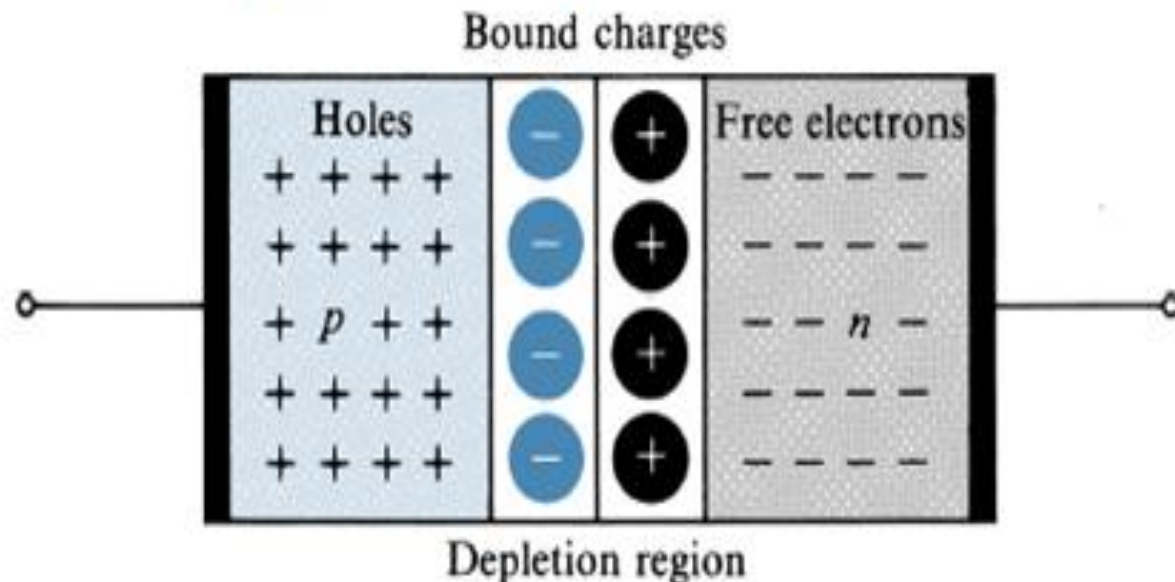


Semiconductor Diode

PN Junction

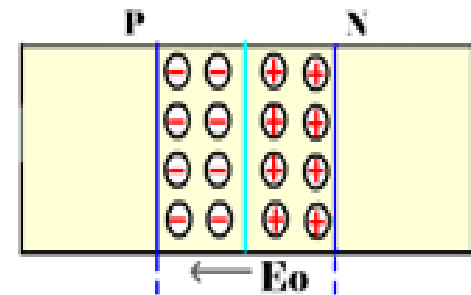
- **N-type** materials: Doping Si with a Group V element, providing extra electrons (n for negative).
- **P-type** materials: Doping Si with a Group III element, providing extra holes (p for positive).

What happens when P-type meets N-type?

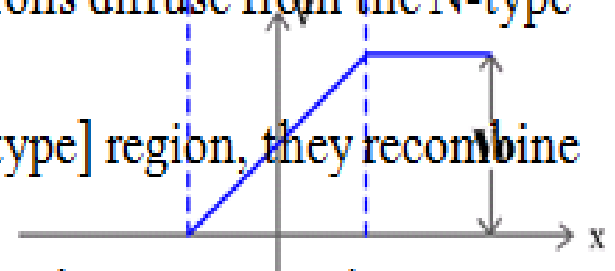


PN Junction

What happens when P-type meets N-type?

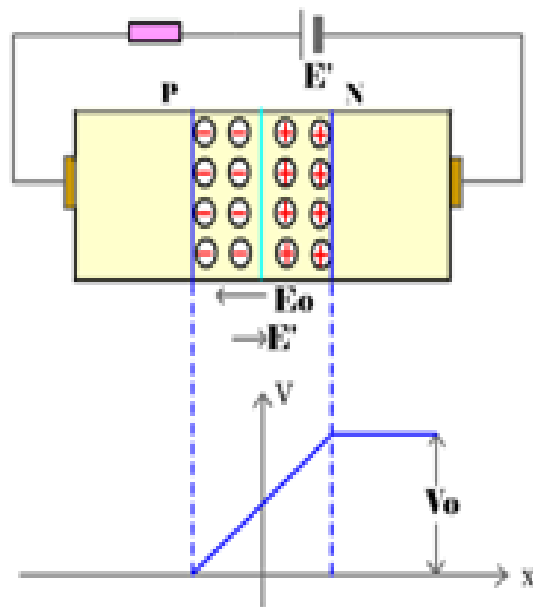


- Holes diffuse from the P-type into the N-type, electrons diffuse from the N-type into the P-type, creating a diffusion current.
- Once the holes [electrons] cross into the N-type [P-type] region, they recombine with the electrons [holes].
- This recombination “strips” the n-type [P-type] of its electrons near the boundary, creating an electric field due to the positive and negative bound charges.
- The region “stripped” of carriers is called the space-charge region, or depletion region.
- V_0 is the contact potential that exists due to the electric field. Typically, at room temp, V_0 is 0.5~0.8V.
- Some carriers are generated (thermally) and make their way into the depletion region where they are whisked away by the electric field, creating a drift current.



PN Junction

Forward bias: apply a positive voltage to the P-type, negative to N-type.

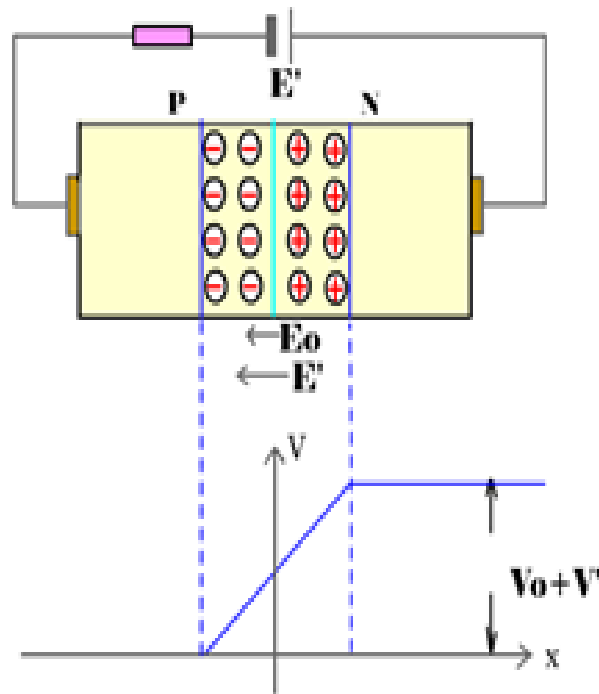


Add more majority carriers to both sides
→shrink the depletion region→ lower V_0
→diffusion current increases.

- Decrease the built-in potential, lower the barrier height.
- Increase the number of carriers able to diffuse across the barrier
- Diffusion current increases
- Drift current remains the same. The drift current is essentially constant, as it is dependent on temperature.
- Current flows from p to n

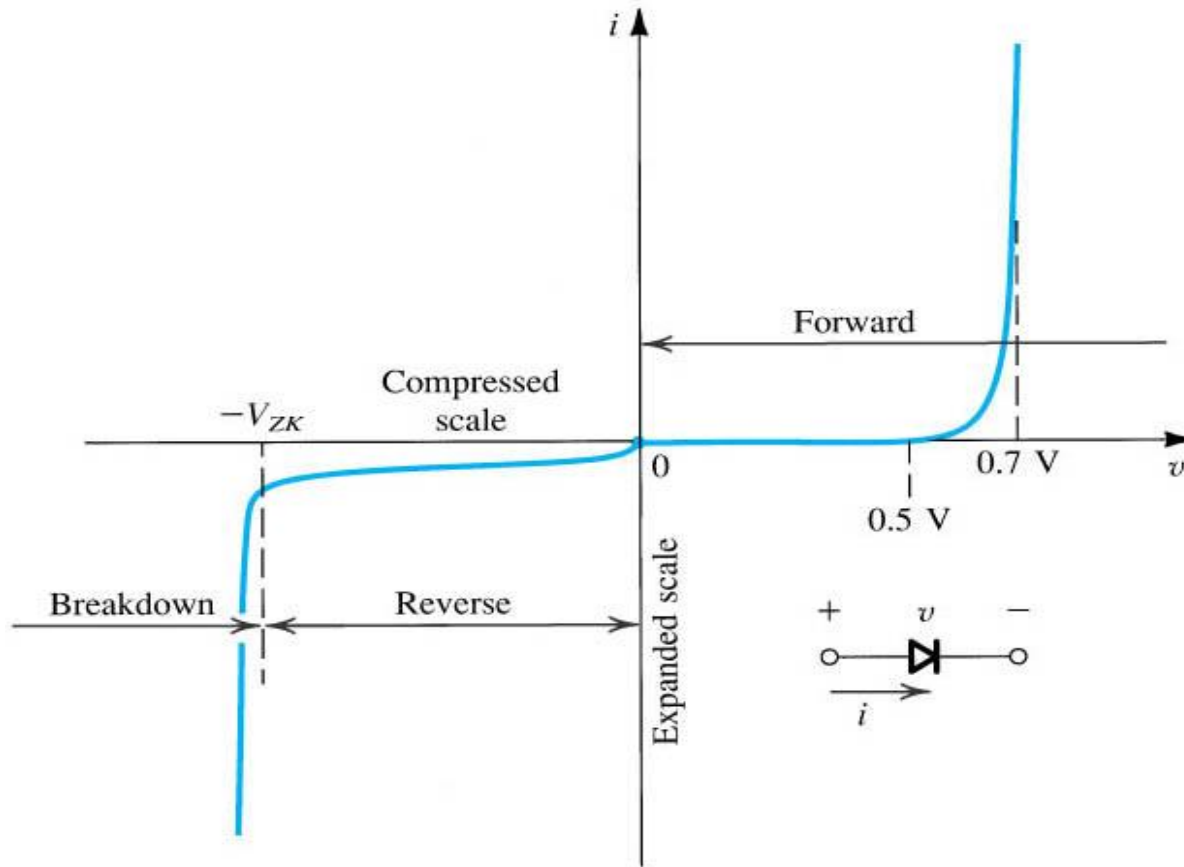
PN Junction

Reverse bias: apply a negative voltage to the P-type, positive to N-type.



- Increase the built-in potential, increase the barrier height.
- Decrease the number of carriers able to diffuse across the barrier.
- Diffusion current decreases.
- Drift current remains the same
- Almost no current flows. Reverse leakage current, I_S , is the drift current, flowing from N to P.

I-V Characteristics



The diode $i-v$ relationship with some scales expanded and others compressed in order to reveal details