Lecture | | 9/2/15 | V

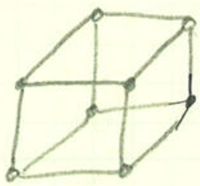
1. Single Crystal Silicon (SCS) → structure and properties

→ has a regular crystal lattice throughout the entire bulk

Si → atomic number of 14 → beneath C in the periodic table (expect some similar properties to C)

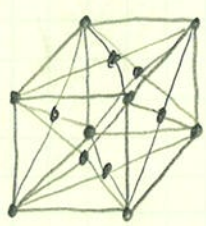
→ Group IV element, has 4 e^-'s to share in covalent bonds with 4 neighboring Si atoms in the lattice

Simple Cubic Structure



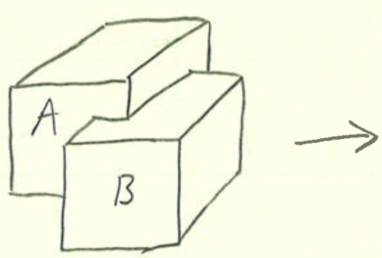
→ 8 atoms in the unit cell

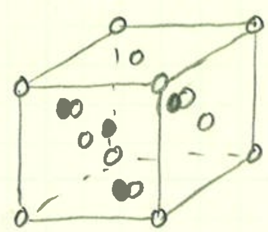
Si has a Face-Cubic-Center (FCC) structure



→ 14 atoms in the unit cell

However, Si has 4 extra atoms in the center → imagine the merging of 2 FCC cystals together



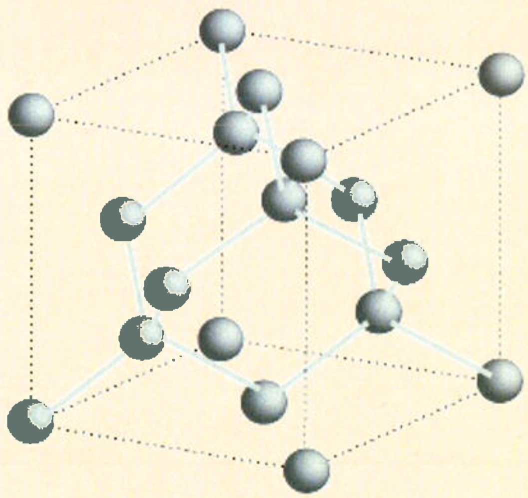


● → A

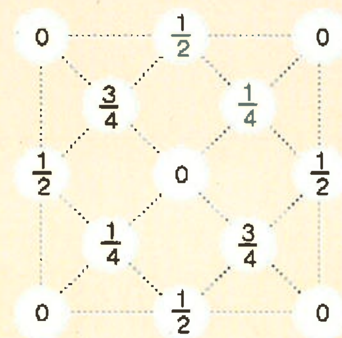
o → B

http://hyperphysics.phy-astr.gsu.edu/hbase/Solids/sili2.html

Silicon Crystal Structure



after Kittel



The above illustration shows the arrangement of the silicon atoms in a unit cell, with the numbers indicating the height of the atom above the base of the cube as a fraction of the cell dimension.

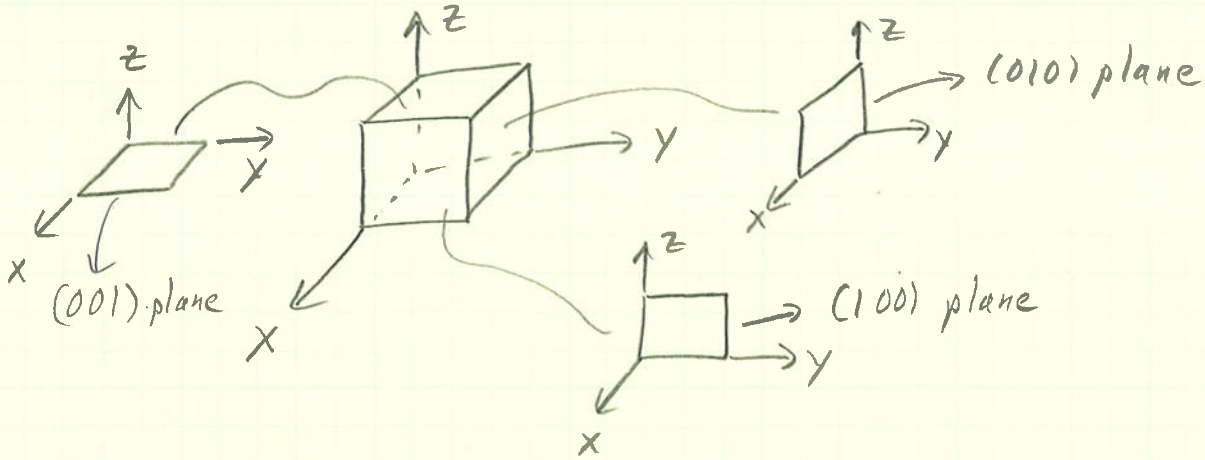
Silicon crystallizes in the same pattern as diamond, in a structure which Ashcroft and Mermin call "two interpenetrating face-centered cubic" primitive lattices. The lines between silicon atoms in the lattice illustration indicate nearest-neighbor bonds. The cube side for silicon is 0.543 nm. Germanium has the same diamond structure with a cell dimension of .566 nm.

2. Si lattice has 3 types of crystal planes

→ plane dependant properties (mechanical, electrical, processing, etc.)

→ the planes are identified according to the "Miller Indices"

Miller Indices → based on a, b, c and a cubic representation

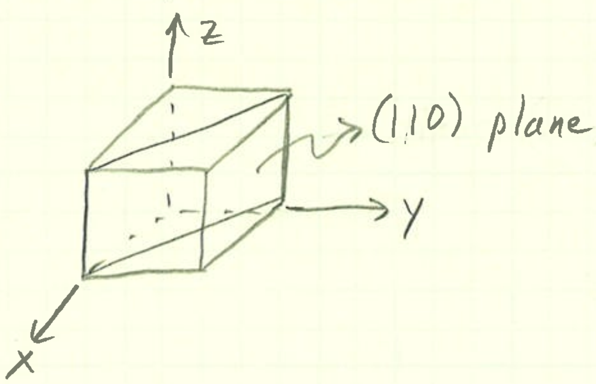


(100), (010) and (001) planes are equivalent and belong to the {100} family

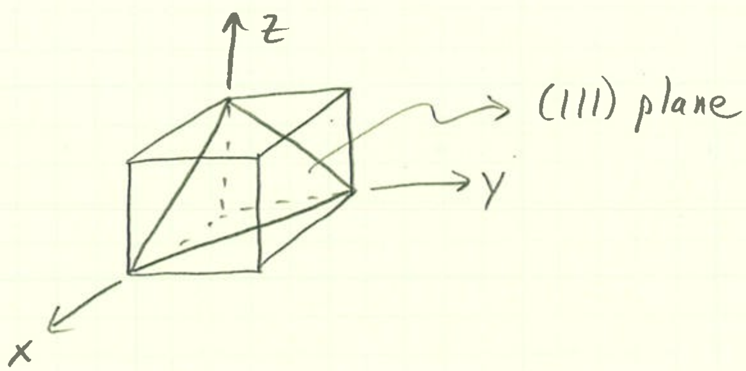
→ ⟨100⟩ represents the vector direction normal to the {100} family of planes

(100) → called the Front Face Plane

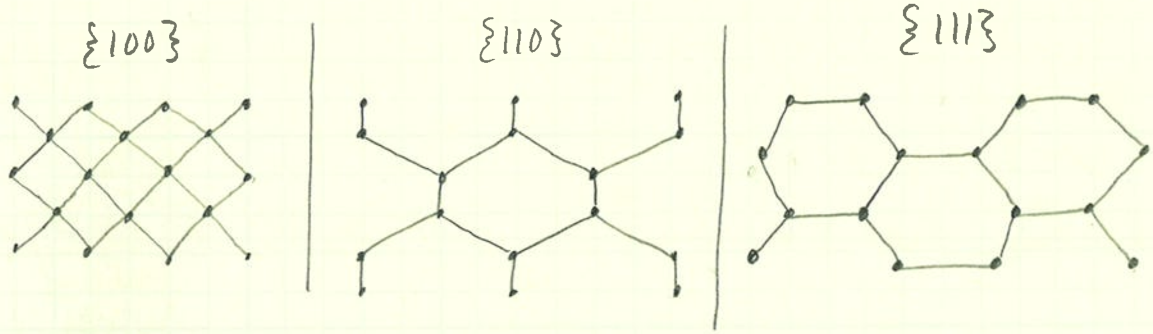
a. Consider the Diagonal Face Plane



b. Consider the Incline Face Plane



3. Si lattice structure in plane directions → along the Si wafer surface of that crystal plane type



Plane Characteristics

(100) → least number of atoms → least mechanically strong, ∴ easiest to work with, used for MOS transistors, often used for bulk micromachined MEMS

(110) → cleanest surfaces in microfabrication

(111) → highest number of atoms → mechanically strongest plane, ∴ toughest to work with, often used for BJT transistors due to high mobility of charge carriers in the <111> direction