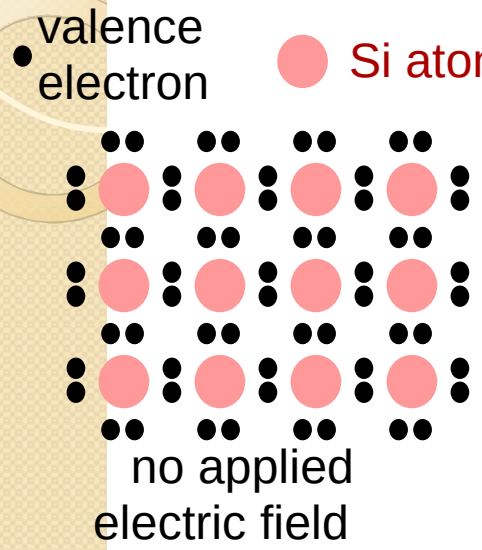
LECTURE 2

Topics to be covered

- Factors affecting conductivity of material
- Mean Free Path
- Conductivity
- Superconductivity

Electron and hole conductivity

- In a semiconductor, there can be electrons ***and*** holes:



- Total Electrical Conductivity thus given by:

$$\sigma_i = n|e|\mu_e + p|e|\mu_h$$

holes/m^3

hole mobility

electrons/m^3

electron mobility

Extrinsic conductivity—p type

- We can do the same thing with “acceptor dopants.”
- Every acceptor generates excess mobile holes ($p=N_a$).
- Now holes totally outnumber electrons, so conductivity equation switches to p domination.

$$\sigma = n|e|\mu_e + p|e|\mu_h \approx p|e|\mu_h = N_a|e|\mu_h$$

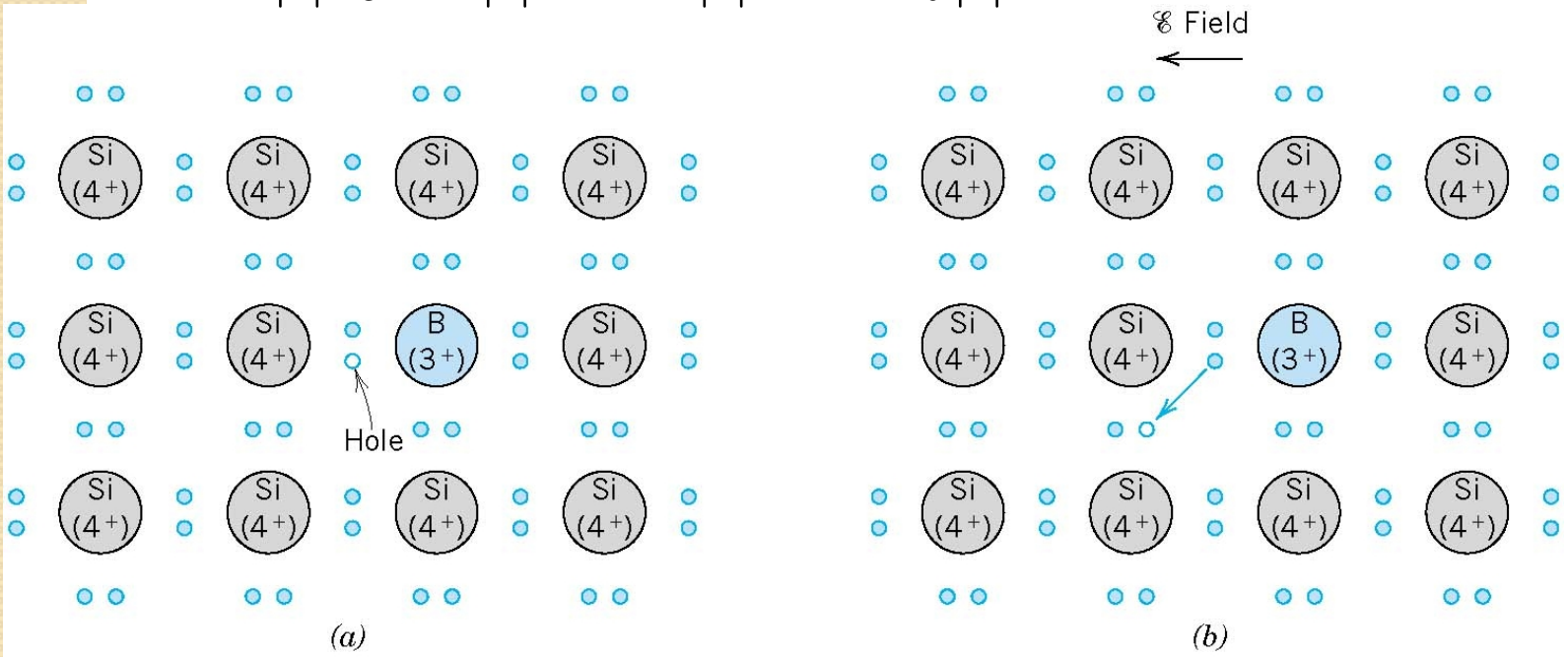
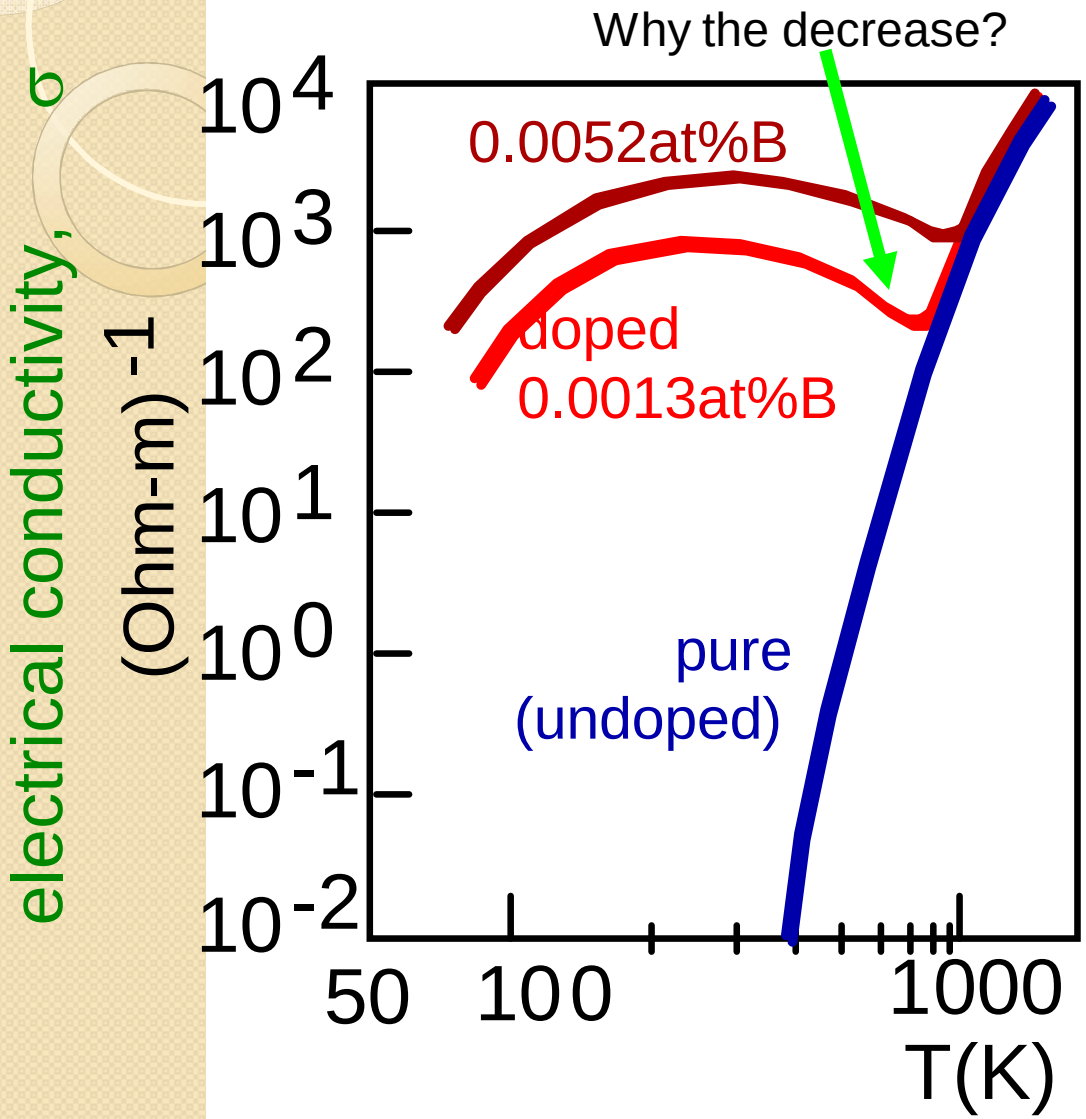


FIGURE 18.13 Extrinsic *p*-type semiconduction model (electron bonding). (*a*) An impurity atom such as boron, having three valence electrons, may substitute for a silicon atom. This results in a deficiency of one valence electron, or a hole associated with the impurity atom. (*b*) The motion of this hole in response to an electric field.

Actual Conductivity vs. Temperature



- Conductivity is not as flat as free charge concentration.
- This is because mobility is always decreasing with increased temperature (more scattering)

Adapted from Fig. 19.15, *Callister 5e*. (Fig. 19.15 adapted from G.L. Pearson and J. Bardeen, *Phys. Rev.* **75**, p. 865, 1949.)

Superconducting

Magnet Division
USPAS Course on Superconducting Accelerator Magnets, June 23-27, 2003
Slide No. 9 of Lecture II Ramesh Gupta, BNL

Critical Surface of Type II Low Temperature Superconductors (LTS)

• Conductors that are currently being used in building accelerator magnets are Type II
Low Temperature Superconductors.
• NbTi, a ductile material, has been the conductor of choice so far. All accelerator
machine magnets have been and are being built with this superconductor.
• For future high field magnet applications one must turn to Nb3Sn, etc.(higher Bc2).
However, Nb3Sn is brittle nature, and presents many challenge in building magnets.

Difference Between the Superconductor

Requirements for Superconducting RF Cavities and Superconducting Magnets for Particle Accelerators

• For superconducting RF cavities, one needs very high purity materials, with no defects.

• For superconducting magnets, the presence of certain defects is essential, as without those defects, it can not stand those high fields.