~ 2 eV

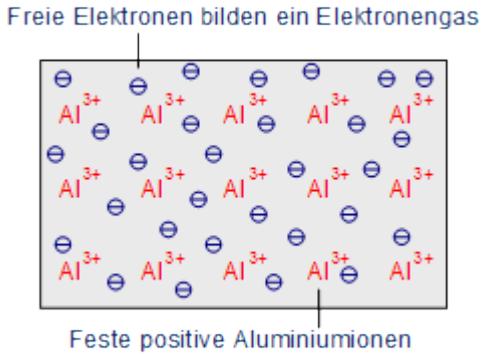
Organic semiconductors: 1.7 ~ 3eV

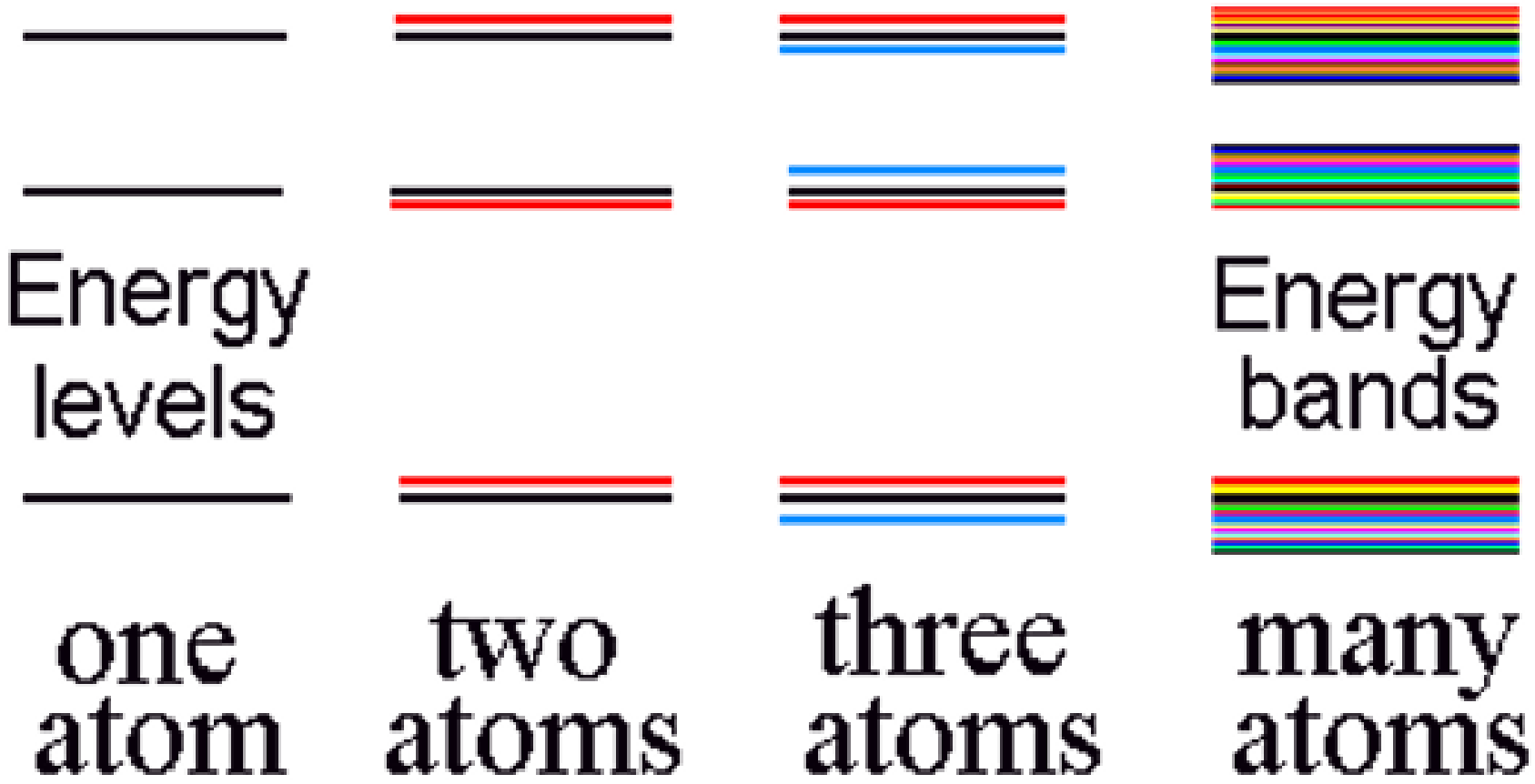
Si: 1.17 @ 0K, 1.11 eV @ 300K

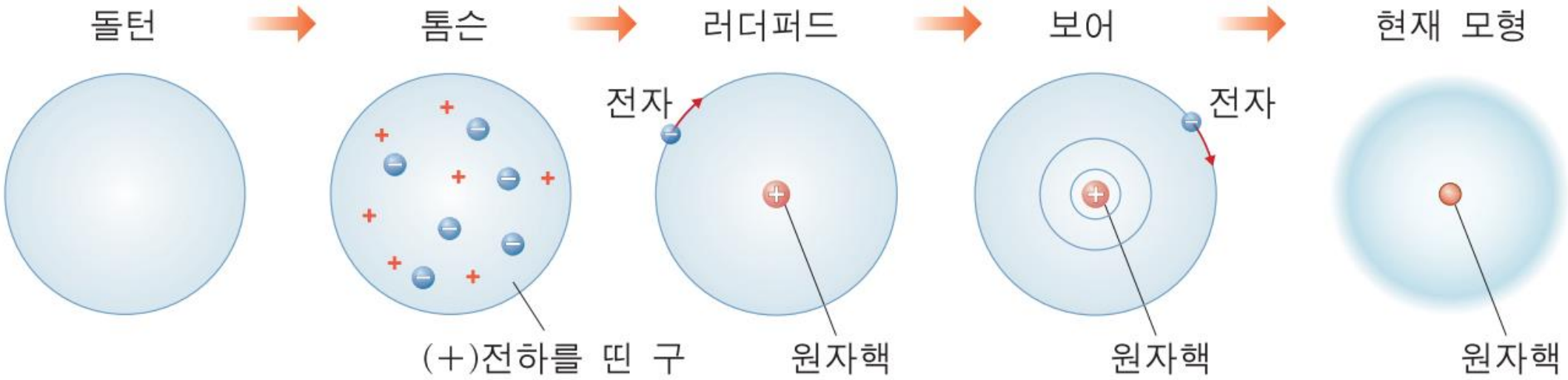
Ge: 0.774 @ 0K, 0.66 eV @ 300K

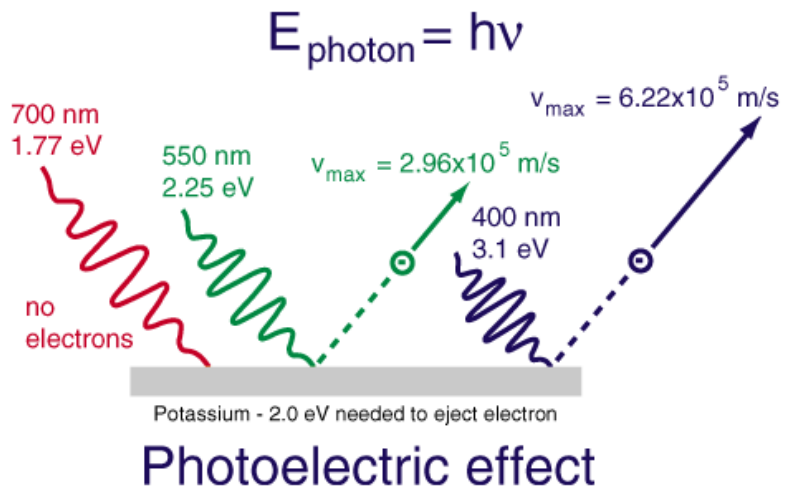



overlap
Increasing energy
Conduction band
Band gap
Fermi energy
valence band
metal
Semiconductor
insulator


Freie Elektronen bilden ein Elektronengas
Feste positive Aluminiumionen

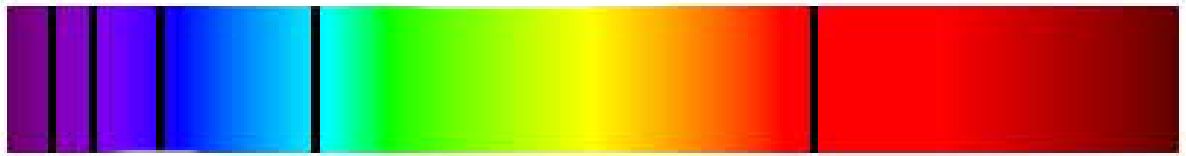

Energy levels
Energy bands
one atom
two atoms
three atoms
many atoms



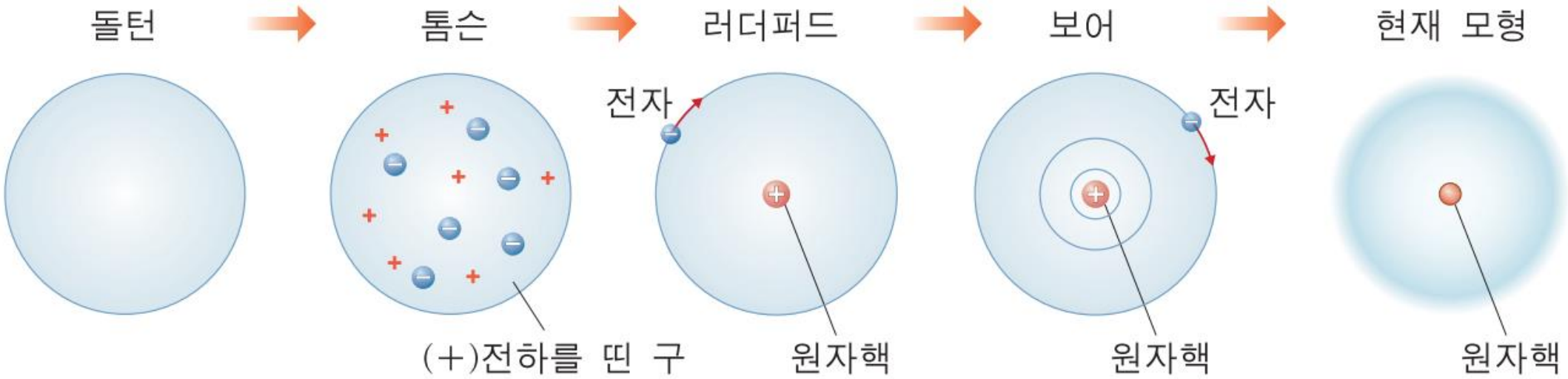


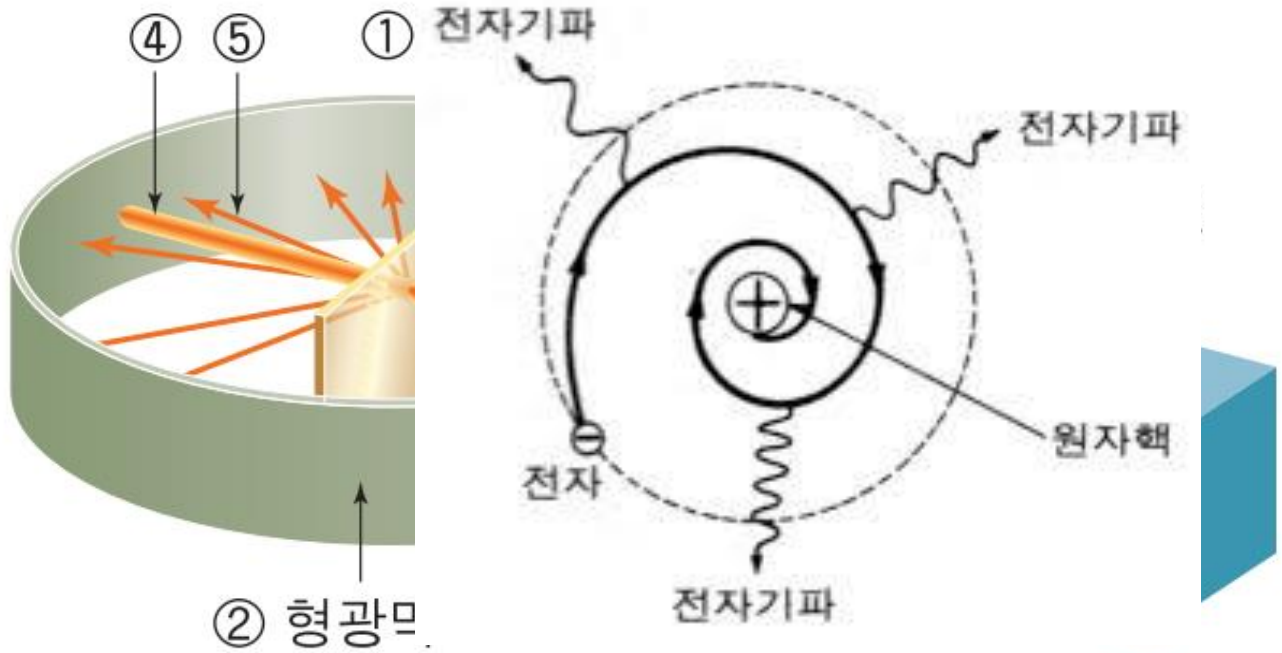
Photoelectric effect

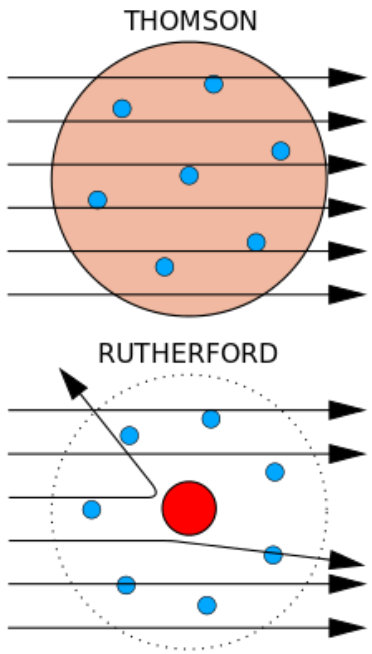
hydrogen absorption spectrum



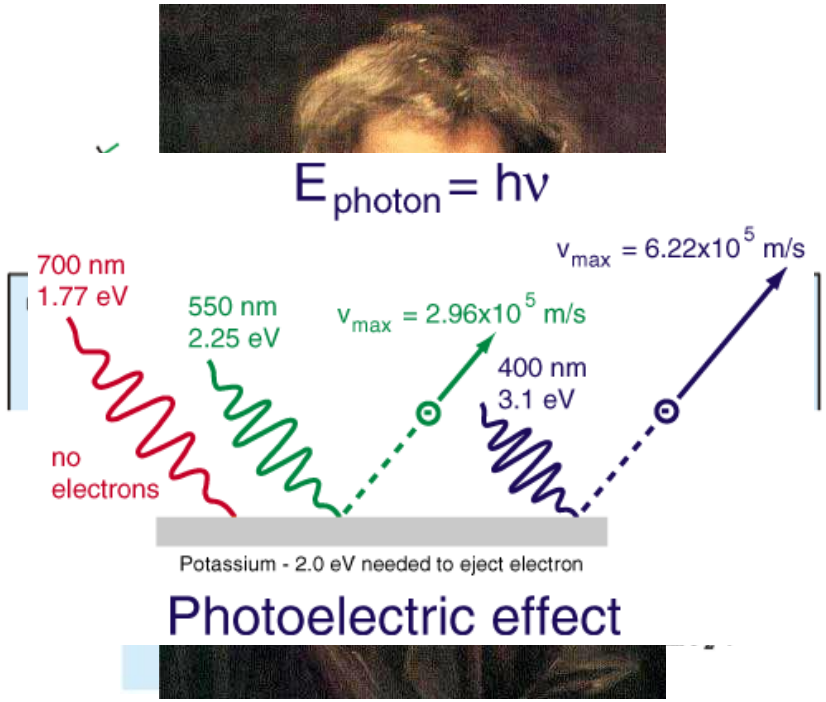
hydrogen emission spectrum

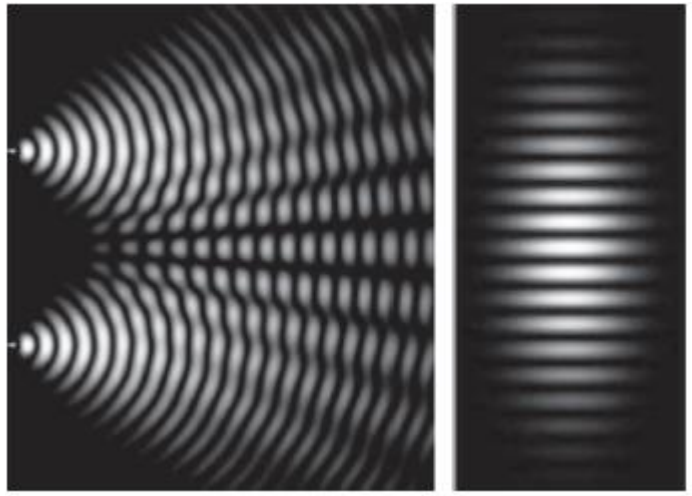

돌턴
톰슨
러더퍼드
보어
현재 모형
전자
전자
(+)전하를 띤 구
원자핵
원자핵
원자핵

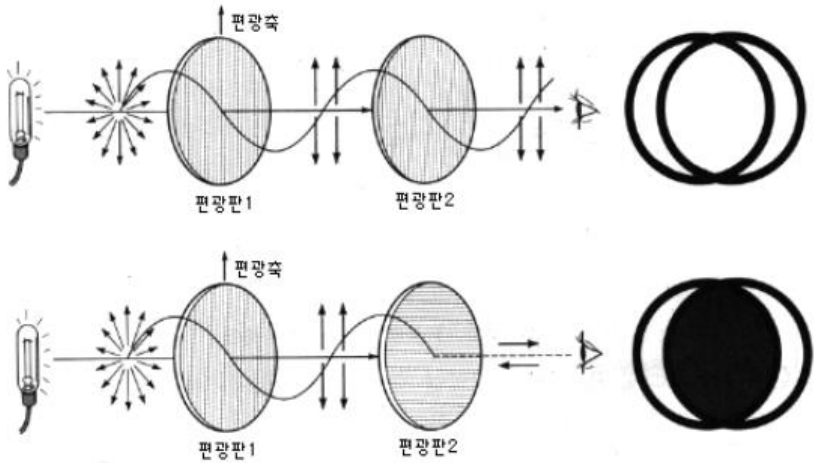

④
⑤
①
전자기파
전자기파
원자핵
전자
전자기파
② 형광물

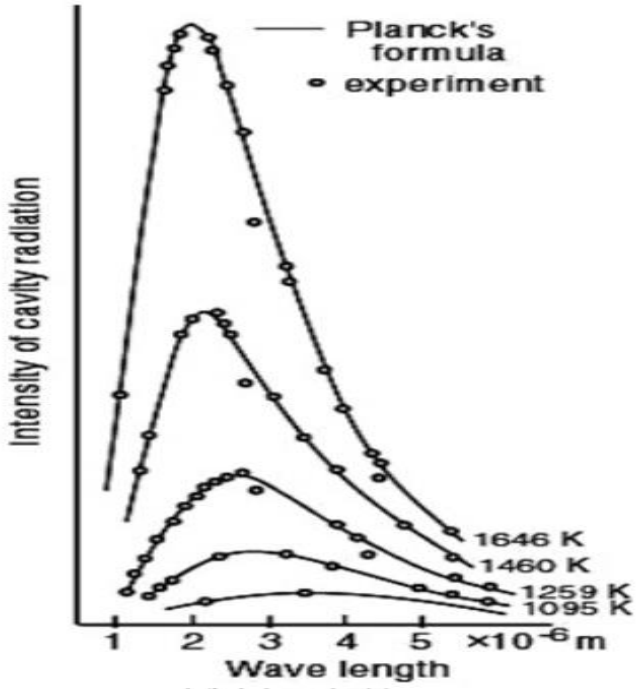

THOMSON
RUTHERFORD

빛은 무엇인가?


$E_{photon} = h\nu$
700 nm
1.77 eV
550 nm
2.25 eV
$v_{max} = 2.96 \times 10^5$ m/s
$v_{max} = 6.22 \times 10^5$ m/s
400 nm
3.1 eV
no
electrons
Potassium - 2.0 eV needed to eject electron
Photoelectric effect



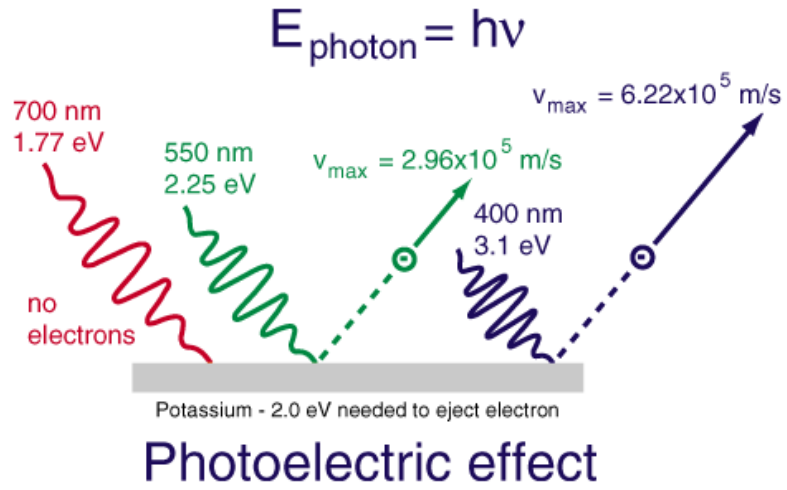

편광축
편광판1
편광판2
편광축
편광판1
편광판2



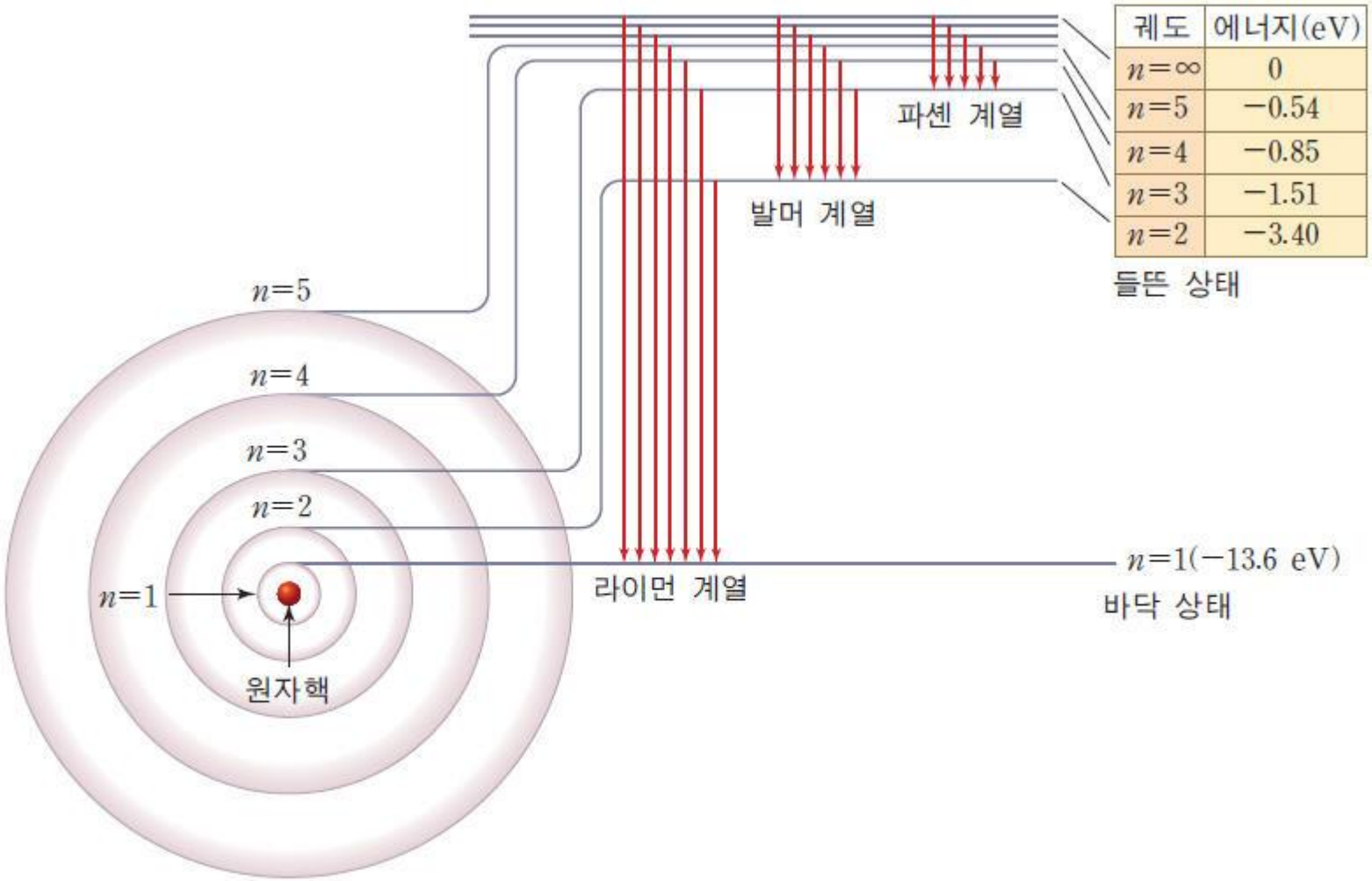
$$\langle E \rangle = \frac{k\beta\nu}{e^{\frac{\beta\nu}{T}}} \longrightarrow \langle E \rangle = \frac{k\beta\nu}{e^{\frac{\beta\nu}{T}} - 1}$$

$$U_\lambda = \frac{du}{d\lambda} = \left(\frac{8\pi}{\lambda^4}\right)\left(\frac{hc}{\lambda e^{\frac{hc}{\lambda kT}} - 1}\right) = \frac{8\pi hc}{\lambda^5}\frac{1}{e^{hc/\lambda kT} - 1}$$

$$U_\nu = \frac{du}{d\nu} = \left(\frac{8\pi\nu^2}{c^3}\right)\left(\frac{h\nu}{e^{\frac{h\nu}{kT}} - 1}\right) = \frac{8\pi h\nu^3}{c^3}\frac{1}{e^{h\nu/kT} - 1}$$

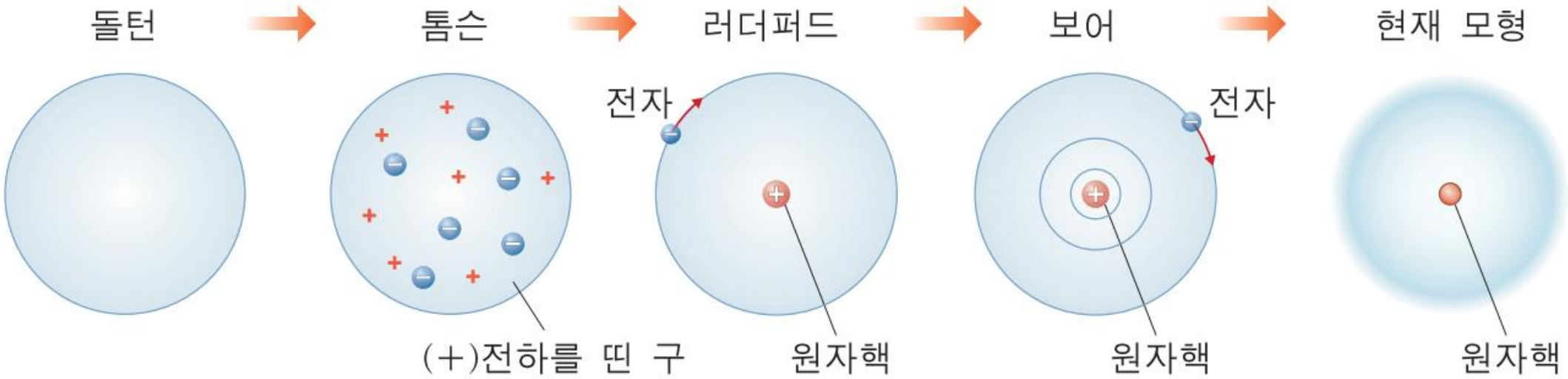


Photoelectric effect

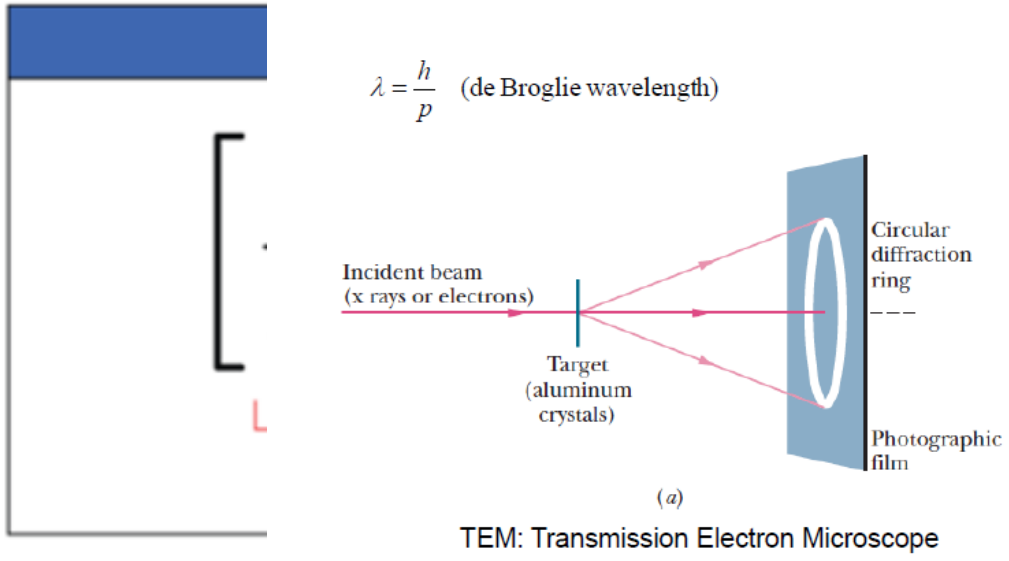


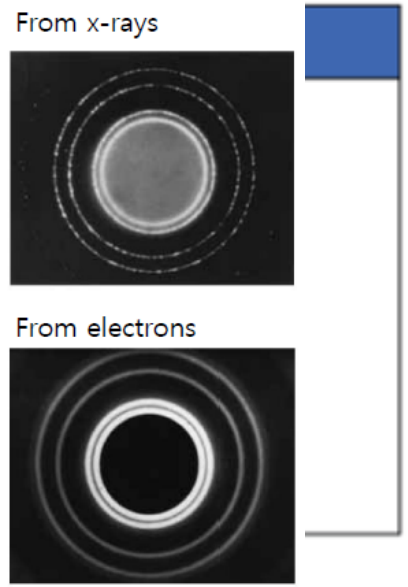
궤도	에너지(eV)
$n=\infty$	0
$n=5$	−0.54
$n=4$	−0.85
$n=3$	−1.51
$n=2$	−3.40

그림 II-35 수소 원자의 전자 궤도 에너지 분포



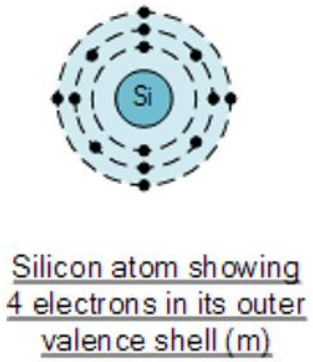
de Broglie suggested that $p = h/\lambda$ not only to photons but also to electrons



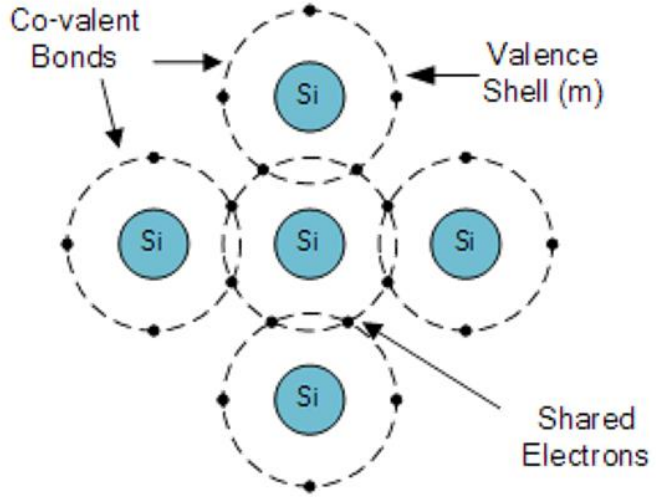


TEM: Transmission Electron Microscope

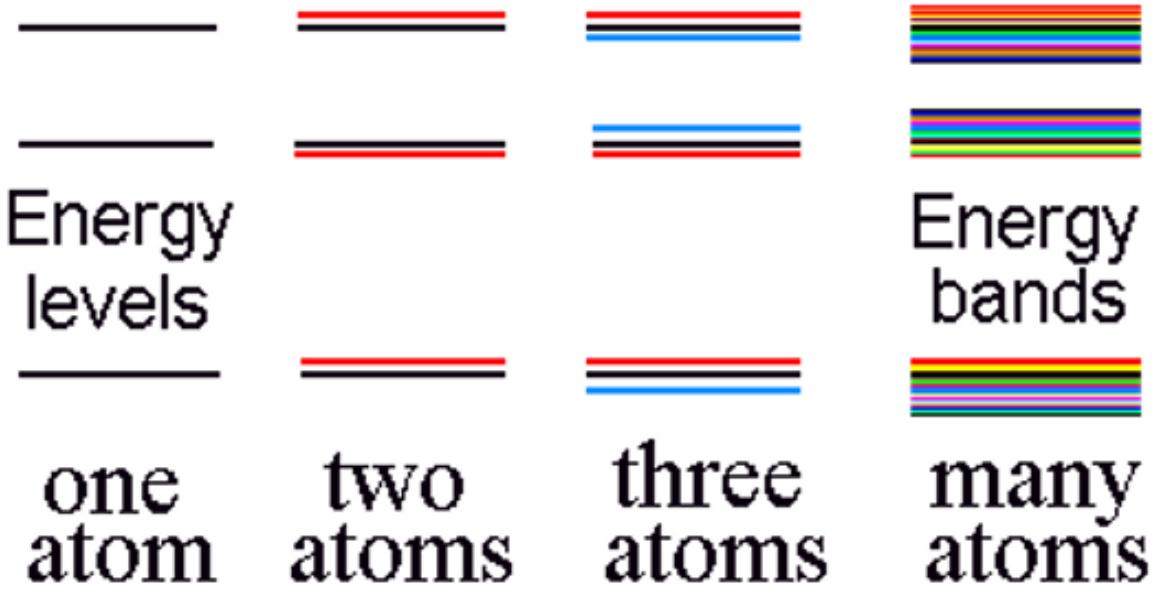
Semiconductor



Silicon atom showing
4 electrons in its outer
valence shell (m)

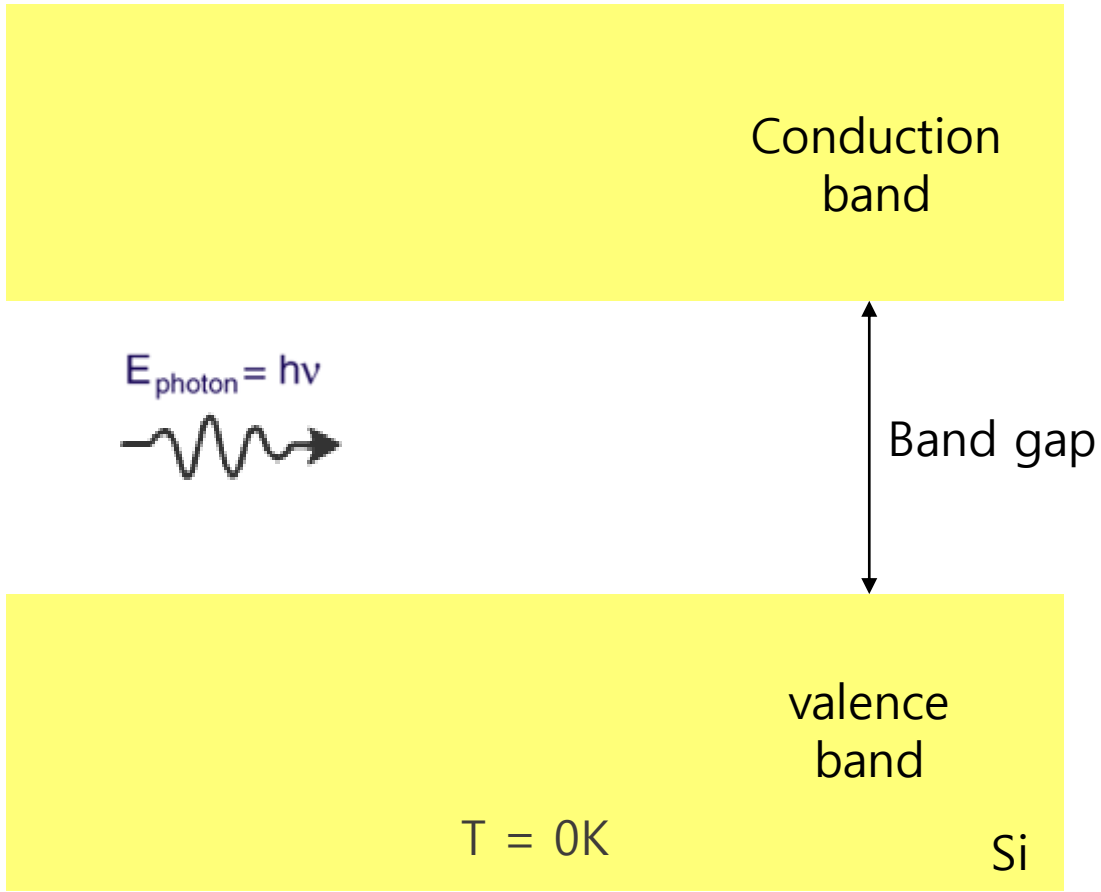


Silicon Crystal Lattice

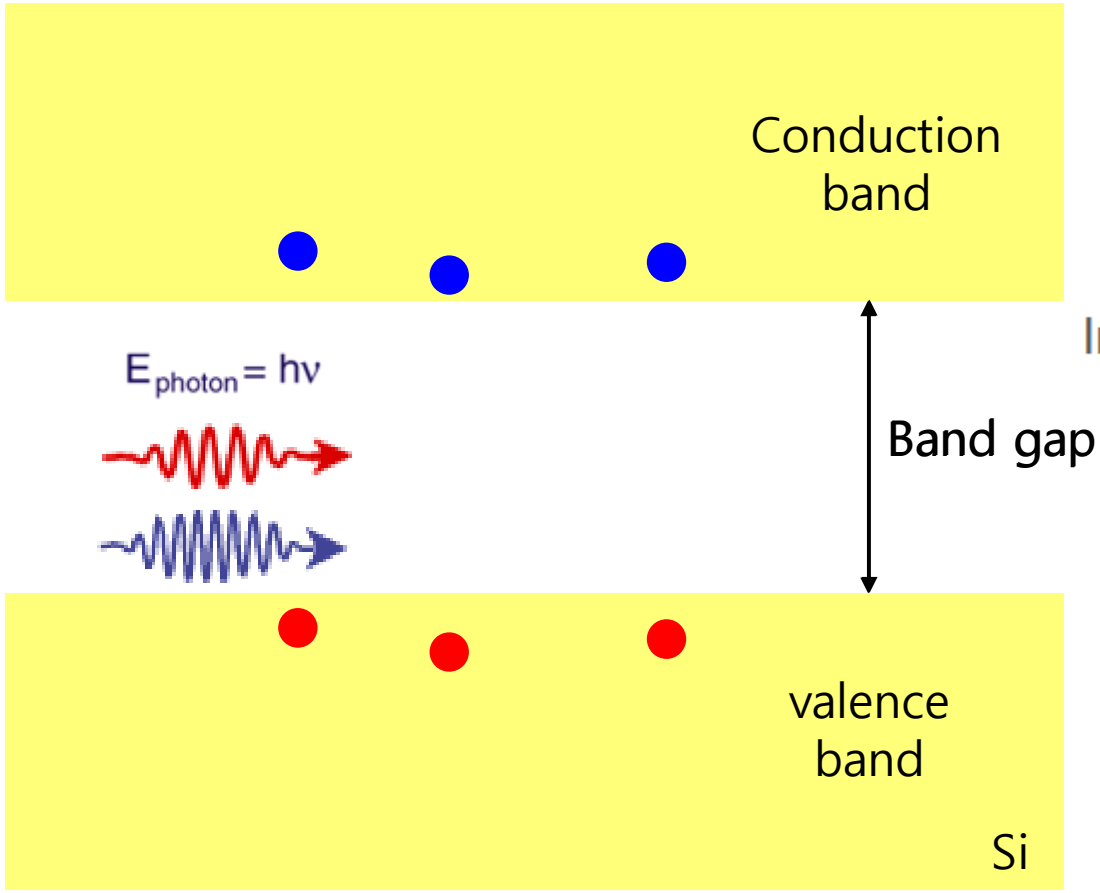


- Solar cell & Semiconductor
- Band gap(quantum mechanics)
- Carrier(Absorption & Recombination)
- Lifetime & Diffusion Length
- Doping(Fermi level)
- PN junction

Carrier



Carrier - Intrinsic Carrier concentration

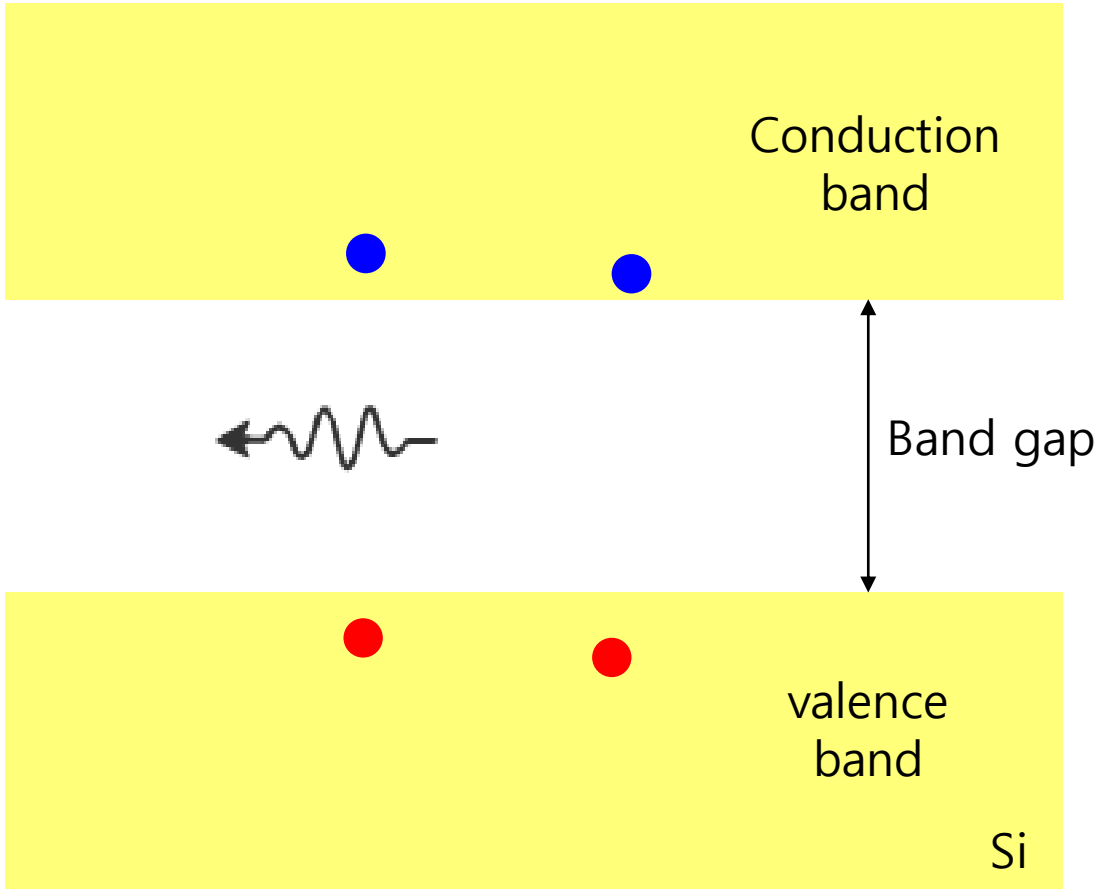


$$n_i(T) = 5.29 \times 10^{19} (T/300)^{2.54} \exp(-6726/T)$$

Intrinsic Carrier Concentration, $n_i = 8.3 \times 10^9\ cm^{-3}$

In T = 300K

Recombination & Lifetime(Diffusion Length)



$$L = \sqrt{D\tau}.$$

where:

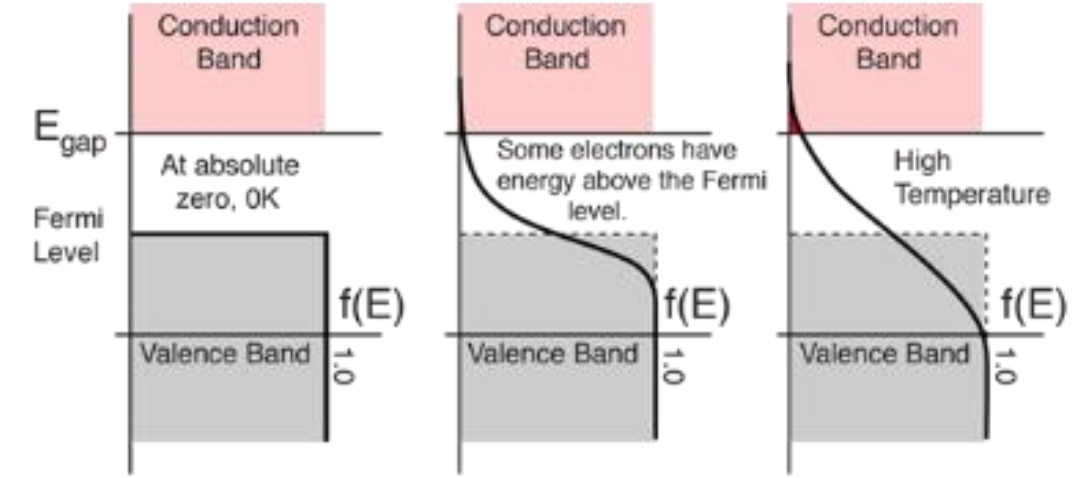
L is the diffusion length in meters;

D is the diffusivity in m^2/s and

τ is the lifetime in seconds.

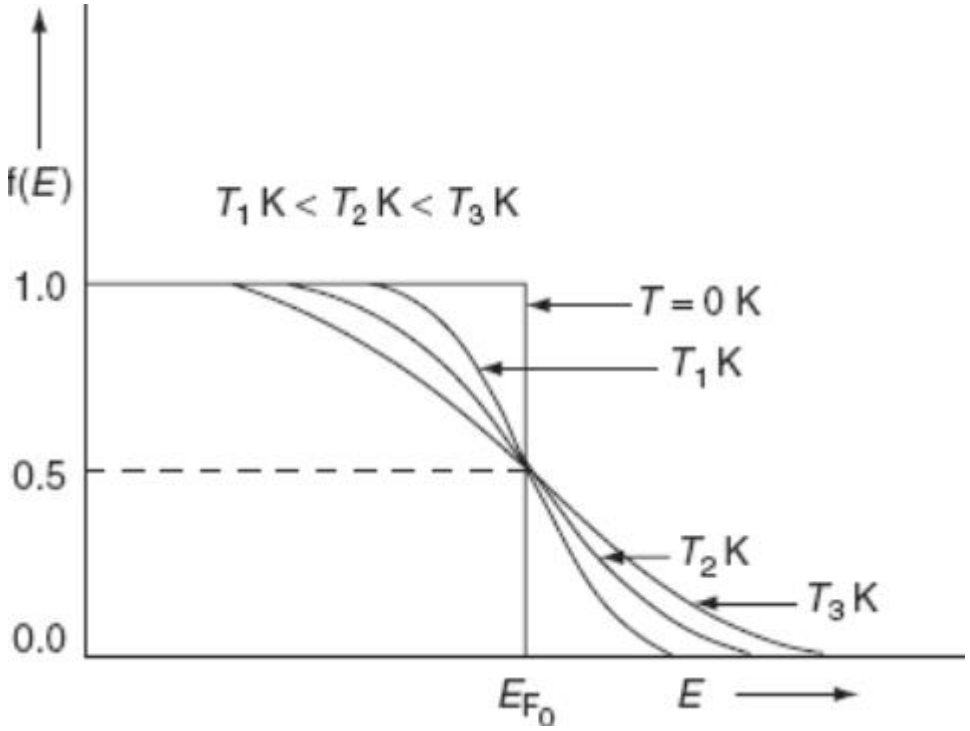
Fermi level

$$f(E) = \frac{1}{e^{(E - E_F)/kT} + 1}$$



No electrons can be above the valence band at 0K, since none have energy above the Fermi level and there are no available energy states in the band gap.

At high temperatures, some electrons can reach the conduction band and contribute to electric current.



https://en.wikipedia.org/wiki/Fermi_level

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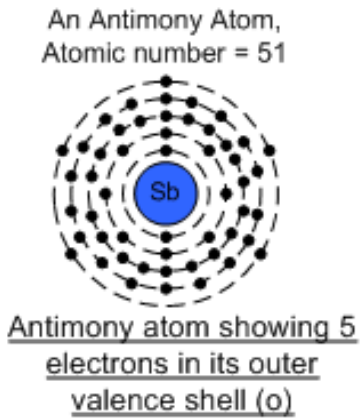
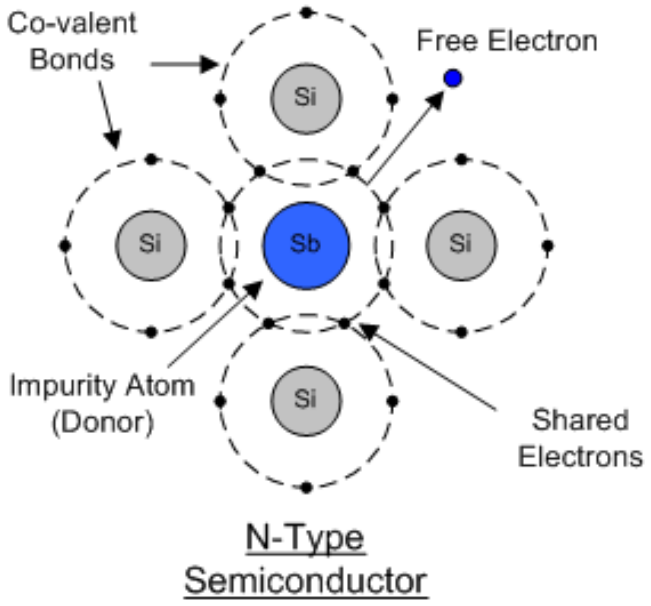
Doping

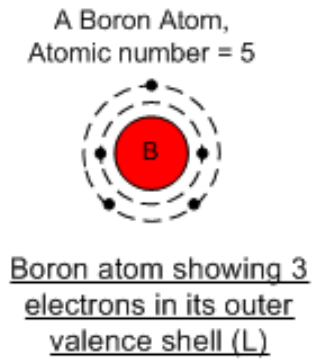
III	IV	V
B	C	
Al	Si	P
Ga	Ge	As
In		Sb

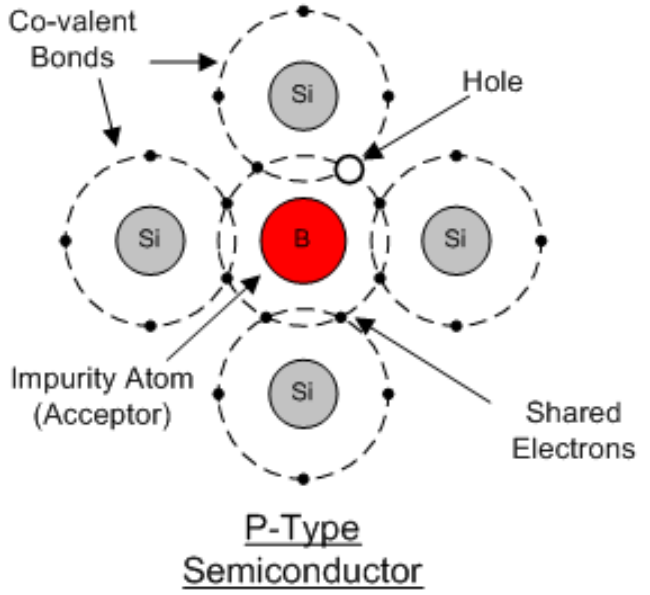
- Donor
  - a dopant atom that, when added to a semiconductor, can form a n-type region
  - P, As, Sb, Bi
- Accepter
  - a dopant atom that when added to a semiconductor can form a p-type region
  - B, Al, Ga

https://en.wikipedia.org/wiki/Donor_(semiconductors)

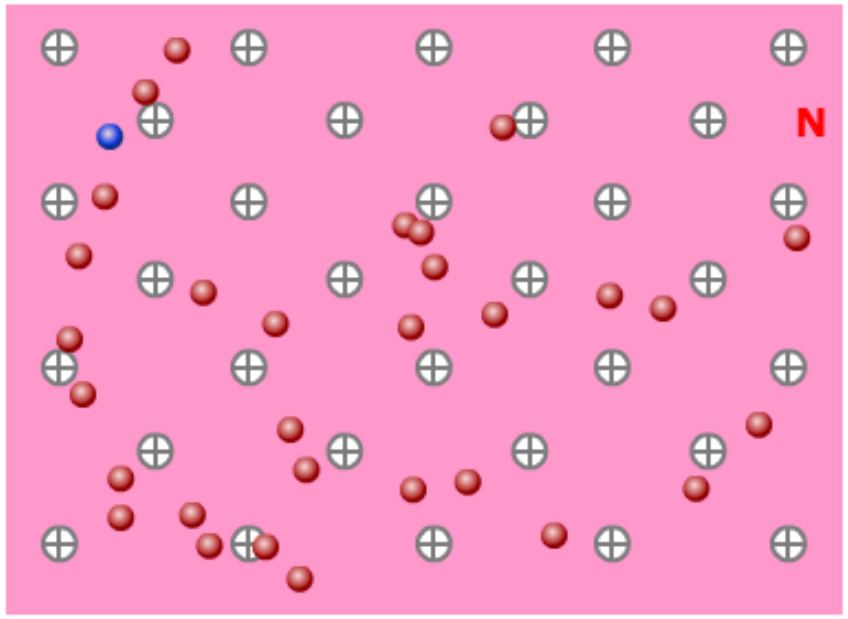


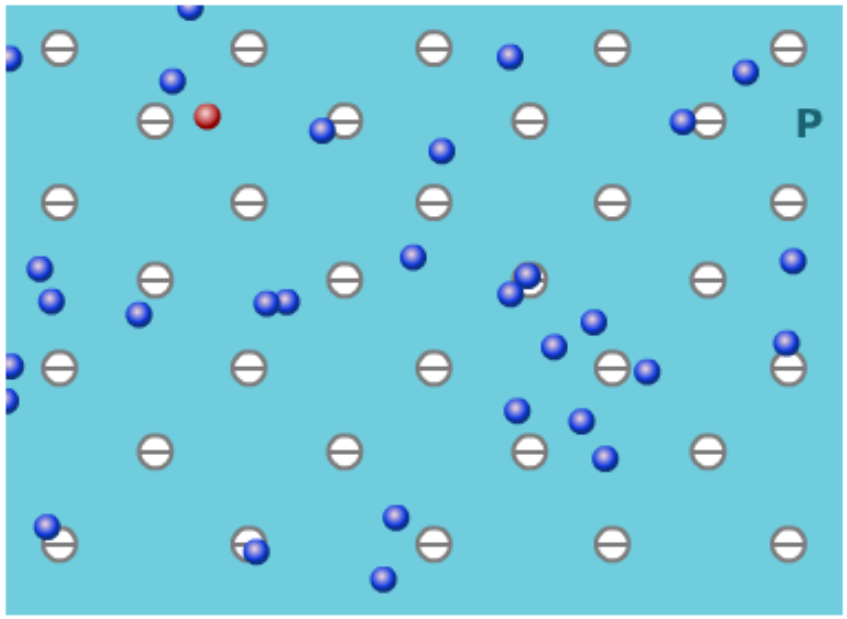






Doping

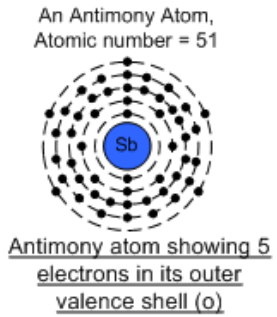


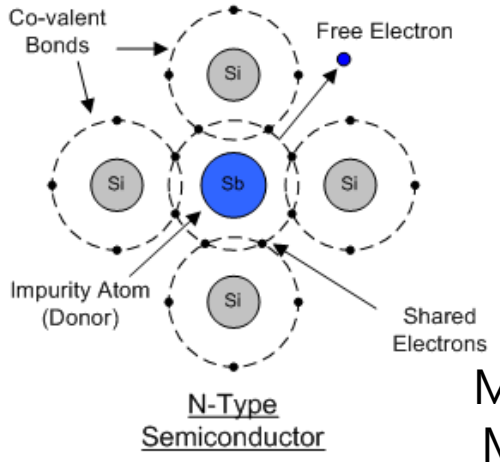


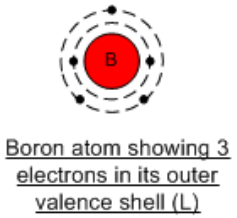
$$n_0 p_0 = n_i^2$$

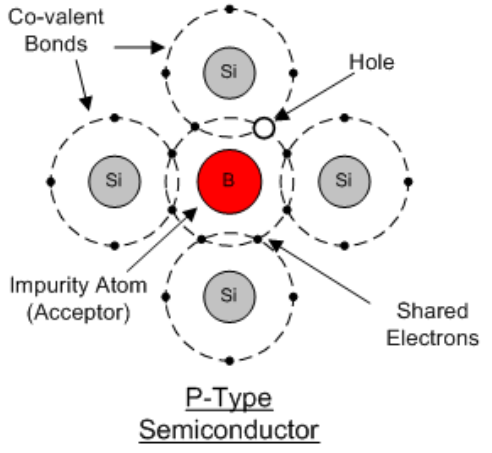
n-type: $n_0 = N_D$, $p_0 = \frac{n_i^2}{N_D}$

p-type: $p_0 = N_A$, $n_0 = \frac{n_i^2}{N_A}$







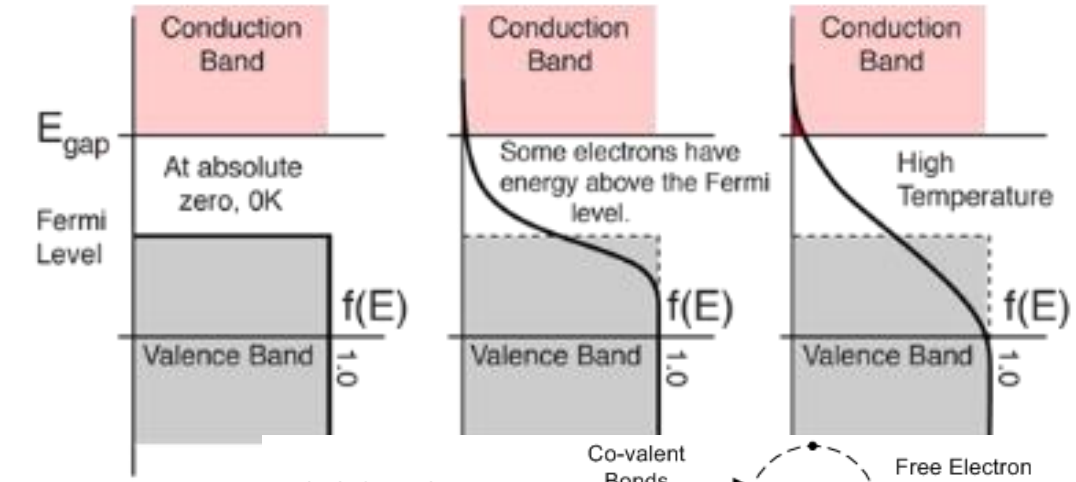


Majority carriers $\sim 10^{17} cm^{-3}$

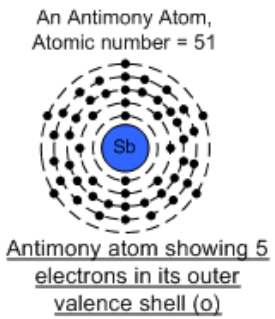
Minority carriers $\sim 10^{6} cm^{-3}$

Fermi level

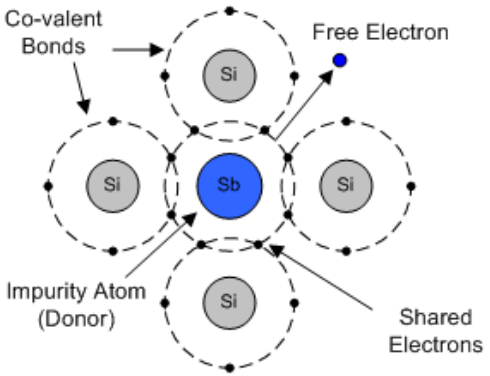
$$f(E) = \frac{1}{e^{(E - E_F)/kT} + 1}$$



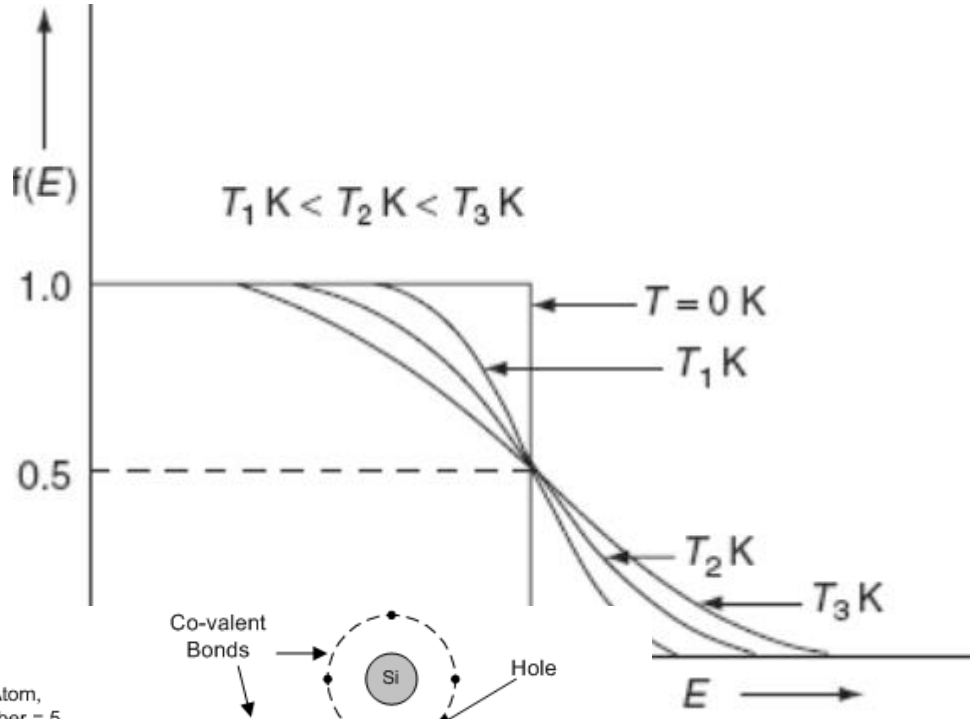
No electrons can be band at 0K, since no above the Fermi leve no available energy s gap.

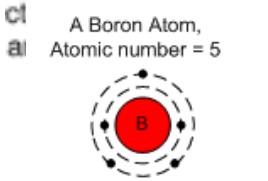


Antimony atom showing 5 electrons in its outer valence shell (o)

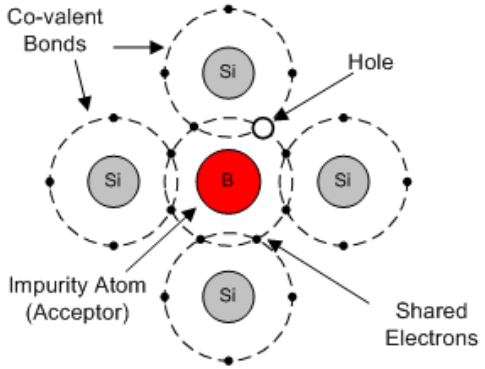


N-Type Semiconductor





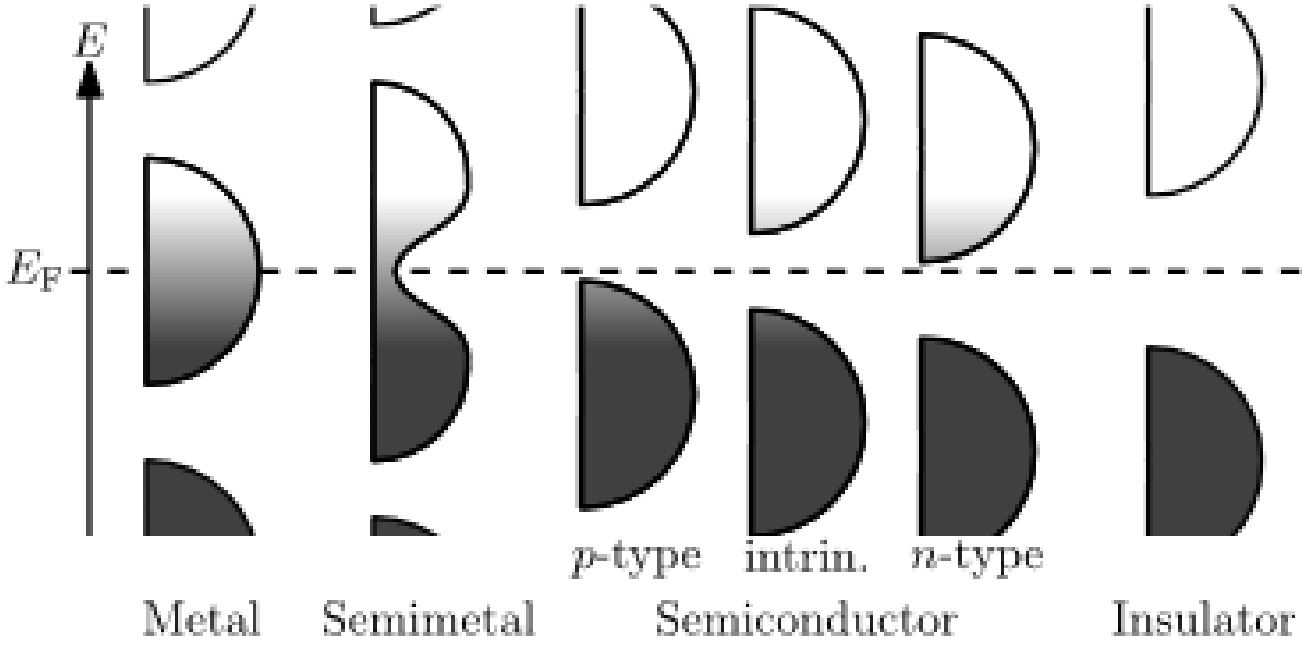
Boron atom showing 3 electrons in its outer valence shell (L)

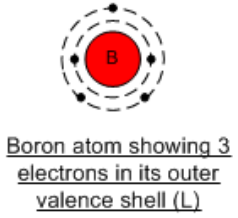


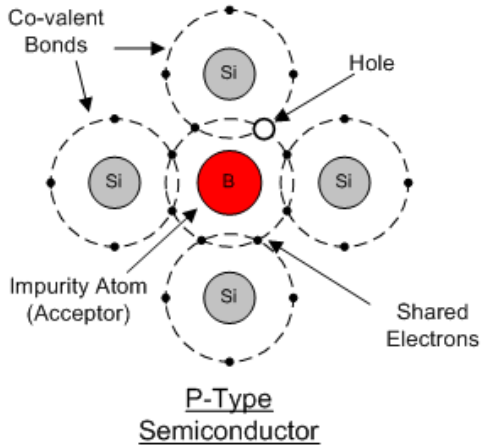
P-Type Semiconductor

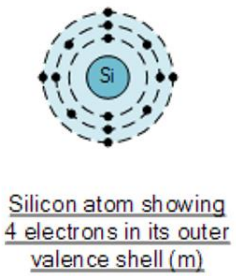
https://en.wikipedia.org/wiki/Fermi_level

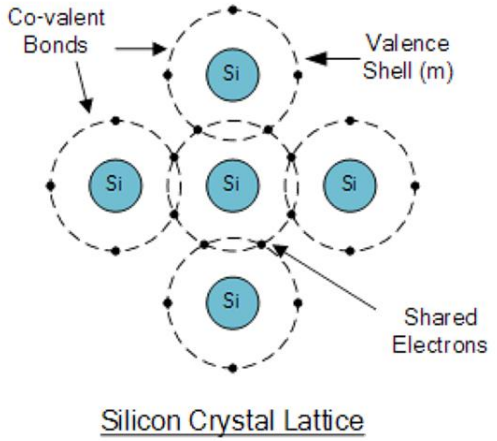
Fermi level

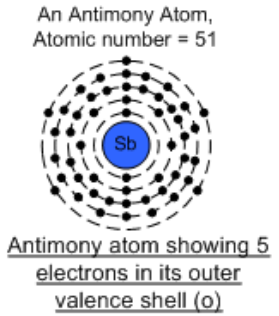

E
E_F
p-type
intrin.
n-type
Metal
Semimetal
Semiconductor
Insulator

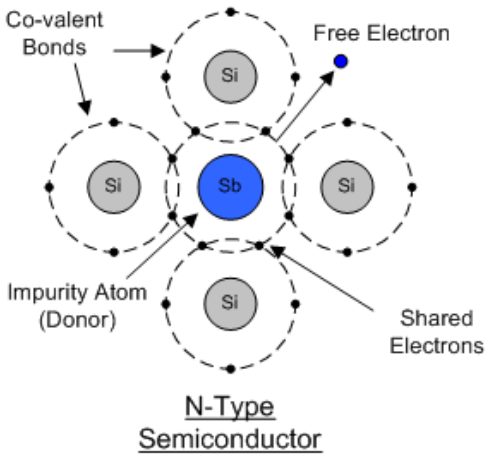

A Boron Atom,
Atomic number = 5
B
Boron atom showing 3 electrons in its outer valence shell (L)


Co-valent Bonds
Hole
Si
B
Impurity Atom (Acceptor)
Shared Electrons
P-Type Semiconductor


A Silicon Atom,
Atomic number = "14"
Si
Silicon atom showing 4 electrons in its outer valence shell (m)


Co-valent Bonds
Valence Shell (m)
Si
Shared Electrons
Silicon Crystal Lattice


An Antimony Atom,
Atomic number = 51
Sb
Antimony atom showing 5 electrons in its outer valence shell (o)


Co-valent Bonds
Free Electron
Si
Sb
Impurity Atom (Donor)
Shared Electrons
N-Type Semiconductor

- http://mae488jhpark.blogspot.com/2014/06/soft-tactile-sensor-piezoresistive-type.html
- http://study.zum.com/book/14150
- https://m.blog.naver.com/PostView.nhn?blogId=toshizo&logNo=221203360954&proxyReferer=https%3A%2F%2Fwww.google.co.kr%2F
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- http://m.blog.daum.net/windada11/8767753?tp_nil_a=1
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- http://cikguwong.blogspot.com/2013/07/physics-form-5-chapter-4-doping-of.html