Experiment No. 3

Crystal Structures

INTRODUCTION:

The crystal structure of several metals is composed of a unit cell of cubic geometry with atoms located at all corners of the cubes as well as the center of all faces. Such an arrangement is referred to as a face-centered (FCC) crystal structure. Common metals exhibiting the FCC structure include copper, aluminum, silver, and gold. Each corner atom in the FCC structure is shared by eight neighboring unit cells, and each face-centered atom is shared by two-unit cells.

Another common metallic structure known as the body-centered cubic (BCC) is also composed of a unit cell of cubic geometric with atoms located at the corners of the cube and a single atom in the center of the cube. Similar to the FCC structure, the corner atoms of the BCC crystal are shared by eight unit cells, while the center atom is not shared at all.

The last common crystal structure exhibited by metals is not based on cubic structure, instead of a cubic geometry, the hexagonal-closed packed (HCP) structure consists of three planes of atoms stacked together. The top and bottom planes are symmetrical and consists of six atoms arranged in a hexagon with an additional atom in the center of a hexagonal face. The midplane consists of three interior atoms that complete the stacking arrangement.

OBJECTIVES:

1. To learn more about the basic crystal structures that metal atoms form (BCC, FCC, and HCP) with the aid of hard-sphere representations.
2. To understand how metal atoms packing arrangements exist such as face centered cubic (FCC) and hexagonal closest packing (HCP); and
3. To obtain a tangible grasp of the similarities and differences among each of these crystal structures

MATERIALS AND SUPPLIES:

Ping-ping balls, 31 balls
Glue with glue gun or other adhesives
Caliper
Protractor and straight edge

SAFETY:

When using hot-melt glue guns, be extremely careful when handling the glue gun as the tip will likely exceed 160^{o}F and can cause burns. Also, be cautious of recently dispensed glue as it is also hot and has the potential to cause burns.

PRODCEDURE:

Construction of FCC Model (14 ping pong balls)

1. Measure the diameters the diameters of ping-pong balls and determine the mean value of the diameter of ping-pong balls used in this activity.
2. Assemble the top and bottom of the FCC structure using five (5) ping-pong balls for each.
3. Orient the balls in the shape of a plus sign "+" using the straight edge positioning at 90^{o}.
4. Assemble the remaining four ping-pong balls in the shape of a perfect square.
5. Complete the model by combining the three sections together.

Construction of a BCC Model (9 ping-pong balls)

1. Measure the diameters the diameters of ping-pong balls and determine the mean value of the diameter of ping-pong balls used in this activity.
2. Assemble the diagonal plane of the BCC structure using five ping-pong balls.
3. Orient the spheres in a flattened "x" shape.
4. While holding the assembly at an inclined of 45^{o}, position two additional ping-pong balls in the correct location on the bottom of the structure.
6. Reposition the assembly consisting of seven ping-pong balls to facilitate adding the last two pingpong balls to complete the BCC structure.

Construction of HCP Model (17 ping-pong balls)

1. Measure the diameters the diameters of ping-pong balls and determine the mean value of the diameter of ping-pong balls used in this activity.
2. Assemble the top and bottom of the HCP structure using seven ping-pong balls for each.
3. Start with a triangle comprised of three ping-pong balls, and then add a fourth ping-pong ball to form an elongated diamond.
4. A fifth ping-pong ball will form a stacking arrangement of two ping-pong balls on the bottom, and three ping-pong balls on the next level.
5. Two additional ping-pong balls on top of the row with three will form a hexagon with an additional ping-pong ball in the center.
6. Repeat the steps above for the top of the model.
7. Assemble the remaining three ping-pong balls in the shape of a triangle.
8. Complete the model by combining the three sections together.

Mean diameter of the ping-pong balls:

QUESTIONS:

1. Which packing arrangement, FCC or HCP, is denser?

2. What is the difference in FCC and HCP arrangements?

3. About how small would an atom have to be to fit in an interstitial hole in an FCC or HCP crystal structure?

CONCLUSION: