Solid State Physics
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture – 12
Crystal Structure (Contd.)

So, we will see this some planes and how to find out the direction of that those planes as well as the so to define the planes we use the negative indices also. So, just I will give 1 example from where things will be more clear.

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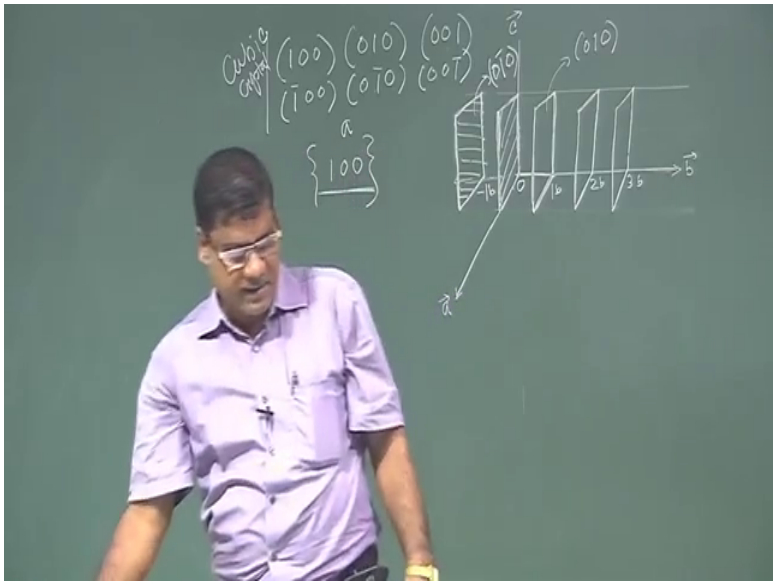

So, and this is c direction. So, just let me this parallel fit 1 can. So, these are parallel planes if you want to draw more right. So, if I draw 1 more plane other side. So, then just let me remove this and what is this plane. So, this plane immediately you can say that is the 0 1 0 plane; 0 1 0 plane, right. So, planar distance so from the origin we take the normal distance of that 1. So, in this case it is the normal distance it is the normal distance, it is say basically b value in case of cubic crystal it is a that we have seen for 1 00. So, what we are saying 100, 010, 001 so for all these planes 1 bar 0 0, 0 1 bar 0, 0 0 1 bar. So, these are the planes the planar distance is a, planar distance is a for basically for whwn it is cubic crystal. So, cubic crystal right, and these planes basically so 1 0 0 plane. So, this is 0 1 0 if you drop this planes on this axis.

So, similar set of palapines you will get. So, that will be represent by 1 0 0 other if you take planes intersect on c axis. So, you will get these planes.

In all cases this will be the planar distance and this all planes basically it is it has same property know it has same property. So, it is written in a third bracket like this. So, it represents to represent a family of planes which are which has say similar property same property. So, those plane together is represented by a with some 1 of them their indices in a second bracket. So, it represent the plane family. So, if I represent with this 1 0 0 in second bracket. So, it represents basically is 1 of 1 of any plane. So, these are the plane family and negative you see here just here I have drag this picture to tell you that is this is this these are the plane these are all represented by single indices miller indices set of miller indices so h k l, 010. So, for this plane which is passing through the origin? So, here it is difficult to tell this is 0 1 0 plane because it has a it has not cut v axis at unit 1 right.

So, that is why for any plane. So, we take the distance from the origin assuming that there is a plane at the origin parallel plane at the origin, but to find out the miller indices of this plane which is passing through the origin basically what we do we just shipped translate; translate towards the nearest plane and for that either you can translate these are translating these are to the nearest plane. So, 1 has to translate by the value is b unit 1 b by 1 b if it is a 1 b this is 2 b this is 3 b right. So, it will coincide with this plane, it is translated towards b axis with 1 b value.

So, now whatever the indices of this one that will be the indices of this one so this is the indices of this 1 if 0 1 0, that is why it is 0 1. Now other side here now to so to find out the indices of this 1 if I go other direction. So, then what I have to do if it is origin O. So, this is the minus 1 b. So, it will be translate towards the opposite direction of b axis by value minus 1. So, then this plane basically 0 1 bar 0 1 1 bar 0 so plane wise you can see these 0 1 0, 0 1 bar 0 it is a same plane these are same plane. So, that is why that is why this 0 1 0 0 1 bar 0 these are the same plane only directions are different.

In this case this direction is towards positive direction and for this plane it is towards negative direction.

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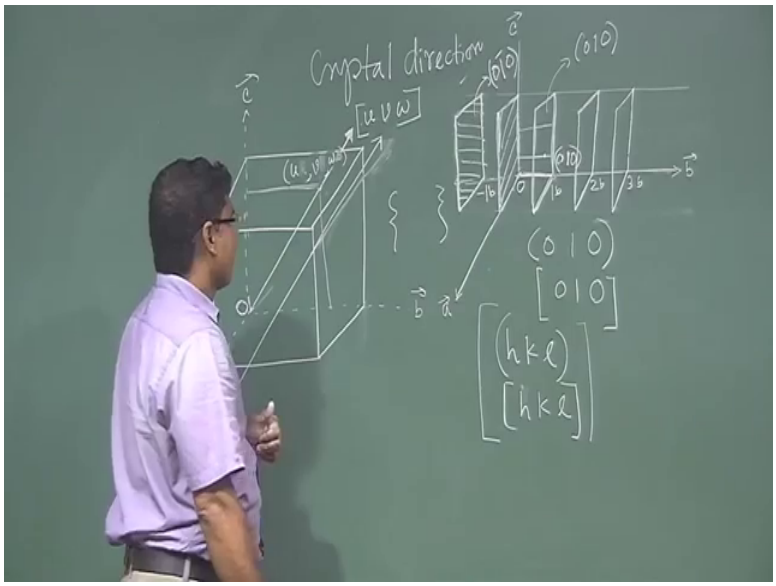

So, here actually I want to discuss that about the crystal direction, about the crystal direction or direction of a lattice order of a crystal. So, crystal direction see you have a crystal you have a crystal. So, it has unit cell. So, if this is the origin, this is the origin and this is the a; this is the b direction b axis this is the c direction c axis.

So, direction of a crystal from the origin or of may not be from through the origin. So, it can be so you want to find out the, this is the unit cell of the crystal, but for in a crystal you have a you know this we have basically the many unit cell and if you want to find out the if you want to find out the direction in the crystal this is the direction you want to find out.

So, to find out the direction of the crystal, wherever the line you have drawn. So, that is parallel line we can take which will pass through the which will pass through origin, which will pass through the origin. So, if it is the parallel line if it is the see if it is the so this is the direction we want to find out. So, if it is not passing through the origin just we shift it to the origin. And then we can find out the direction of these direction of these along this direction, what is the how we can represent the direction. So, we use some so this some value to represent the direction of the crystal, how to find out those value.

Basically you do the you have a axis system see if you want to find out the directions. So, take a point on this, take a point on this line, and what is the coordinate of this point 1 can find out; what is the coordinate of this point 1 can find out 1 can find out how to

find out that you know if you have a axis, x axis, y axis, z axis and it is the they are perpendicular to each other in that case.

So, this point can be xyz right, in this crystal system so this point we write basically in terms of a axis unit. So, unit is basically a b and c in terms of that, ua, vb, and wc. So, in terms of that axis unit so a b are always it is there, in terms of that unit we can write u v w so this point you can write u v w; that means, you can say it is 1 has to be u times a and then v times b and then c time c to these to this point. So, that is the coordinate right.

So, whatever these coordinate we got. So, that that we take to represent the direction of the direction of this line so that will be the direction of crystal we want to find out. So, that is written in third bracket this indices are written in third bracket u v w right. So, when indices are written in third bracket so it is basically representing the direction of the crystal and we have seen that when it is indices are written in first bracket. So, it is representing that crystal plane and when it is represented in a second bracket. So, it represent the plane families plane families which have the same similar property.

Let us take example so what is the direction of a crystal plane. So, directions crystal plane we find out we find out also the planar spacing and now if I want to find out what is the direction of this of a crystal plane. So, direction of a crystal plane you know it is represented by a by the direction of the normal of that plane from the origin.

So, from the origin if you draw the normal on a plane so that direction of that normal is basically the direction of that of the planes. So, for these planes for these planes it is 0 1 0 plane 0 1 0 plane 0 1 0 plane now what is the direction of this plane. So, basically the direction of the normal to this plane so what is the normal to this plane normal to this plane is basically this normal to this plane is this you know and this normal to this plane is basically this means this so this is, this is 1 b right. So, normal to this plane, this from origin this is the so what this is the this is the foot of the normal on this plane and what is the u v w value u v w value for this point for this point u v w value is so it is on b axis; that means, x is 0 along the axis this there is no we are not going towards say a axis. So, this is 0 u value 0 b value is 1 as I told we write this v times v that you write it in terms of b unit. So, that is 1 and this along the c it is 0 right. So, v value is v value is a 0.

So, this is the uvw value basically coordinate of the coordinate of this foot of the normal on this plane. So, what will be the direction then from this? So, as I told we will write in

a third bracket write in the third bracket? So, from here you can see from here you can see that the miller indices we had used for the planes, that is 0 1 0 and direction of that plane is basically this uvw this having same value of h kl.

So, we can we can tell that if it is hkl value hkl value of a plane. So, direction of this plane that is normal to this plane that can be written is in third bracket that can be written third bracket. So, that is using the same mirror indices we can represent the direction of the crystal. So, thus we can find out the direction of any plane. So, say if you take a diagonal if you take a diagonal see you have cubic you have a you have unit cell say cubic unit cell.

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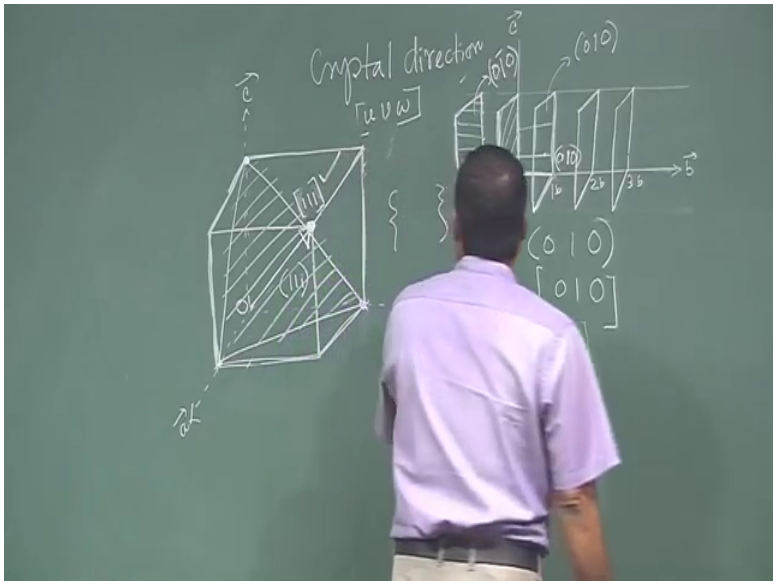

So, if you take a point if you take a point just on the along the diagonal. So, this is 1 corner this is the opposite corner. So, this is the this will be the diagonal this will be the diagonal. So, what is the direction of this? So, the direction so what is the then what is the coordinate of this that will be 1a 1b 1c so; that means, 1 1 1 that is the coordinate.

So, along the body diagonal if that is the direction. So, that direction can be represented by that direction can be represented by so these are the coordinate. So, that coordinate I have to put in a third bracket. So, that would be the direction of a and you can show that this diagonal is basically it will be normal to the plane 1 1 1.

So, which 1 will be the plane? So, basically, these see if I considered this point and this to. So, this will be the this will be the this will be the 1 1 1 plane this will be the 1 1 1 plane this will be the 1 1 1 plane and if you take normal on this plane this 1 1 2 if you take normal on this plane. So, then you will see that the direction of this normal is basically this just you can do yourself it is not difficult job so you can find out.

So, here about the direction of the crystal so basically what are miller indices we are using? So, for basically cubic system what about the miller indices we are using for defining the plane. So, that is that that we are putting it first bracket and when and direction of this plane is basically this can be represented with the same miller indices and we put them in a say third bracket. So, third bracket represents the direction first bracket represent the plane and second bracket it represent the family of planes which have the same properties.

Thank you very much we will continue in next class.