Notes for ECE 30500 - Semiconductor Devices

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January 15, 2025

These are lecture notes for Fall 2025 ECE 30500 by professor Haitong Li at Purdue. Modify, use, and distribute as you please.

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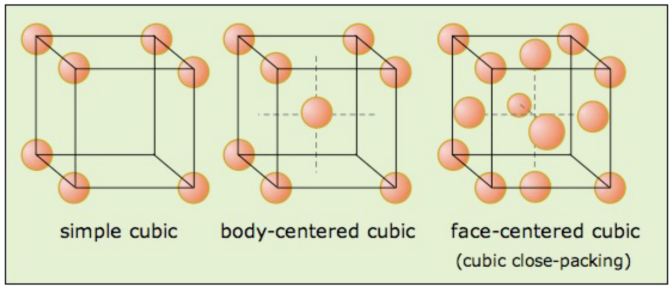
Properties of Silicon

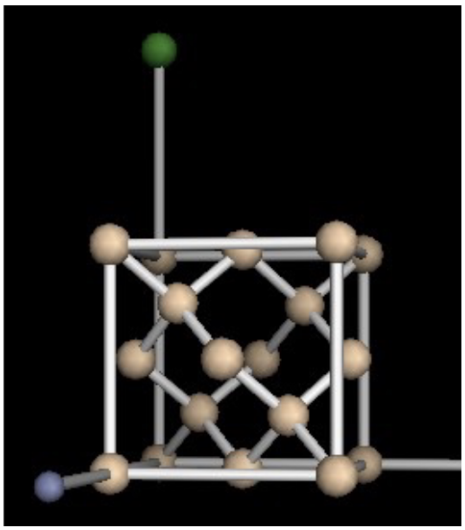
The core of semiconductors lies in the silicon transistor. But, why silicon (**Si**)?

- Si is the second most common element on Earth.
- It is easily purified, and grown defect free, with less than 1 impurity in 10^9 atoms.
- Reasonably good electronic properties
- Resilient to harsh environments
- Excellent mechanical properties
- There are three forms of Si:
  - In a Si crystal, atoms are arranged in an orderly array, allowing arrangements to be easily reproduced.
  - In poly-crystalline Si, many crystalline subsections exist.
  - In amorphous Si, there are no long range patterns or arrangements.

The unit cell is a portion of any crystal that could be used to reproduce the crystal.
The primitive cell is the smallest possible unit cell.
In essence, a unit cell is a subset of a lattice that can be moved in the x, y, z axis, and cover the entire lattice. (*Note the absence of rotation movements.*)
Some examples of cells are the following:



Note: the image is missing a corner atom.
Another important cubic unit cell is the diamond cubic unit cell with 8 silicon atoms in the cell:



Density (diamond cube cell)

Lattice constant: $a = 5.3407 Ang$
Atomic mass: 28.055amu
Density: $\rho = \frac{8*28.0855*1.6605*10^{-23}}{(5.4307*10^{-10})^3} kg/m^3 = 2.3296 g/cm^3$

Miller Indices

Let us consider a plane that intercepts the axes at $x_{int}, y_{int}, z_{int}$. The equation of the plane is:

$$\frac{x}{x_{int}} + \frac{y}{y_{int}} + \frac{z}{z_{int}} = 1$$

The vector that is perpendicular to this plane will have the same components as the Miller indices.
The Miller indices are defined as $LCM * (\frac{1}{x_{int}}, \frac{1}{y_{int}}, \frac{1}{z_{int}})$.