Section 23
Schottky Diode

23.3 Practical Issues

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School of Electrical and Computer Engineering

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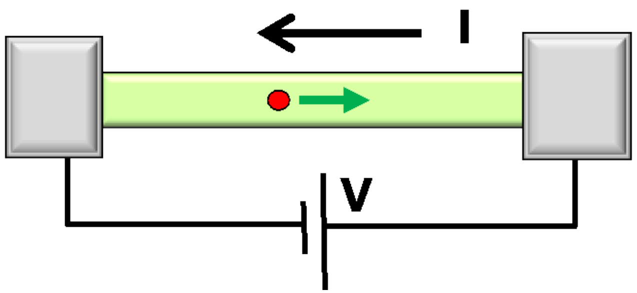
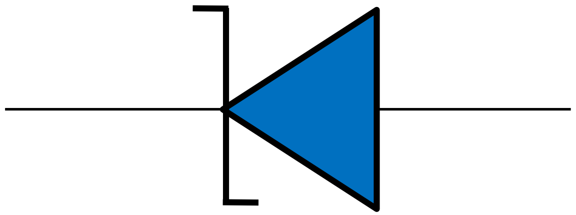


$$I = G \times V$$
$$= q \times n \times v \times A$$

charge density velocity area



Video

- 23.1 Basics
  - » Equilibrium band-diagram
  - » DC Thermionic current (simple derivation)

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- 23.2 Physical Processes
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  - » Recombination/Generation/Ionization
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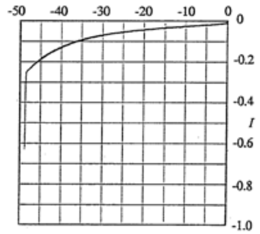
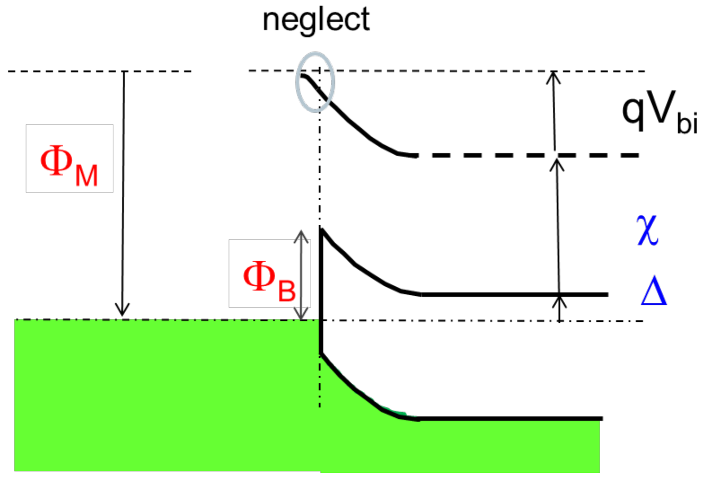
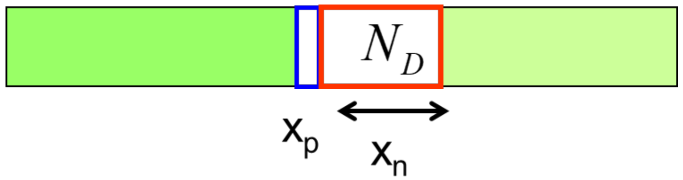
- 23.4 Practical Issues   status
  - » Ohmic vs. Schottky Contact
  - » Schottky Barrier Lowering – Image Charges
  - » Fermi Level Pinning



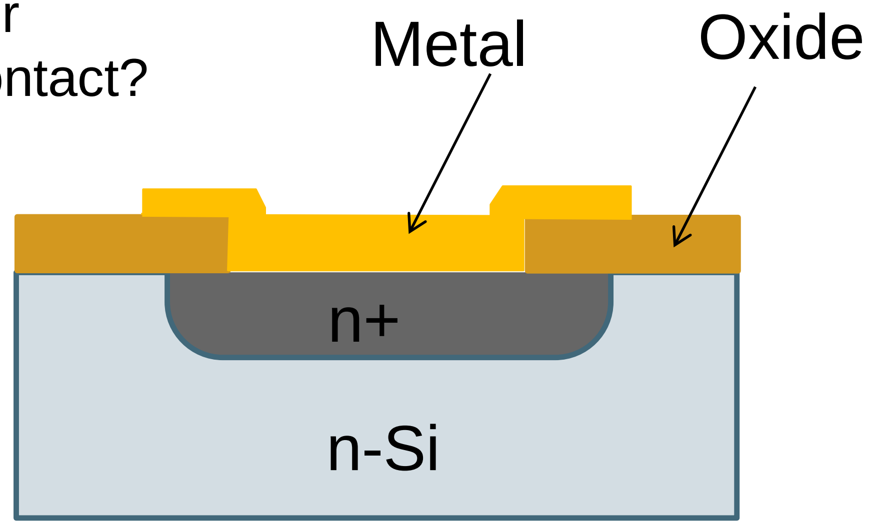




$$J_{s\to m} = \frac{4\pi q m^* k^2}{h^3} T^2 e^{(E_F - E_C - qV_{bi})\beta} e^{qV_A\beta} = A_0 e^{qV_A\beta}$$

$$I = I_o \left(e^{q(V_A - R_S I)\beta / m} - 1 \right)$$

MOS is Metal on Semiconductor
What if we just want to make contact?
How to reduce the barrier of Metal-Semiconductor?



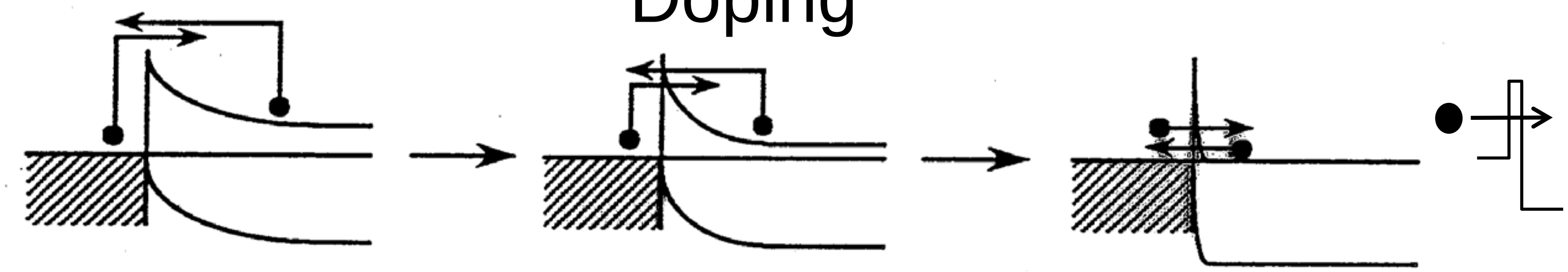
For majority carriers: there's not barrier
For minority carriers: high doping allows them to tunnel through
→Metal will just act like Ohmic Contact

Holes always have an Ohmic contact

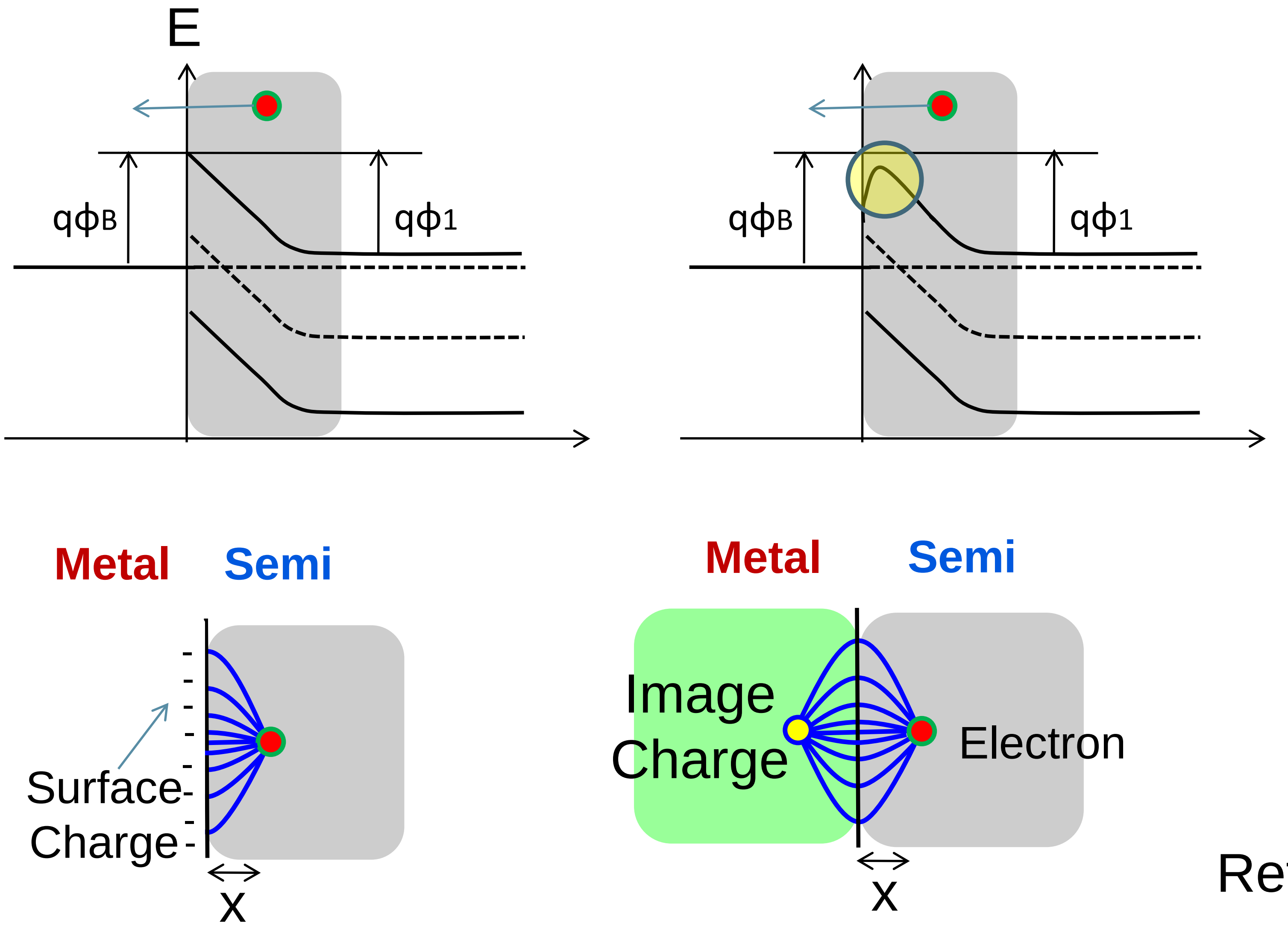
Low Doping

Moderate Doping

High Doping



Lowering of Schottky Barrier



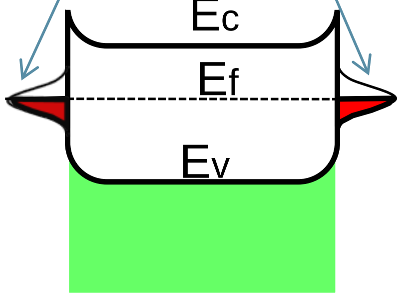
The fields on the metal must be perpendicular (otherwise there will be tangential current flow which is impossible)

as if there's an image charge (positive) in the metal

results in lowering the barrier height

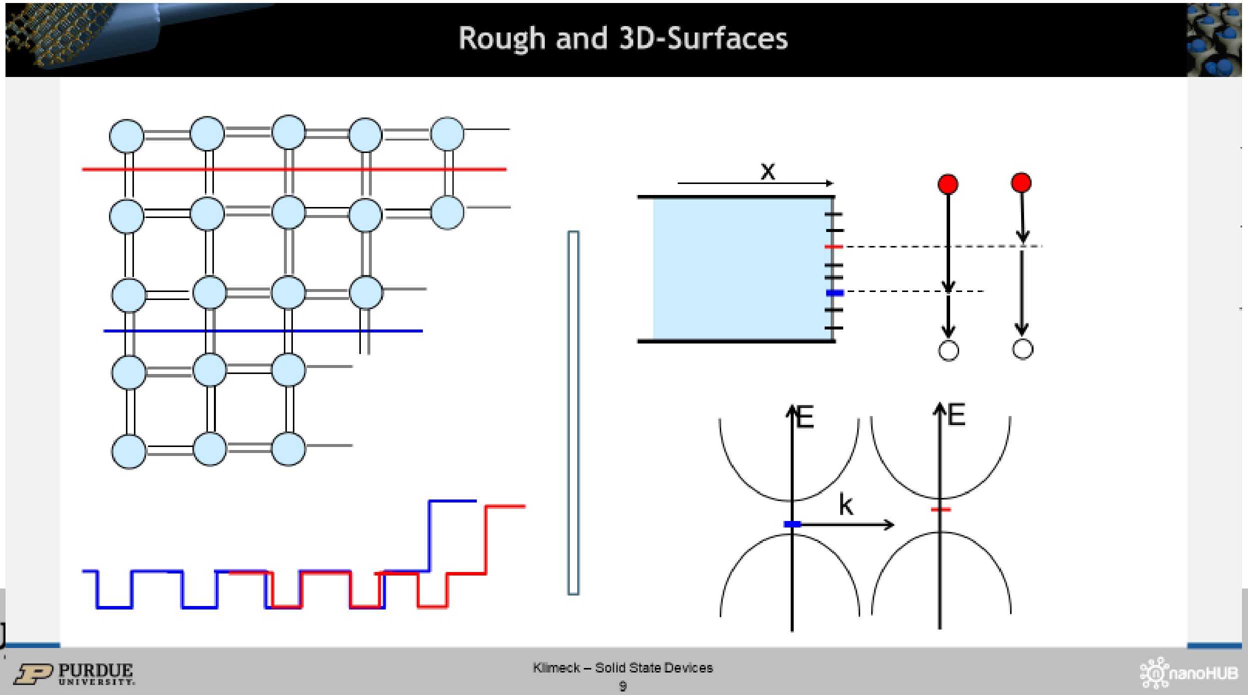
Ref. Sze/Ng., p. 143

Fermi-level Pinning



Why sometimes we don't get conductance at all?

surface states bends E_C/E_V so that the Fermi level is at the center of the bandgap



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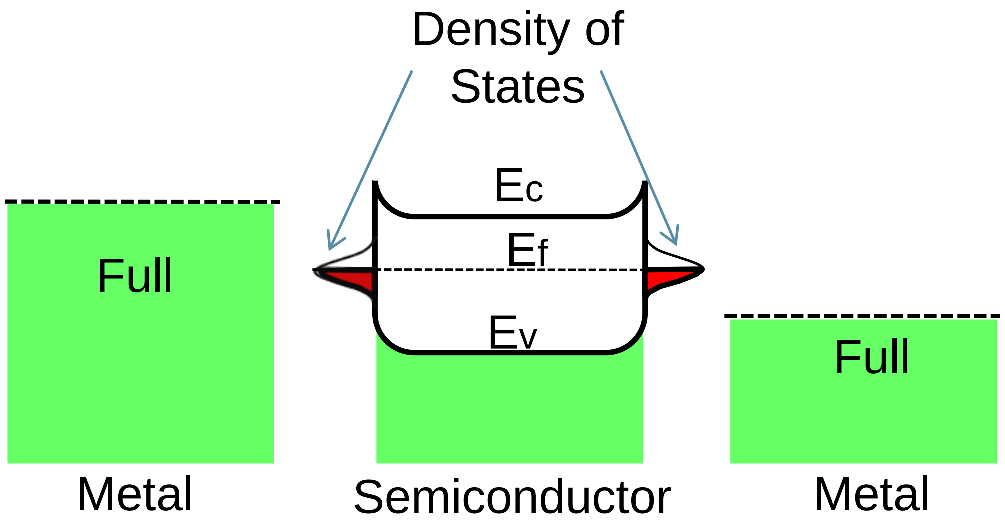
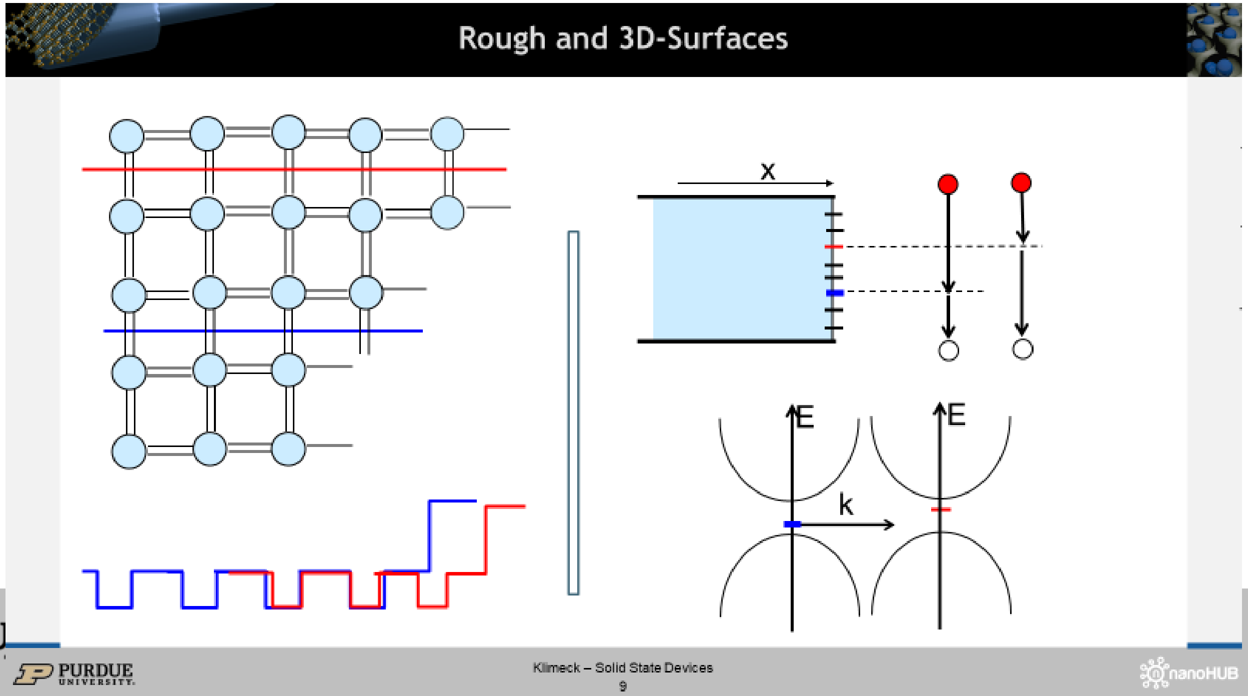




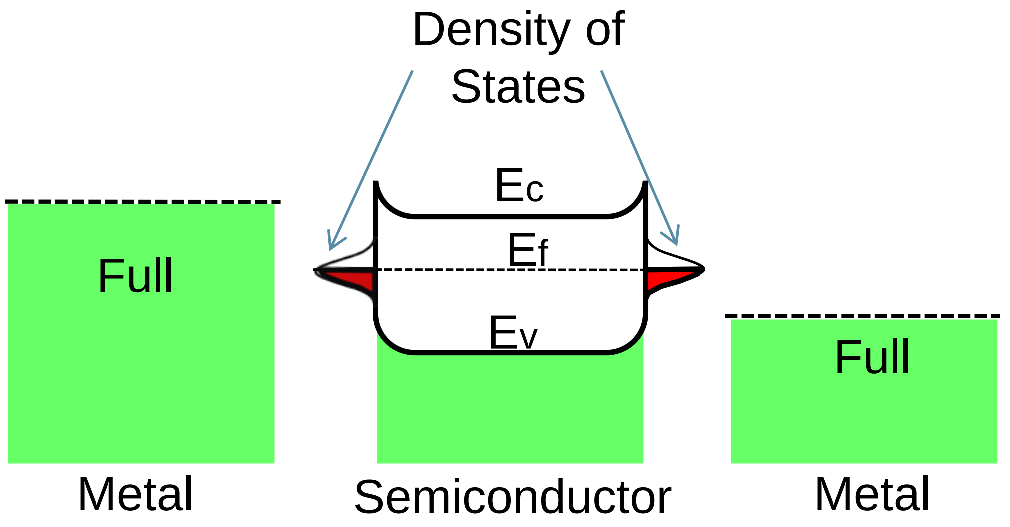
Why sometimes we don't get conductance at all?

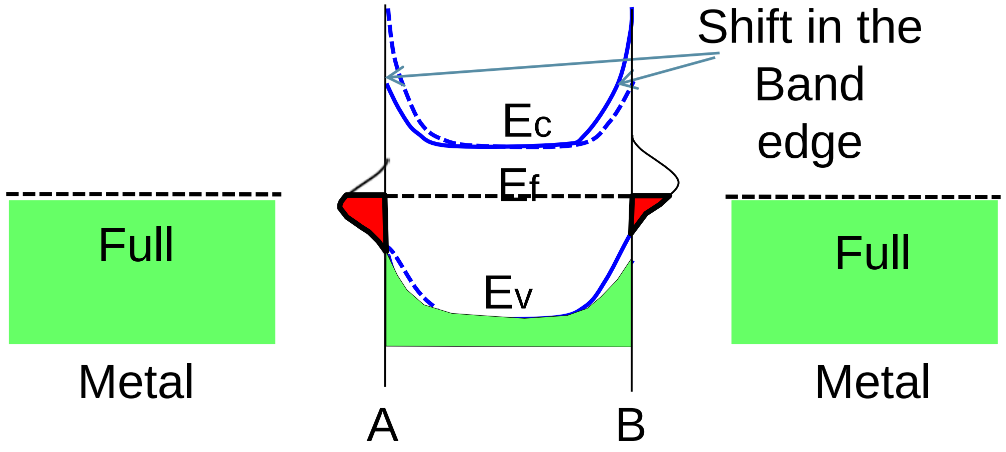
surface states bends E_C/E_V so that the Fermi level is at the center of the bandgap

they exchange carriers with metals, blocking the bulk semiconductor inside→

no modulation in potential barrier even you connected to different metals.

Fermi-level Pinning





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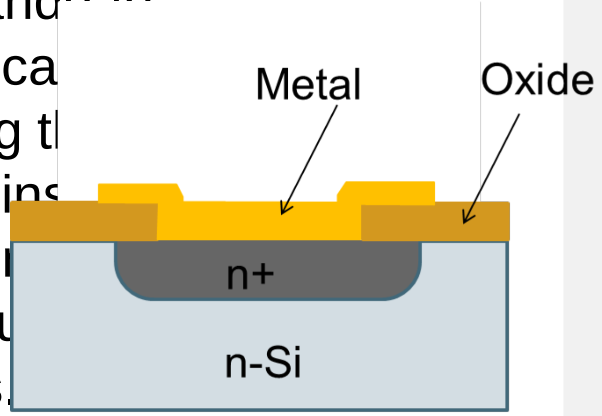
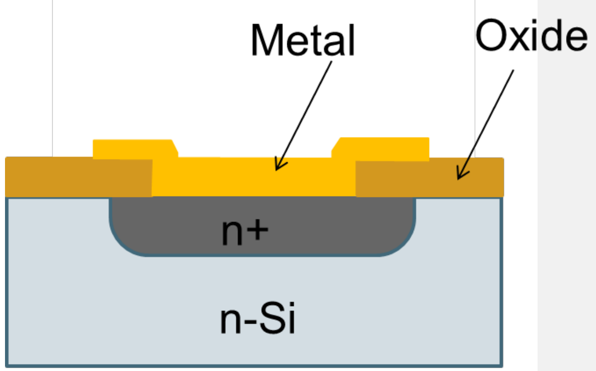
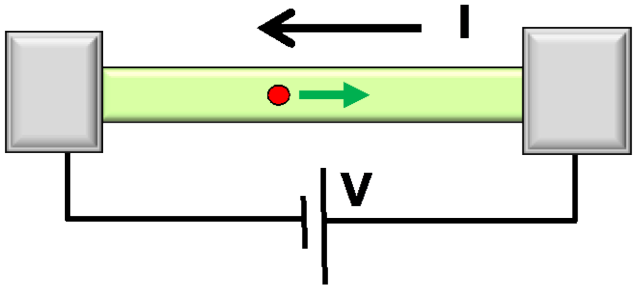


Regardless the workfunction, no modulation in potential.
(e.g. Modern high-k dielectrics)

Schottky Diodes - Conclusions



1) Schottky diodes have wide range of applications in practical devices. They are everywhere!
2) The key distinguishing feature: **a majority carrier device.**
3) Different technique to calculate the current in a majority carrier device. => thermionic emission.
4) Elimination of diffusion capacitance make the response of the diodes very fast.



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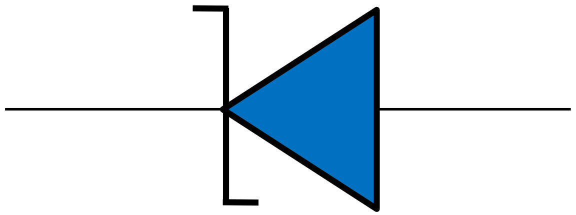

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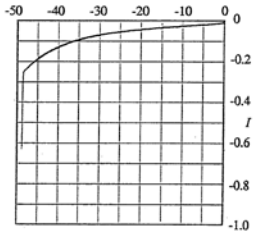

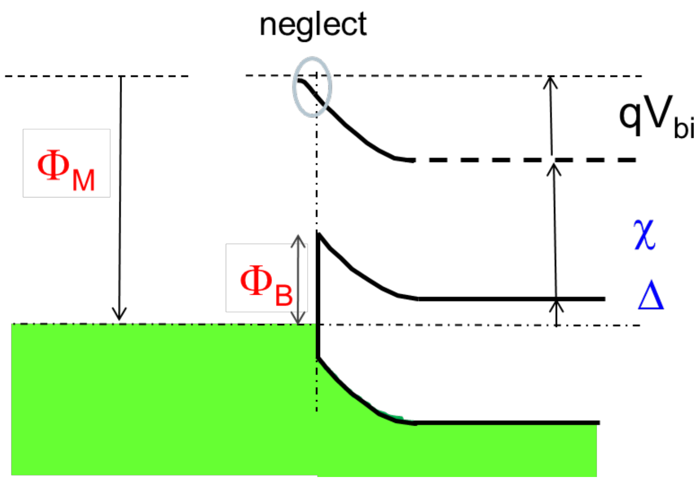

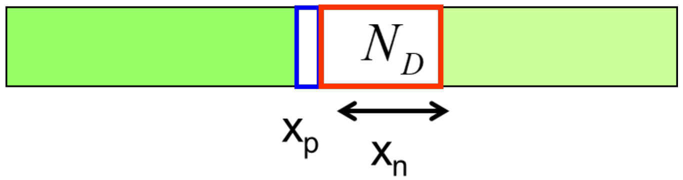

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status