Lecture Outline

• The diamond structure (Si, Ge)
• Atomic bonding
• Impurities in semiconductor materials
Identification of Wafer Surface Crystallization

Flats can be used to denote doping and surface crystallization.
The Diamond Structure

- Materials possess diamond structure: Si, Ge
- 8 atoms per unit cell
- Any atom within the diamond structure will have 4 nearest neighboring atoms
The Zincblende Structure

- Difference with the diamond structure: two different types of atoms (e.g., GaAs)
- Each Ga atom has four nearest As neighbors and each As atom has four nearest Ga neighbors
What Decides the Atomic Structure and Bonding?

A fundamental law of nature: the total energy of a system in thermal equilibrium tends to reach a minimum value

Crystal structure

Type of bond or interaction between atoms

Type of atoms
Bohr Model of An Atom

Numbers shown are mass number $A$:

$A = N + Z$

$N$: number of neutrons

$Z$: number of protons (atomic number)
Types of Atomic Bonds

- Ionic bonds
- Covalent bonds
- Metallic bonds
- Van der Waals bond
Ionic Bond

- Often found in compounds composed of metal element and non-metal element
- Electrons are transferred to form a bond
- Coulomb interaction between charged ions
- Bonding energy 150-370 kcal/mol \((1\text{cal} = 4.184\ \text{J})\)
Covalent Bond

- Often found between non-metal atoms
- Electrons are shared to form a bond
- Examples: Si, Ge, O$_2$, N$_2$
- Bonding energy 75-300 kcal/mol
Metallic Bond

- Valence electrons form electron cloud for bonding
- Examples: Na, Al, Cu
- Bonding energy 25-200 kcal/mol
Van der Waals Bond

- Bonding force between atoms molecules
- Secondary bonding force
- Weak bonding (bonding energy <10 kcal/mol)
Imperfections in Solids

Point Defects

Vacancy – a lattice position that is vacant because the atom is missing

Interstitial – an atom that occupies a place outside the normal lattice position

Linear Defects—Dislocations

Dislocation – an entire row of atoms are missing for its normal lattice site
Impurities in Solids

1 - interstitial impurity
2, 3 - substitutional impurity
Requirements for Chapter 01

- Basic crystal structures (SC, FCC, BCC)
- Crystal planes (100), (111), (110)
- Calculation on volume density and surface density
- Si crystal structure
  - Diamond structure
  - Every atom has four nearest neighboring atoms
  - 8 atoms/per unit cell
  - bounding type: covalent bonding

Related content from the textbook: Chap. 1.1-1.5