3.091 Solid State Chemistry: Week 8

Logan Pachulski

April 12th, 2019

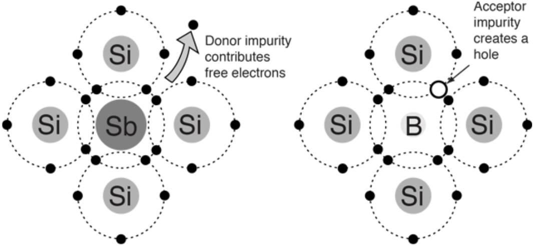
Progress Update

Over the past week I have been introduced to:

1. Doping of semiconductors.
2. Crystal lattices and their features.

Doping of semiconductors.

“Doping” of semiconductors is the act of adding in minuscule quantities of impurities to control the electronic properties of the semiconductor.
Consider adding boron or antimony to a lattice of silicon:



The antimony fills all molecular orbitals, but brings an electrons that falls away. The boron brings one less electron than necessary, creating a hole.

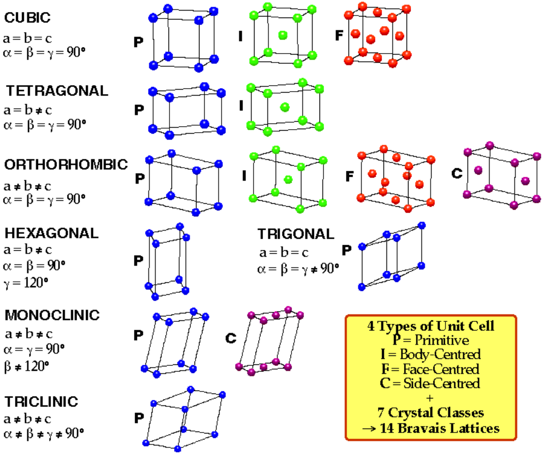
Doping of semiconductors (Continued).

But why does this affect the electric properties of a semiconductor? We have the proportionality that the current

$$\sigma \propto 2n_i + n_{ex}, \tag{1}$$

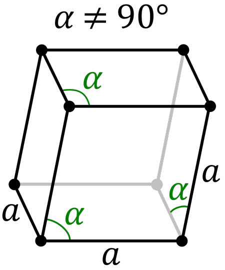
where n_i is the sum of the concentration of holes and electrons in the base crystal, and n_{ex} is the concentration of electrons in the conduction band. Adding Sb to a Si lattice (This is called n-type doping by the way) increases n_{ex} and thus σ; Adding B drives σ up in a similar manner (This is called p-type doping).

A crystal lattice takes on a variety of repeating shapes; 11 of them more specifically, with 14 "Bravais lattices" within them:



Features of the crystal structure.

As seen on the previous slide, crystal lattices have structure and associate side lengths and angles, defined by a variety of letters; for clarity of ideas, we let a, b, c be the side lengths, and α, β, γ be the angles associated with those sides. Consider the rhombohedral lattice:



We have that $\alpha = \beta = \gamma \neq 90$ degrees, and that $a = b = c$. Notice that all crystal lattices are variations of parallelepipeds!

Example Problem: N-type silicon (Statement)

Problem: You wish to make n-type silicon. Select all suitable dopant atoms from the following list:

1. P
2. B
3. Mg
4. Ga
5. As
6. In
7. Sb
8. Al
9. Tl
10. H

Example Problem: N-type silicon (Solution)

Solution: We simply look for all elements in the list located one column to the right of silicon: See that this is P, As, Sb.