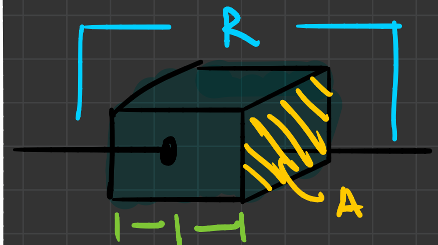
MATERIAL USED IN ELECTRONICS.

↳ ค.สามารถในการนำไฟฟ้า / ต้านไฟฟ้า.

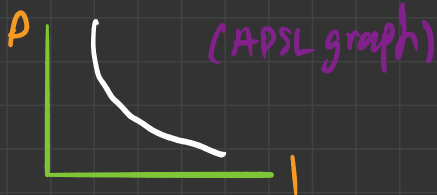


① [Resistivity] → สภาพต้านทานไฟฟ้า.

$$\boxed{\rho = \frac{RA}{L}} = \frac{\Omega m^2}{m} = \Omega \cdot m.$$

↳ แบ่งออกเป็น 3 แบบ. → 1. Conductor / 2. Semiconductor / 3. Insulator.

Note! ρ with l (length)



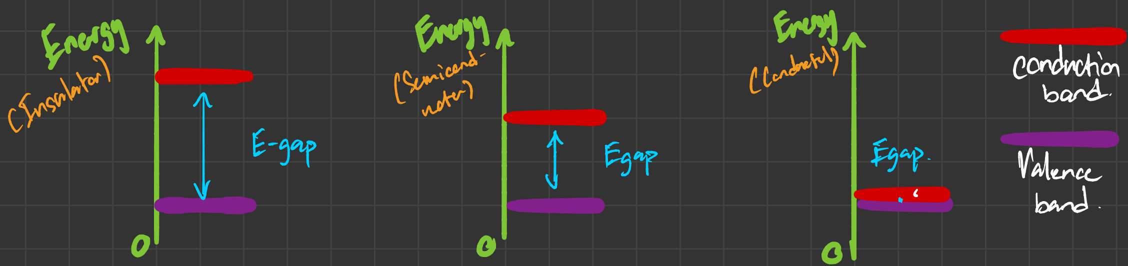
∴ ยิ่งความยาวลวดเยอะ ค่าค.ต้านทานก็จะน้อยลง

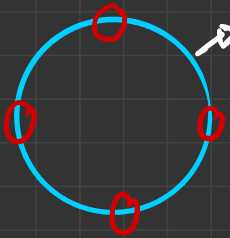
$$\rho \approx \frac{1}{L}$$

[1.1] Insulator. → have very high resistivity. ($\rho \approx 10^{12}\ \Omega \cdot m$)
(rubber) ↳ a few free e^- [hard to lose].

[1.2] Conductor. → have very low resistivity ($\rho \approx 10^{-6}\ \Omega \cdot m$)
(copper) ↳ a high free e^- [easy to lose].

② [Comparison of Semiconductor, Conductor, Insulator]





valence band.

valence e^- $\xrightarrow{\text{remove}}$ going to conduction band.

[Silicon vs Germanium.]

↳ 2 | 8 | 18 | 4 → 4th

↳ 2 | 8 | 4 → valence e^- → 3th

Note! we use Silicon in diodes, transistor, semiconductor, etc.

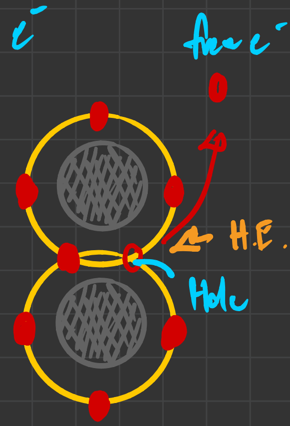
$E_{A\,\text{Germanium}} > E_{A\,\text{Silicon}}$ then.

Germanium is unstable in high temp.

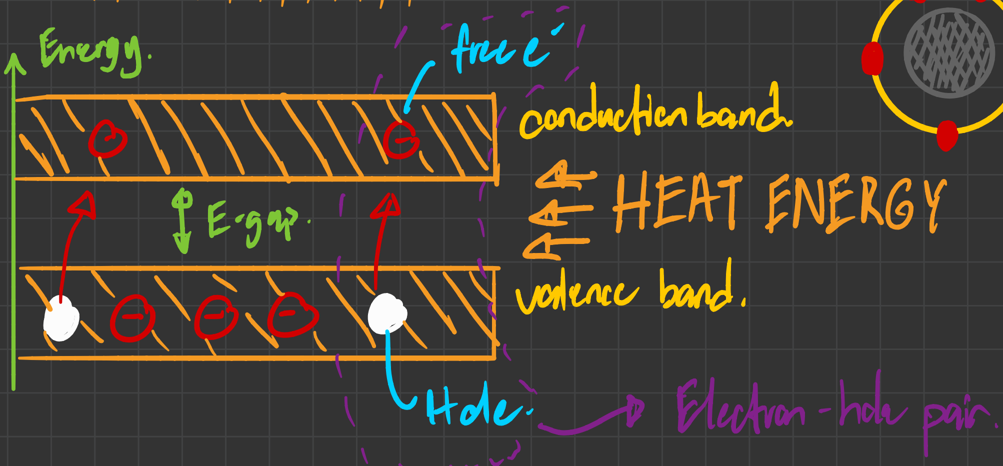
③ [Conduction e^-, Holes]

↳ at room temp. has termal energy. some valence e^- jump from valence band → conduction band and become free e^-

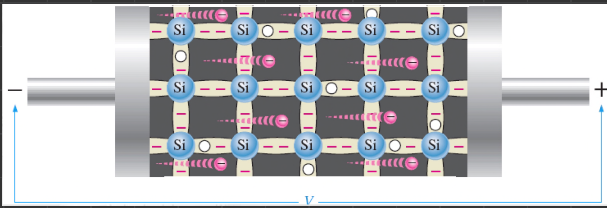
Note! ☆ free e^- ⇌ conduction electron.



ENERGY DIAGRAM.

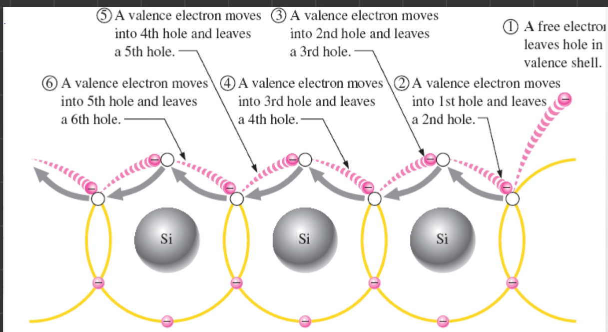


[3.1] Recombination → Occurs when a conduction band e^- loses and falls back into a hole in the valence band.



(e⁻ ไปตกหลุมสักที่หนึ่ง วนไปวนมา)

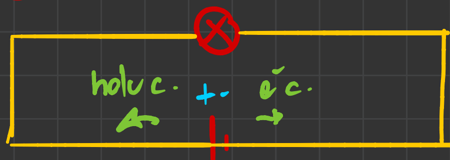
[3.2] Electron and Hole current.



When a valence electron moves left to right to fill a hole while leaving another hole behind, the hole has effectively moved from right to left. Gray arrows indicate effective movement of a hole.

Current Flow!

1. hole current → + to -
2. e^- current → - to +.



4 [Intrinisc Semiconductor].

→ Semiconductor materials donot conduct well and have limit value in their intrinisc state. → กึ่งตัวนำบริสุทธิ์.

→ The process dopping is increase material's conductivity + number of current carriers (e^- or holes). Then they become N-type / P-type.

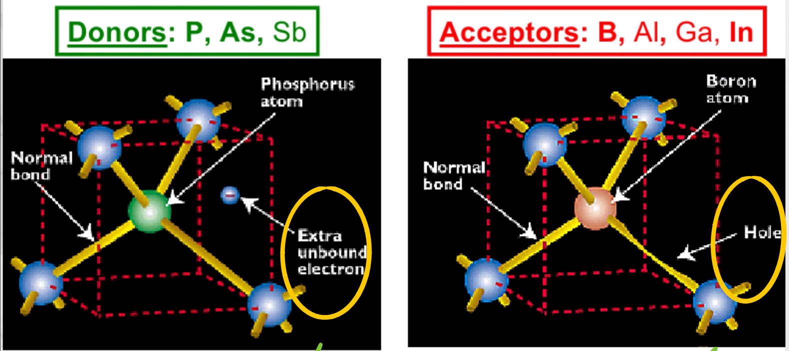
→ Electrons-hole pair make materials more conductivity.

Note! Most of Intrinisc matterials have 4 valence e^- ☆

[4.1] Dopping. → Dopping a intrinsic to become more conductivity.

Doping

By substituting a Si atom with a special impurity atom (Column V or Column III element), a conduction electron or hole is created.



$4+5=9$

$8 \mid 1$ — free e^-

$4+3=7$

$7 \mid 1$ hole

Column V.

↳ 5 Valence e^-

After Dope: Donors.

(have 1 left free e^-)

Column III

↳ 3 Valence e^-

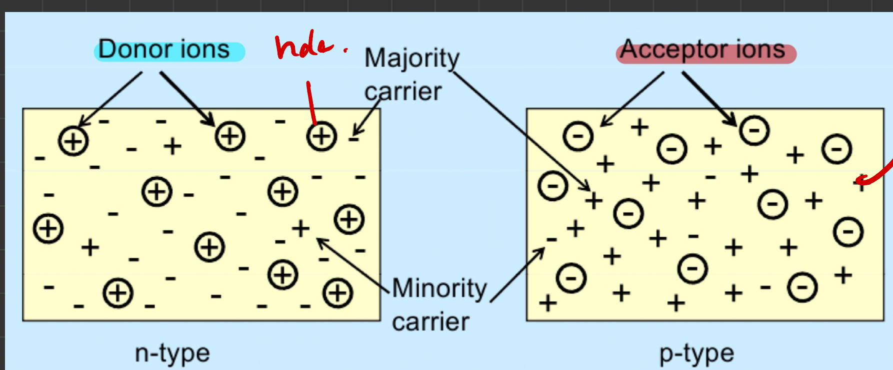
After Dope: Acceptors

(have 1 hole)

[4.2] Majority Carrier / Minority Carrier.

Donors. (N) → 1 left free$^-$ → major: free e^-, minor: hole

Acceptors. (P) → 1 left hole → major: hole, minor: free e^-



hole