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Determination of Crystalline Planes and Directions in Cubic System

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Abstract

A new method to draw the planes in cubic crystal system has been introduced. According to this method, it is very convenient to draw the planes along negative directions. The origin for the plane along all the directions can be identified easily by referring the standard table given in the text. After referring various technical papers, journals and textbooks it is noticed that there is no definite method and proper directions to draw planes in all possible directions of cubic crystals. In general, it is not a familiar technique for a teacher to explain fundamentals especially to draw the planes along negative directions. In addition to refer x, y and z directions according the available directions, it has been introduced an alternative method by considering a fixed site index for each plane. By using both reference axes and specific lattice point, one can draw all possible planes successfully including negative directions. It is an easy and new method to draw planes. Identification of origin to draw plane is important. Table provides the origin or lattice point out of eight points. Based on this table, it is possible to draw planes for n number of planes in all the possible directions including negative directions. Therefore, the information highlighted in the manuscript is very much helpful in the field of crystallography.

Keywords: *Planes, Cubic crystal system, Miller Indices*

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INTRODUCTION

Introduction will be given about planes and directions of the cubic crystal system using the idea of Miller indices. This will be done in the form of a review available in literature on the subject relevant to this report. The orientation of a surface or a crystal plane may be defined by considering the nature of the intercepts made by the planes along with the main crystallographic axis of the solid [1].

The application of the set of rules leads in the assignment of miller indices (*hkl*), a set of numbers which quantify the intercepts and thus may be used to uniquely identify the planes or surface [2–4].

The crystal lattice may be assumed to be regarded as an aggregate of set of parallel equidistant planes which passes through lattice points are known as lattice planes [5]. These lattice planes can be chosen in different ways for a given lattice. Miller suggested a scheme for indicating these planes of the lattice using integers. These indices are known as Miller indices of lattice planes. A simple method is introduced by the authors to draw the planes along any possible directions by referring a table given in the next section [6].

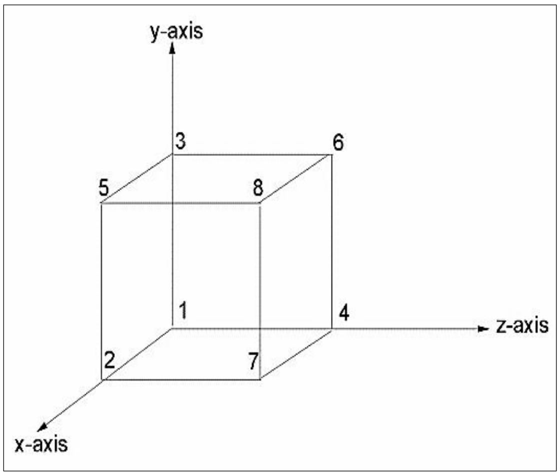


Fig. 1: *Representation of Lattice Points in a Cubic Crystal.*

METHODS

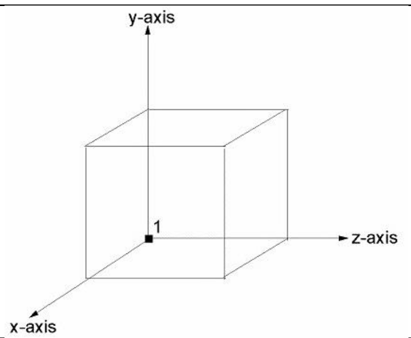
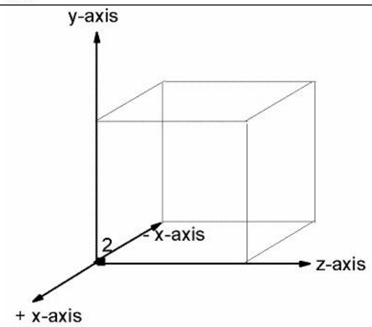
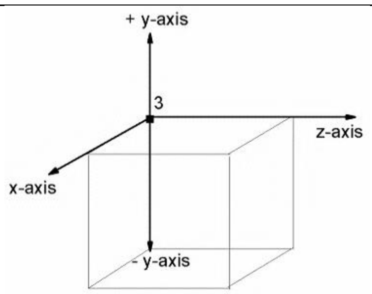
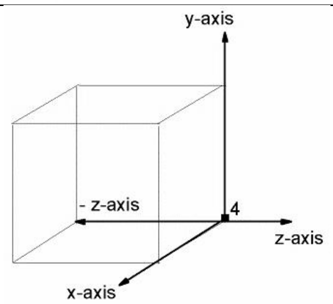
The researchers in the field of materials science are facing a problem to identify the origin to plot a crystal plane along negative directions [7]. To overcome the difficulty it is proposed to introduce a new method along positive as well as negative directions [8,9]. In the cubic crystal, there are eight lattice pints at eight corners as shown in Figure 1.

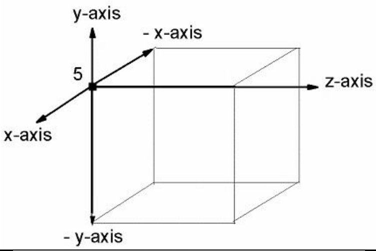
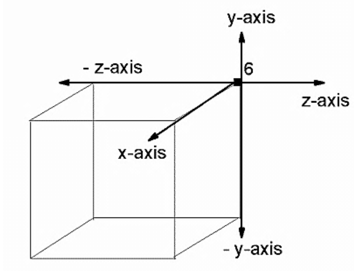
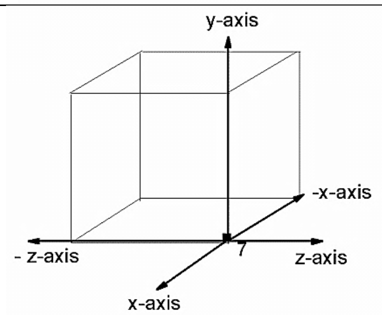
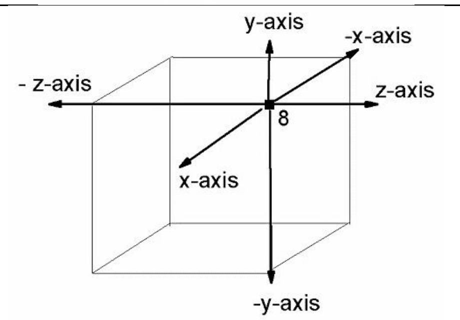
Lattice point identification number along x, y and z axes with block diagram is depicted in Table 1. A comparison has been made with the results by introducing a table which consists of lattice point identification numbers and a block diagram of each lattice points with respective directions of a cubic crystal along x, y and z directions.

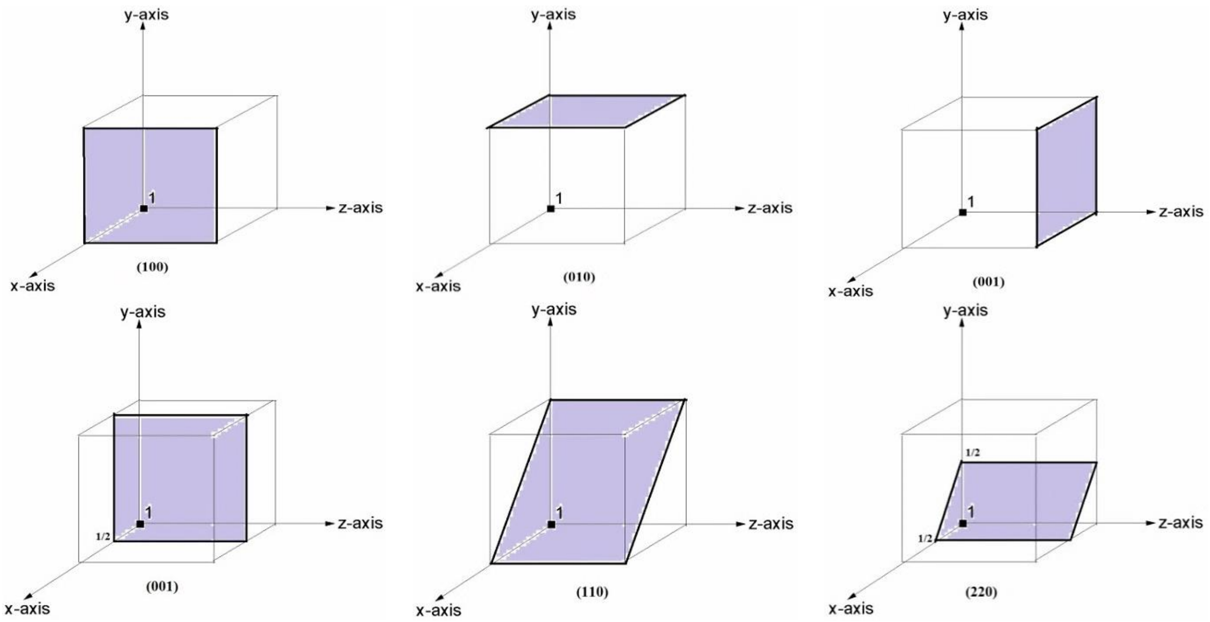
In the cubic crystal, there are eight lattice points at eight corners. The possible directions can be identified by considering each lattice points in the cubic crystal system.

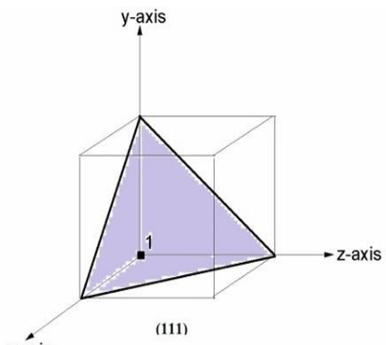
This method is very much convenient to draw any type of planes in any directions in a cubic crystal.

Table 1: *Lattice point Identification Number along x, y and z Axes with Block Diagram.*

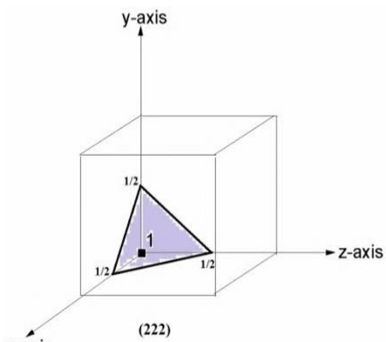
Sl. No.	Lattice point identification number	Block diagram	x-axis	y-axis	z-axis
1	**1**		+	+	+
2	**2**		-	+	+
3	**3**		+	-	+
4	**4**		+	+	-

5	**5**	y-axis - x-axis 5 z-axis x-axis - y-axis	-	-	+
6	**6**	y-axis - z-axis 6 z-axis x-axis - y-axis	+	-	-
7	**7**	y-axis -x-axis - z-axis 7 z-axis x-axis	-	+	-
8	**8**	y-axis -x-axis - z-axis z-axis 8 x-axis -y-axis	-	-	-


y-axis
1
z-axis
x-axis
(100)
(010)
(001)
1/2
(001)
(110)
1/2
(220)



(111)



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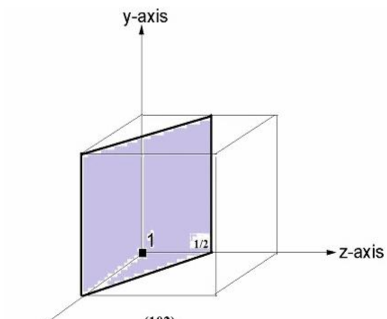

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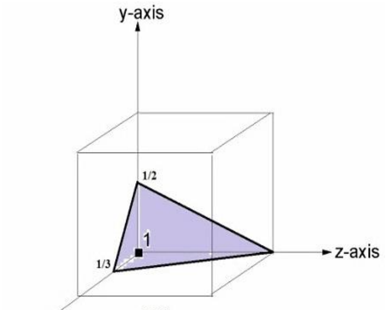

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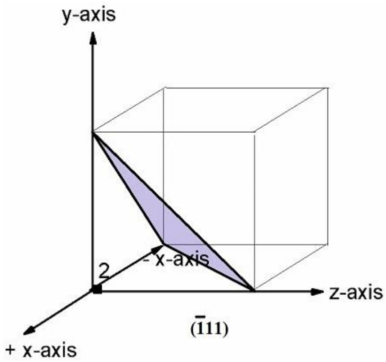
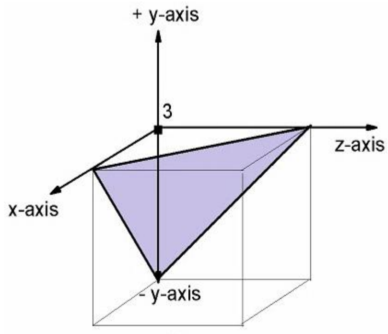
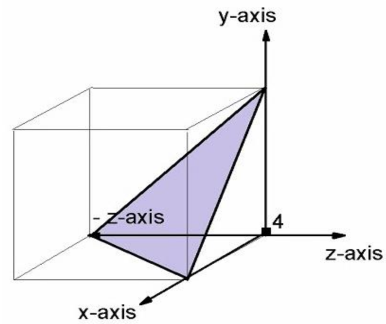


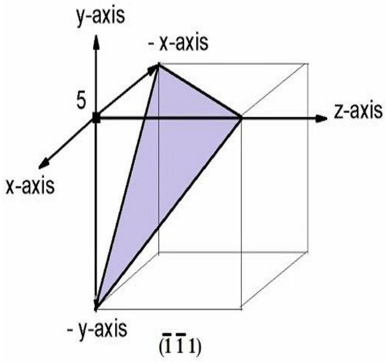
$(\bar{1}11)$



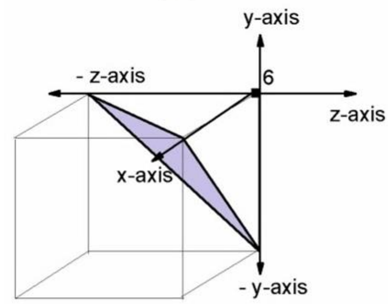
$(1\bar{1}1)$



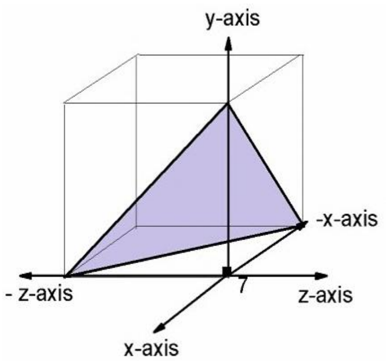
$(11\bar{1})$



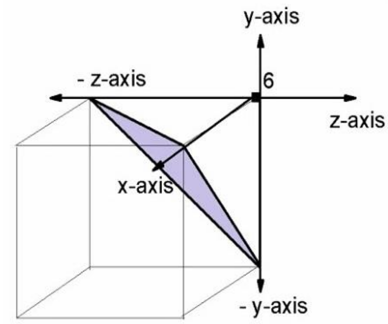
$(\bar{1}\,\bar{1}\,1)$



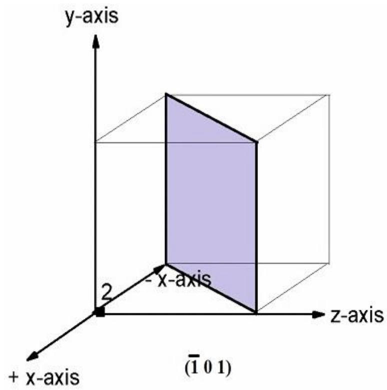
$(1\,\bar{1}\,\bar{1})$



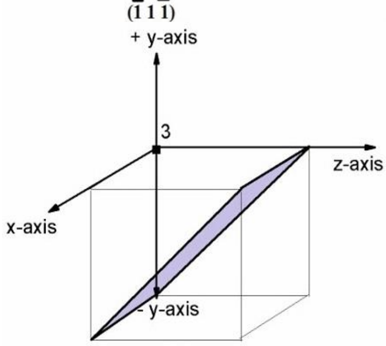
$(\bar{1}\,1\,\bar{1})$



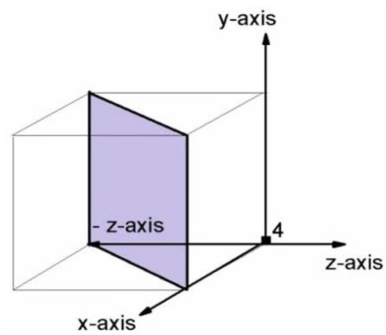
$(\bar{1}\,\bar{1}\,\bar{1})$



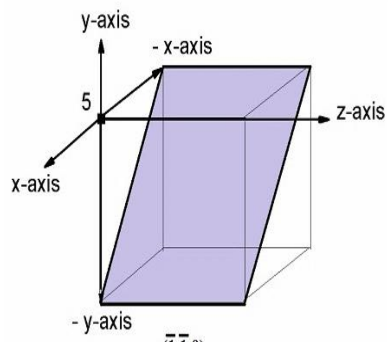
$(\bar{1}\,0\,1)$



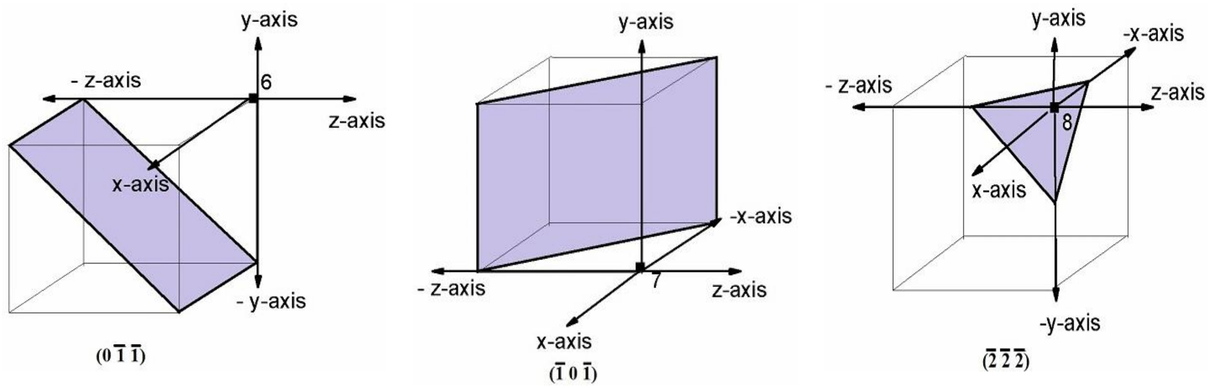
$(0\,\bar{1}\,1)$



$(1\,0\,\bar{1})$



$(\bar{1}\,\bar{1}\,0)$



CONCLUSIONS

A simple method to draw the planes in positive directions as well as negative directions is introduced in this report. The orientation of a plane can be specified by miller indices *hkl* enclosed by parentheses ( ), (*hkl*). This is obtained by three intercepts on *x*, *y* and *z*-axes in terms of lattice constants *a*, *b* and *c*, i.e., (*x/a, y/b, z/c*). Take the reciprocals of these three numbers (*a/x, b/y, c/z*). Reduce them to the three smallest integers by multiplying the common factor *n* (*na/x, nb/y, nc/z*) and enclose these three integers in parentheses to give (*hkl*).

For example, a plane intercepts *x*, *y* and *z* axes at ∞, ∞ and 1, respectively. Then the reciprocals of ∞, ∞ and 1 are 0, 0 and 1, respectively. If a plane intercepts negative side of the z axis at -1*c*, with infinity at the *y* and *z* axes, then the miller indices are labeled by placing a minus sign over the number like this: $\left(00\bar{1}\right)$. By referring the Table 1, it is possible to identify the origin in any directions. If the plane lies along only positive directions, the origin should be the point 1 as represented in Figure 1. Similarly, the planes along negative directions should follow the other points based on the lattice points. It is a convenient method to draw the plane in any complicated directions for a cubic system. For a cubic system, it can be shown that the vector (*hkl*) is normal to the planes defined by the miller indices {*hkl*}.

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