Band Diagrams

Semiconductors

- Band gaps:
  - diamond: 580 kJ/mol
  - silicon: 105 kJ/mol
  - germanium: 64 kJ/mol
- Pure Si or Ge conduct well at high T or if exposed to light. Why would that increase conductivity?
Semiconductors

- Energy from heat, light, etc.
- With electrons promoted, material begins to conduct

Doped Semiconductors

- Pure elemental (Si, Ge, etc.) semiconductors only useful where light or heat can be supplied to promote electrons
- More useful devices are made using “doped” semiconductors

n-Type Semiconductors

- Initially, valence band full, conduction band empty
- Added e⁻ must go into conduction band
n-Type Semiconductors

- Added electron(s) can be promoted easily, so can serve as charge carriers
- How can we add extra electrons to Si?

n-Type doping

- "Dope" with phosphorous (or another element with more valence e\(^{-}\)'s)
- Typical n-type devices contain on the order of 0.00001% dopant
- Energy levels for dopant atom will be slightly different than for the silicon.

n-Type Semiconductors

- In a real material, we can't add just one electron
- Extent of conductivity depends on # of e\(^{-}\)'s added
p-Type Semiconductors

- Initially, valence band full, conduction band empty

Removing an electron creates a “hole” in valence band

Holes allow promotion of electrons within the valence band, so they serve as charge carriers

How can we remove electrons from Si?

“Dope” with aluminum
Small, controllable doping levels, similar to n-type

As for n-type, can’t really remove just one electron
Extent of doping determines conductivity
Semiconductor Devices

• Properties of n & p type differ slightly. Most real devices contain combinations of the two.
• Most important circuit functions are controlled by “junctions” where n & p type materials meet.

p-n Junction

Apply voltage - current flows

Opposite voltage - no current