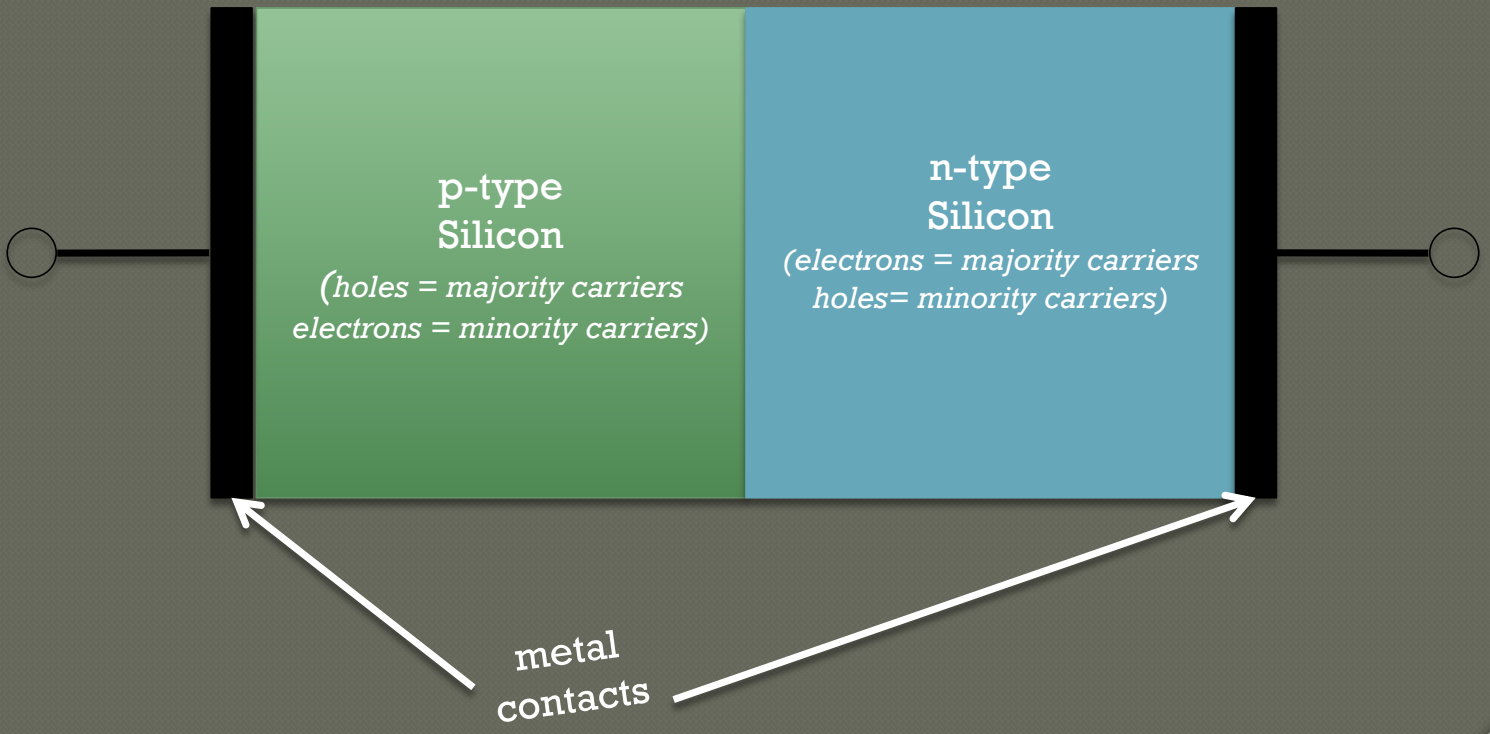
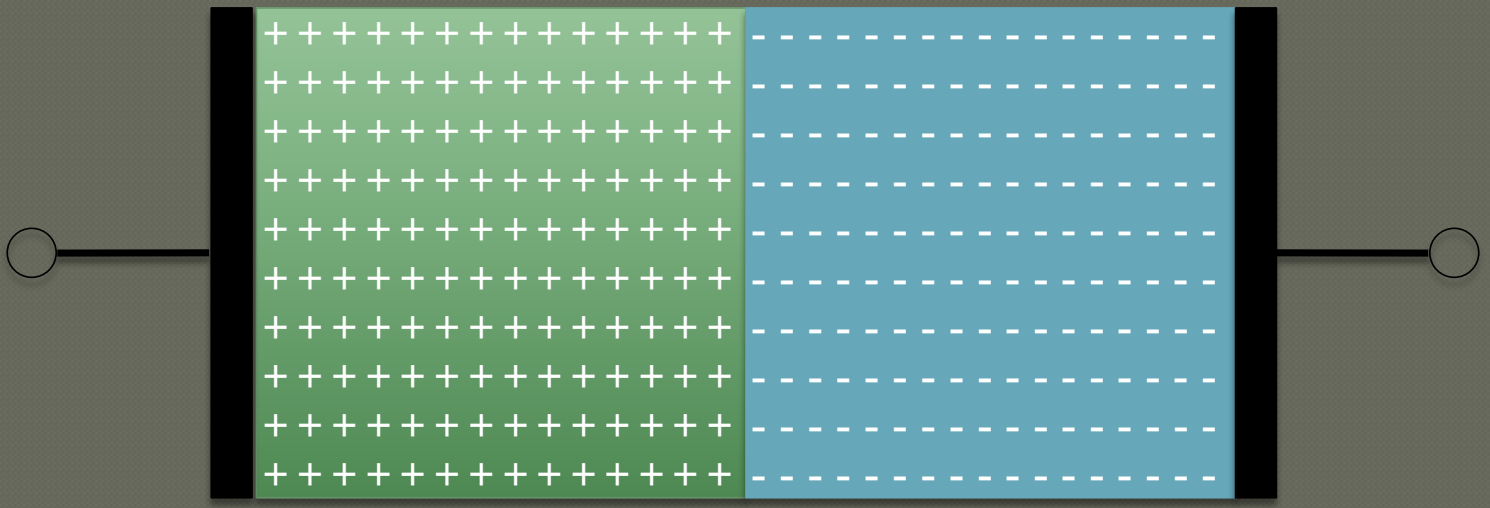
Silicon PN Junctions

A Basic Summary

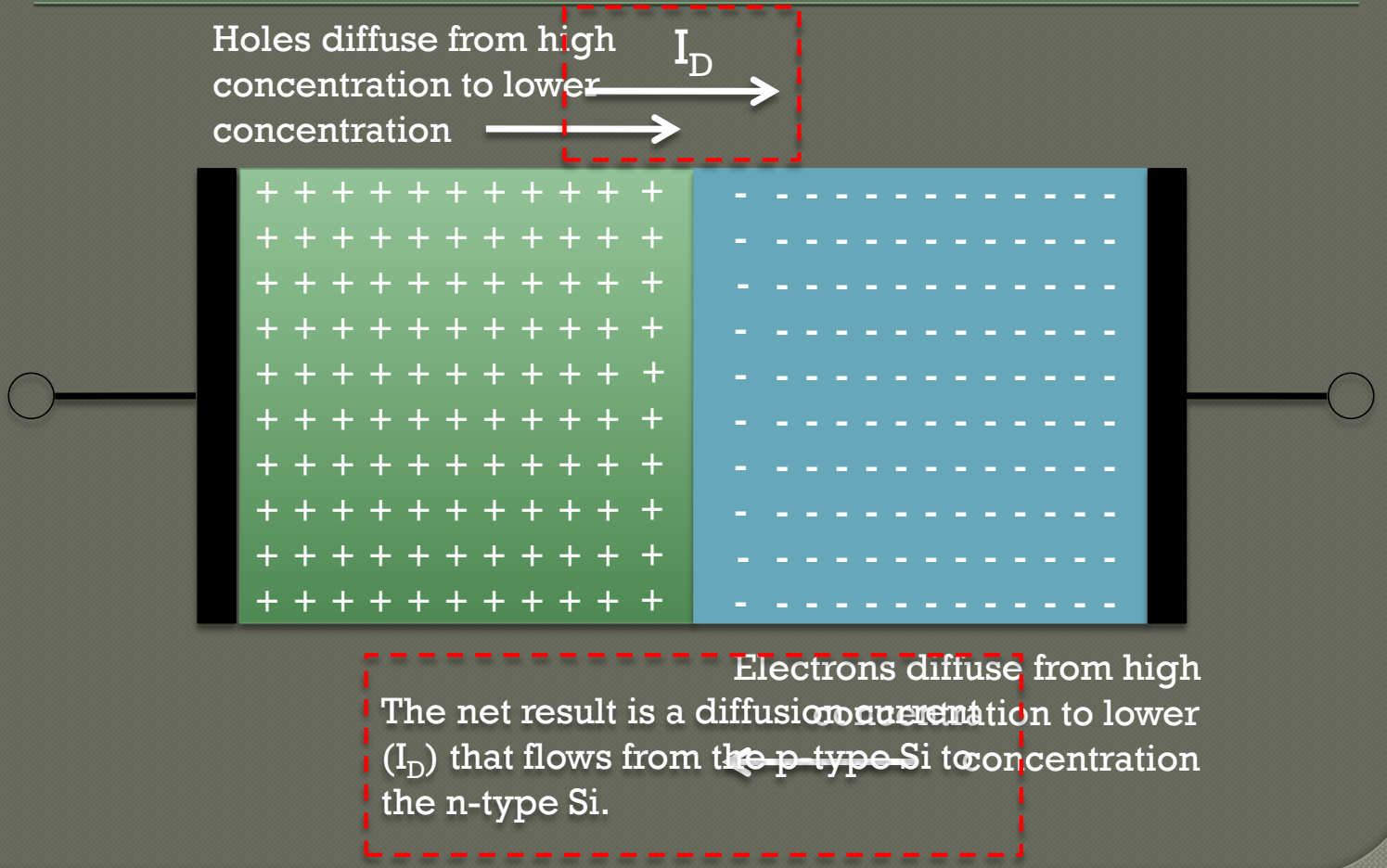
The pn junction



The pn junction: open–circuited

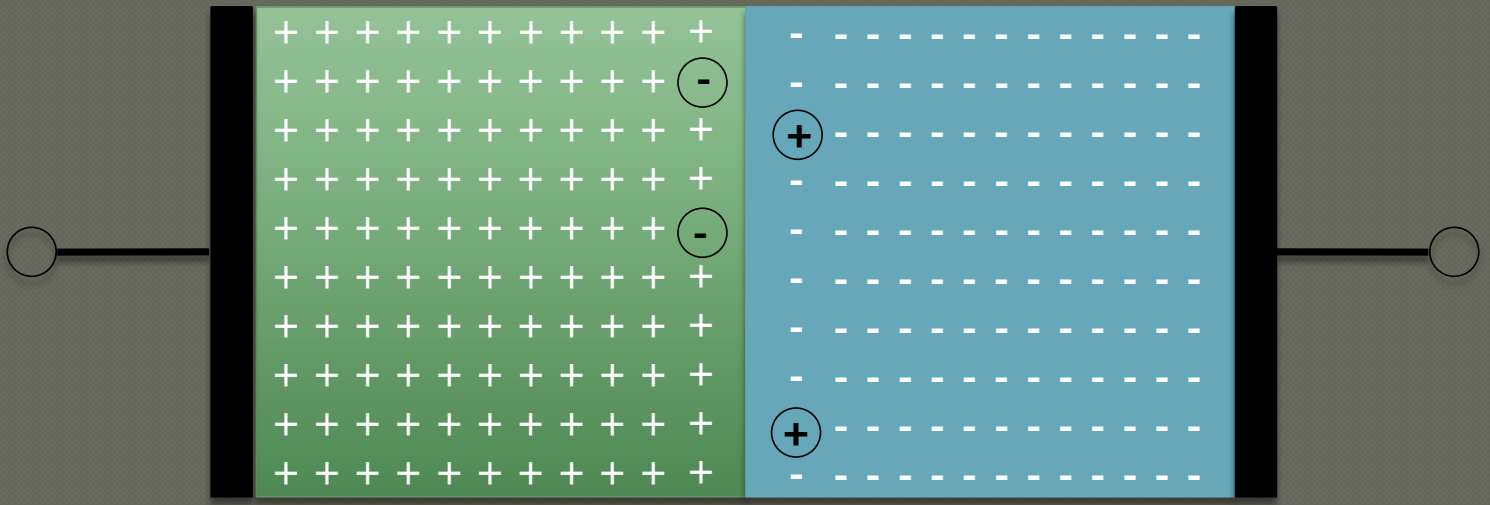


The pn junction: Diffusion Current



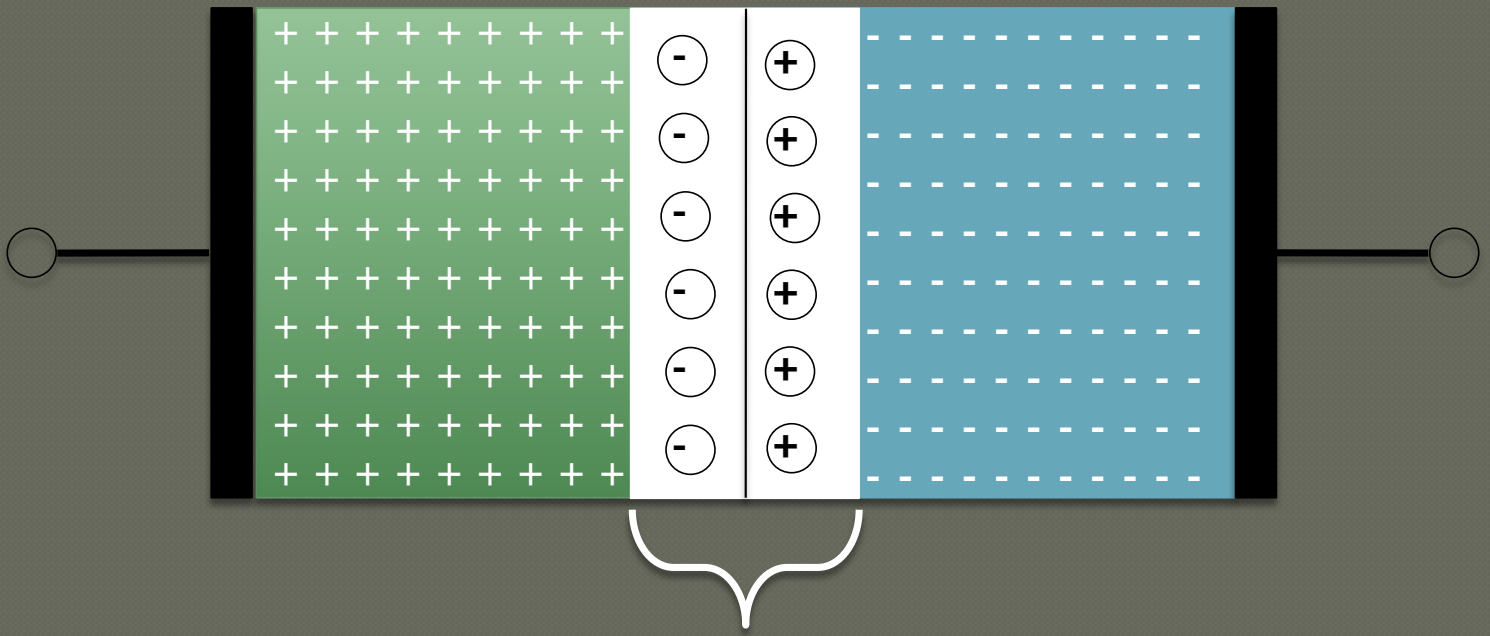
The pn junction: Depletion Region

- As diffusion occurs, electron-hole pairs are formed. This leaves uncovered or "bound" minority carrier charge near the junction.



The pn junction: Depletion Region

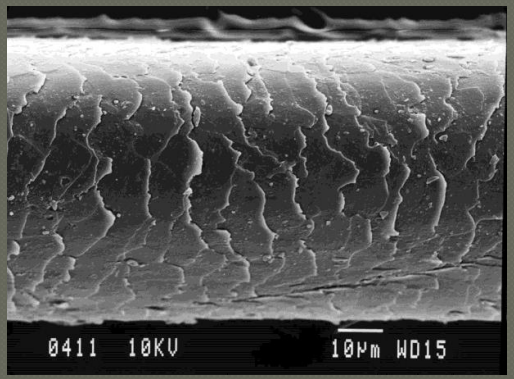
- Eventually, the area on each side of the junction becomes depleted of majority carriers.

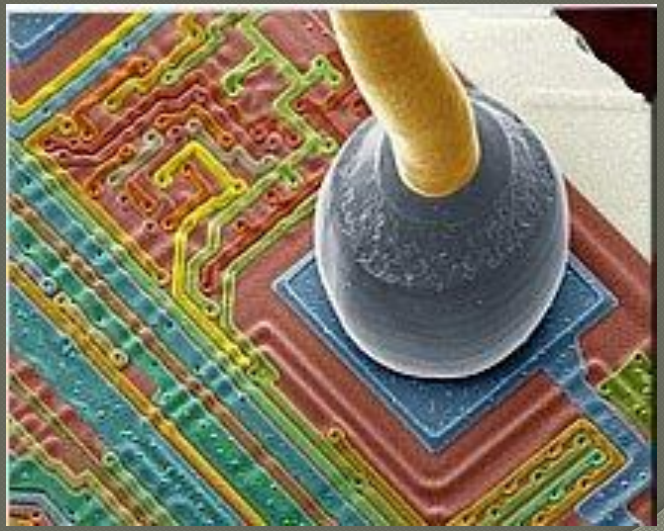


What's a micron?

- 1 micron = 1 x 10^{-6} meters

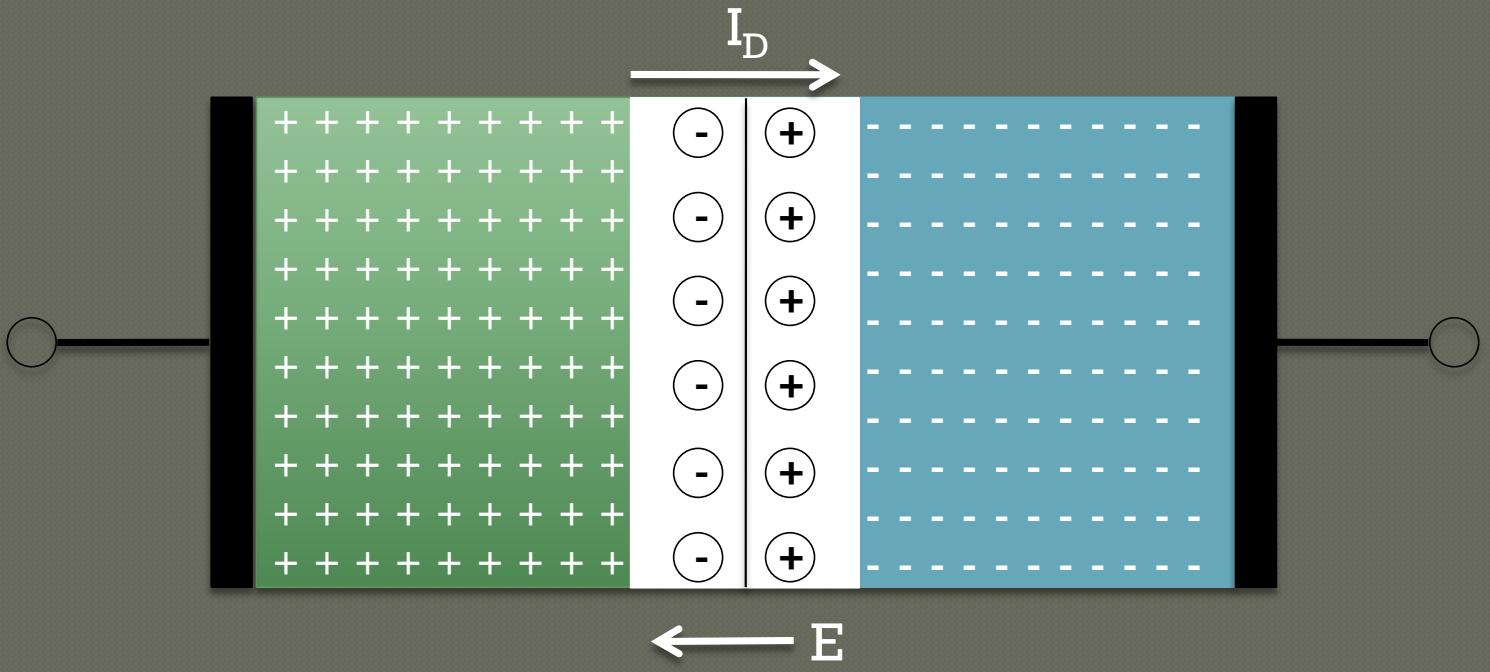
- Dust mite length: 250-300 microns
- Human hair diameter: 10-100 microns
- Red blood cell diameter: 7 microns





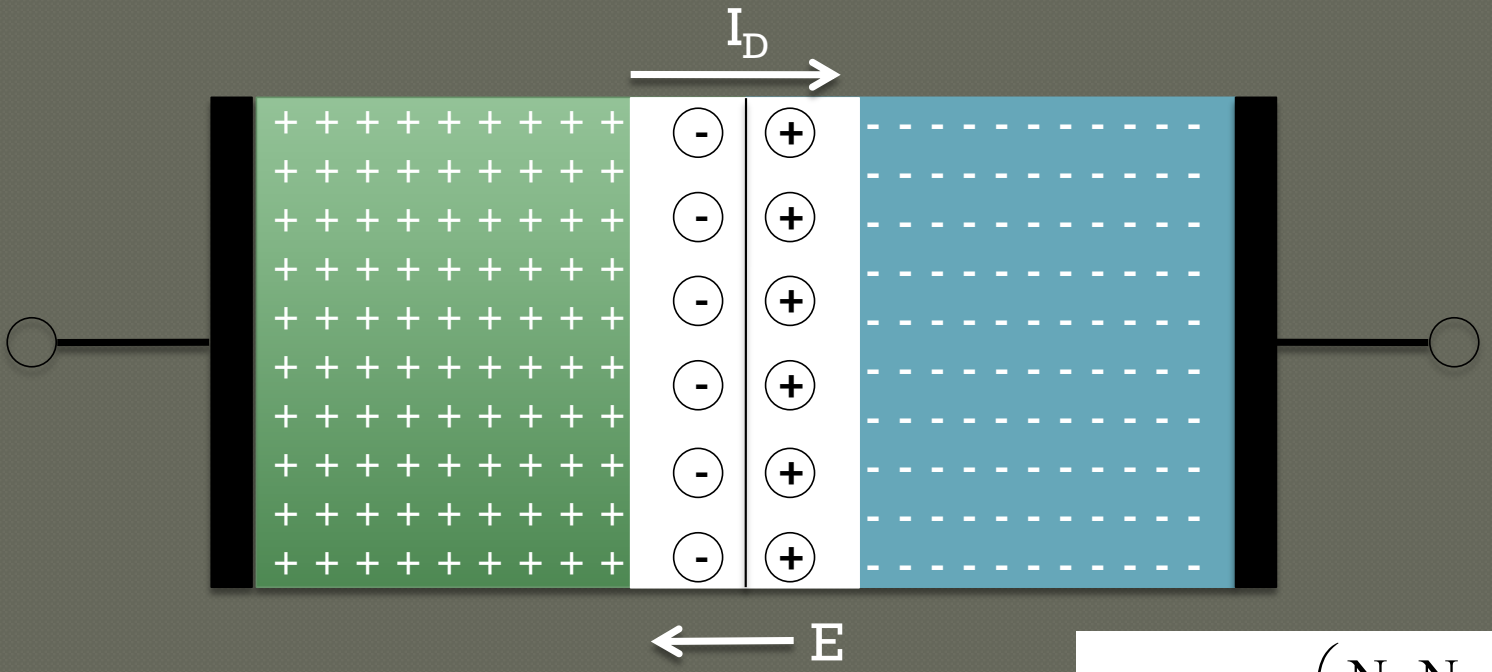
The pn junction: Barrier Voltage

- The charges on each side of the depletion region establish an electric field (i.e. a voltage drop across the region)



The pn junction: Barrier Voltage

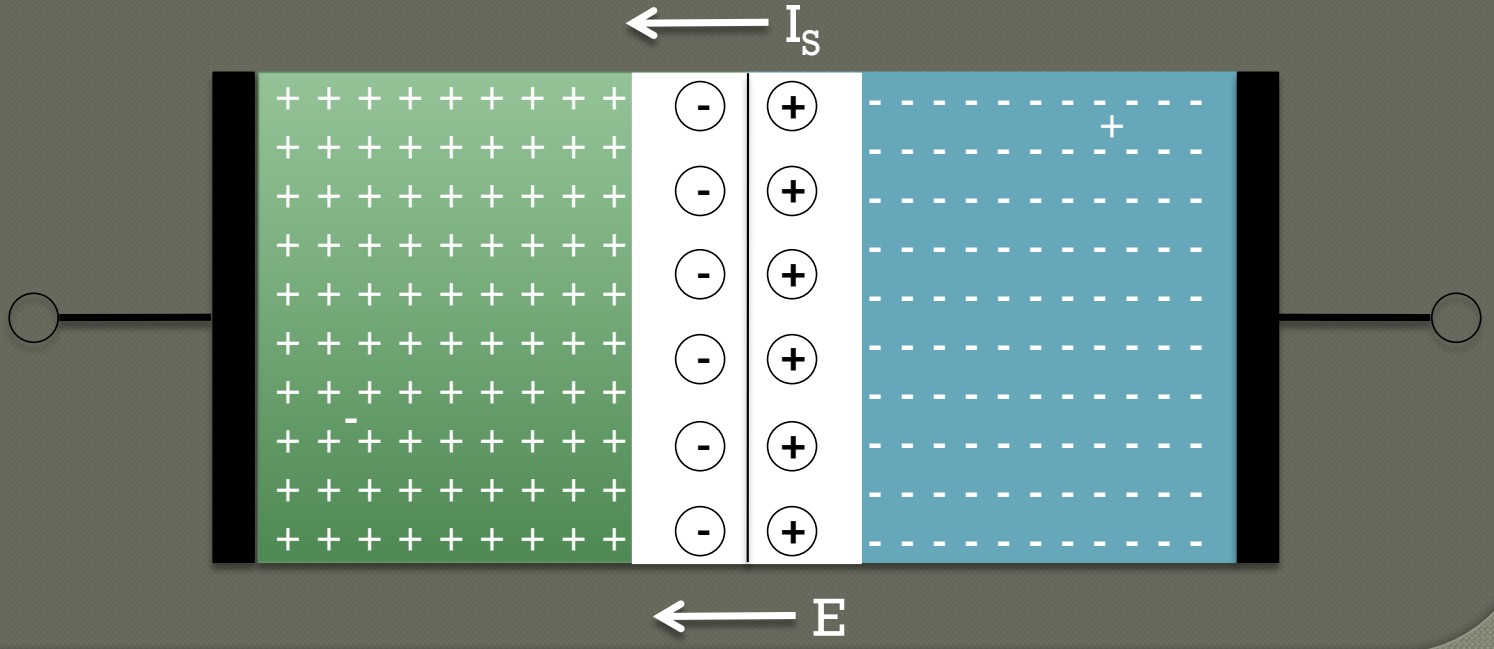
- This voltage drop – *the barrier voltage* - will limit the number of carriers that can diffuse across the region and thus limits I_D



$$V_O = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

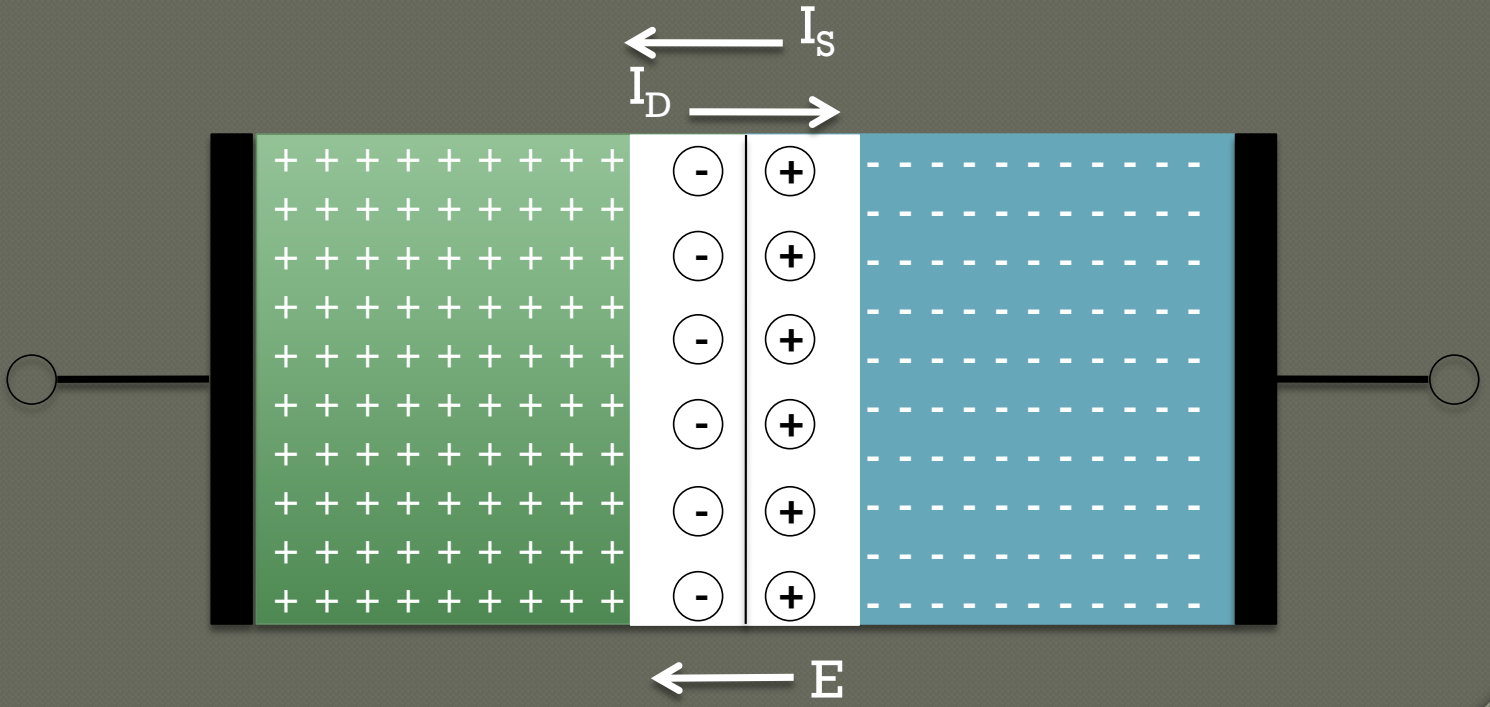
The pn junction: Drift Current

- Minority carrier drift current (I_S) occurs when thermally generated holes (n-type Si) and electrons (p-type Si) move towards the edge of the depletion region.
- The electric field sweeps the minority carriers across the junction creating current flow.



The pn junction: Equilibrium

- Under open-circuit conditions (i.e. no external voltage), the drift current will equal the diffusion current.
- The barrier voltage ensures this equilibrium.



The pn junction: Forward Bias

- When a voltage, V_F, is applied the barrier voltage is decreased by that voltage and the depletion region narrows.
- The diffusion current will increase.