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UNIT -IV CRYSTAL PHYSICS

TOPIC – II   PLANES IN A CRYSTAL AND MILLER INDICES
1.9 MILLER INDICES

We imagine certain planes in the crystal which contains large concentration of atoms. The physical properties are dependent on concentration of atoms at planes. The orientation of the plane can be described by the intercepts of the plane with three crystallographic axes. In figure 1.9, a plane is drawn which cuts the three crystallographic directions. It has one unit in the x-axis, three units in the y axis and one unit in the z axis. The intercept values are (1,3,1).
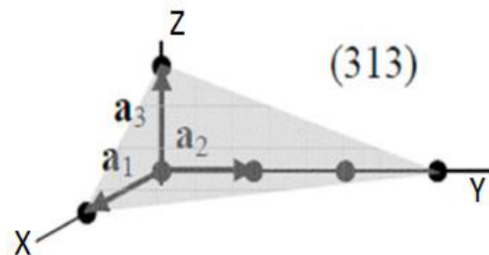

Fig 1.9

Miller suggested a better way for the representation of a plane in a crystal, and the indices are called as Miller indices.

The procedure for finding the Miller indices for a plane is illustrated as follows:

1. Determine the intercept of the plane on the three coordinate axes in terms of lattice constant. In the above example the intercepts are (1,3,1)
2. Take a reciprocal of these intercepts. In the above example the reciprocals are (1/1, 1/3, 1/1).
3. Reduce the reciprocals by whole numbers by multiplying each with LCM which gives the Miller indices of concerned plane. In the example 3,1,3
4. Enclosed these numbers in square brackets. The miller indices of the plane in the figure 1.10 are [3,1,3]

Example:

Find the miller indices of the following planes given in figure 1.10 (a, b, c).
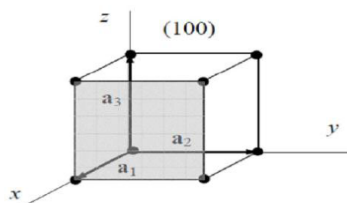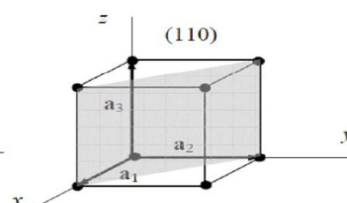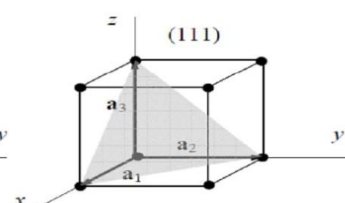

Fig 1.10 (a)   Fig 1.10(b)   Fig 1.10(c)

1. The plane is at a distance of one unit to x- axis, ∞ distance to both y and z-axes. The

intercepts are $1,\infty,\infty$.

2. The reciprocals are $1/1, 1/\infty, 1/\infty$. Hence, Miller indices are [1 0 0] shown in fig 1.10 (a).

3. The plane touches the x-axis at one unit distance-axis at one unit distance and does not touch to the z-axis. The intercepts are 1, 1, ∞. The reciprocals of the intercepts are 1/1, 1/1, 1/∞. The miller indices are [1 1 0] shown in fig 1.10 (b).

4. The plane intercepts are 1, 1, 1, reciprocals of the intercepts are 1, 1, 1, Hence the Miller indices are [1 1 1] shown in fig 1.10 (c).

5. If the intercept of a plane to certain axes are in negative direction, then a bar should be kept on the indices.

Important features of Miller indices:

1. Miller indices describe the angular position of a plane with respect to the crystallographic axes but not their actual distances from the origin.

2. All equally spaced parallel planes have the same miller indices. Thus the Miller indices do not describe the angular position of a single plane but a set of parallel planes.

3. When the plane is parallel to one of the coordinate axis, it is said to meet that axis at infinity, i.e. the length of the intercept is infinity. The reciprocal of this parameter is zero and the Miller index for that intercept is zero.

4. It is only the ratio of indices that is important, i.e. [8, 4, 2], [4, 2, 1] represents the same set of planes.

5. A negative index shows that the plane cuts that axes on the negative side of the origin.

6. A normal to the plane with index number [h, k, l] is the direction of [h, k, l].

Procedure for drawing the plane for given Miller indices:

It is the reverse procedure for the finding of Miller indices when intercepts are given.

1. Take the reciprocal of Miller indices. If Miller indices are [h,k,l], the reciprocals are 1/h,1/k,1/l.

2. These reciprocals will give the intercepts of the plane on the three axes.

3. These intercepts are marked in the unit cell and a plane is drawn.

4. If intercept value is infinity on any axis, then the plane drawn is parallel to that axis.