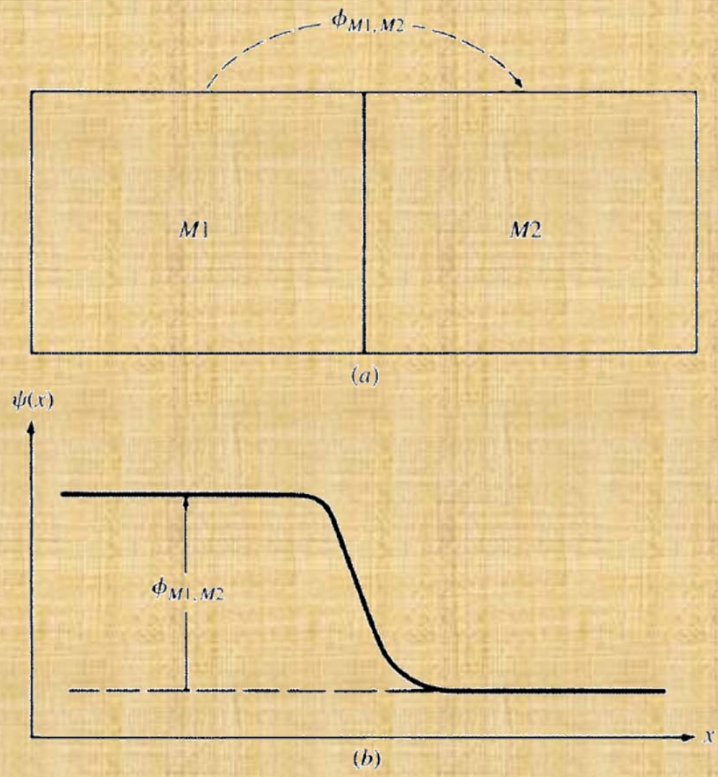
Contact potentials

Contact potentials

- M1 and M2 Material are without external field
  - When the two materials are brought together, at first carriers move from one to the other..
  - No electric field at first and carriers move
  - Electric field establishment – Carrier movement inhabitation!
  - Contact potential: Depending on the two materials, the potential change can occur on both sides of the junction

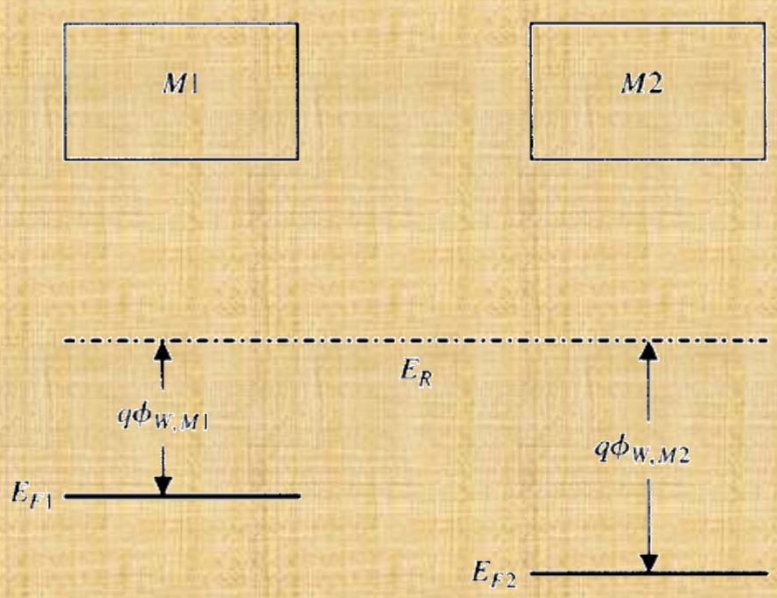


Contact potential…

- Work function concept
  - E_R: Vacuum energy level
  - $\Phi_{w.Mi}$ *(V)*: Work function divided by *q*
  - The work function is a measure of how difficult it is for an electron to leave its host material
  - Electrons move form M1 to M2
  - When electron movement finished?
    - If electron in M2 material gain $q\Phi_{w.M2}$- $q\Phi_{w.M1}$ Energy! Why?
    - Contact potential

$$\emptyset_{M1,M2} = \emptyset_{w1,M2} - \emptyset_{w,M1}$$

    - Work function complexity



Contact potential…

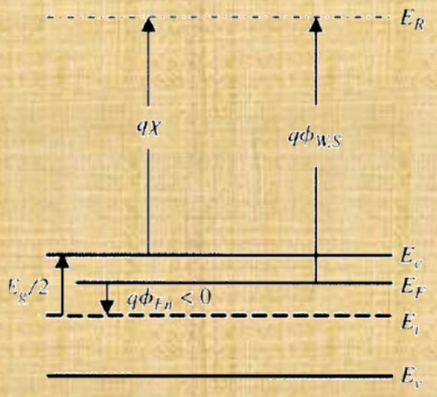
- Work function in semiconductors:

$$\phi_{w,S} = \chi + E_g/2q + \phi_F$$

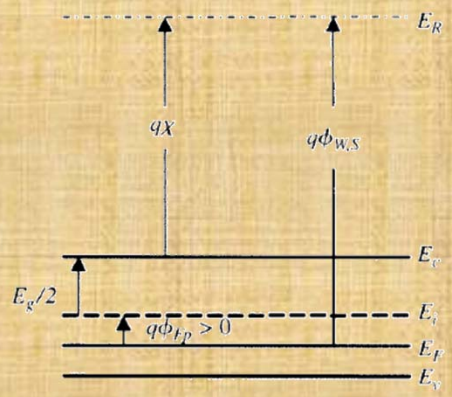
  - X: electron affinity
  - For silicon: $\phi_{w,S} = 4.05\ eV$
  - For degenerate semiconductor:

n-type: $\phi_{w,S} = \chi$

p-type: $\phi_{w,S} = \chi + Eg/q$



n-type



p-type

- Example:
  - Find the contact potential of aluminum to p-type silicon with a doping of 10^{17} cm^{-3}, at room temperature. Assume that the work function potential of aluminum is 4.1 V.

$$\phi_{w,S} = \chi + E_g/2q + \phi_F = 4.05 + 0.56 + 0.42 = 5.03\ V$$

$$\phi_{w,Al} = 4.1\ V$$

$$\phi_{Al,S} = 5.03 - 4.1 = 0.93\ V$$

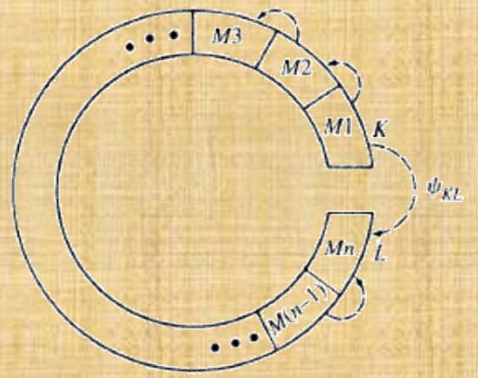
Contact potential…

- Several Materials in Series

$$\psi_{KL} = \phi_{M1,M2} + \phi_{M1,M2} + \cdots + \phi_{M(n-1),Mn}$$

$$\psi_{KL} = (\phi_{w,M2} - \phi_{w,M1}) + (\phi_{w,M3} - \phi_{w,M2}) + \cdots + (\phi_{w,M(n-1)} - \phi_{w,M(n-2)}) + (\phi_{w,Mn} - \phi_{w,M(n-1)})$$

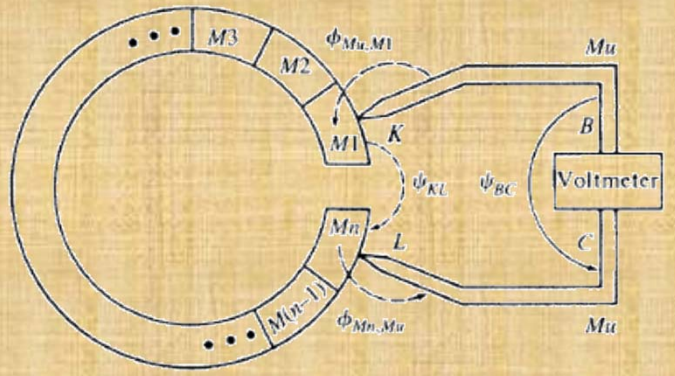
$$\psi_{KL} = \phi_{w,Mn} - \phi_{w,M1}$$



- Can we measure the potential ψ_{KL} with a common voltmeter?

$$\psi_{BC} = \phi_{Mu,M1} + \psi_{KL} + \phi_{Mn,Mu} = 0$$

- No matter how many materials are in the loop, the electrostatic potential difference between its two ends depends *only* on the first and the last material and cannot be measured by a common voltmeter.



Contact potential…

- Consider following case where ideal voltage source connected in series with other materials:

$$\psi_{KL} = V_{source} + \phi_{w,Mn} - \phi_{w,M1}$$

- Now consider a voltmeter connected to M1 and Mn material

$$\psi_{BC} = V_{source}$$

- Contact potentials never seem to enter the picture when one works with circuits, provided all contacts are at the same temperature.
- Neglecting contact potentials can lead to serious errors.