Solid State Physics
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Lecture – 10
Crystal Structure (contd.)

So, we will continue the miller indices of planes. So, in last class, I have discussed the how to find out the miller indices for a crystal plane.

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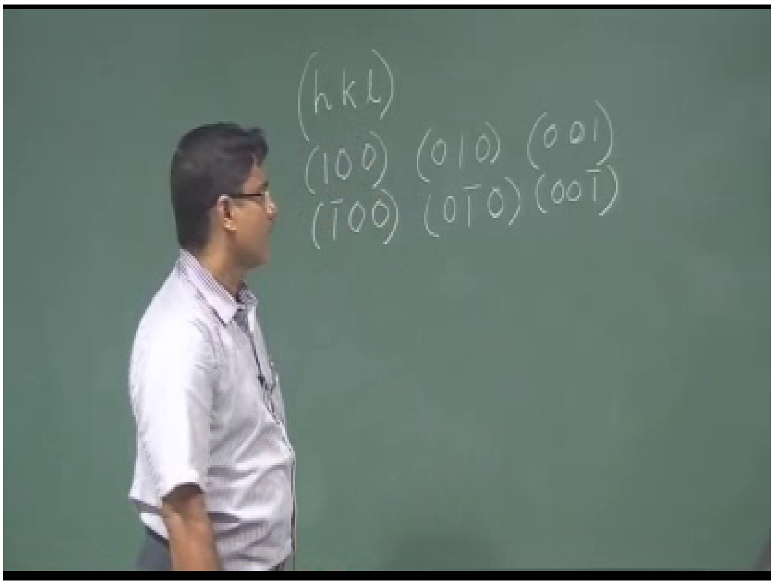

So, this h k l is basically miller indices putting in a first racket represent the crystal planes. So, this miller indices value it is value it is basically integer value. So, for cubic crystal from just faces of the unit cell there we have seen 3 planes 1 0 0, 0 1 0 and 0 0 1, 0 0 1, right.

So, three planes we have seen now when I showed this one 1 0 0. So, that basically that plane intersect the a axis intersect at a axis right at 1 a or 2 a. 3 a, 4 a. So, it can intersect also this other side other direction negative direction of a axis. So, minus 1 a, minus 2 a, minus 3 a. So, to differentiate it weather; it is intersect at plus side or minus side. So, we write this one not minus 1, but 1 bar. So, 1 bar it represents that it intersect at the negative side. So, this can be planes 1 bar 0 0 0, 1 bar 0 0 0 1 bar. So, this here just I want to say that if it intersect at negative side negative direction of the axis. So, that information; we include in the miller indices taking the bar on the indices.

So, let us see some planes other than this simple plane 1 0 0 010, etcetera.

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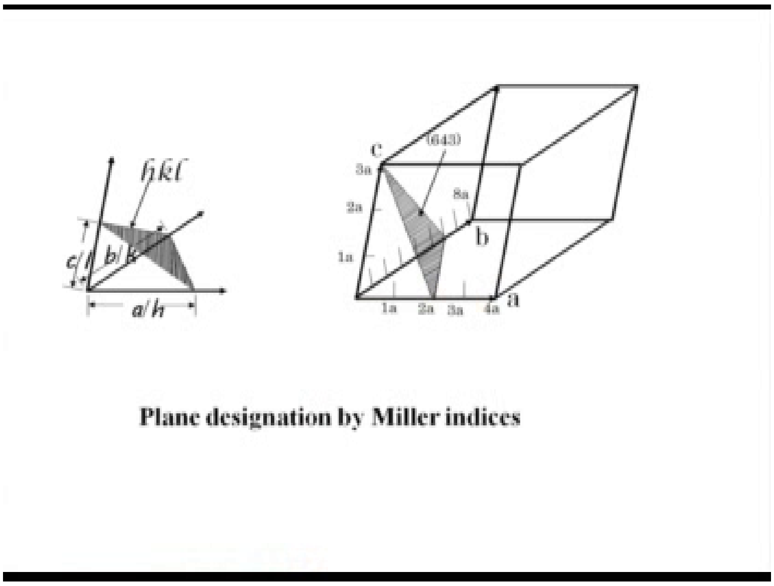

So, I think here; it can show you.

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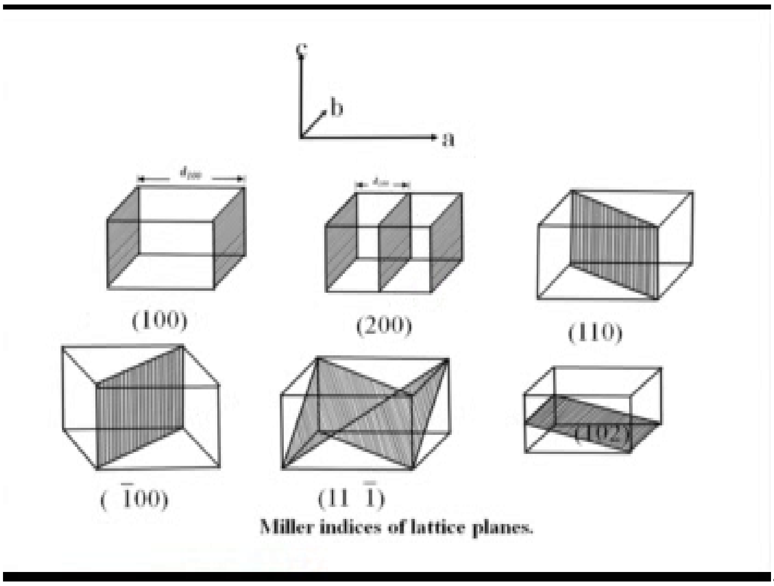

This some planes c c, as I showed this just this this planes are 1 0 0 if this is this is a axis this is b axis this is c axis. So, this plane intersect only the a axis right. So, see it is 1 0 0 planes intersect. So, how to find out already you know, it intersects 1 a 1 a, then b and c axis it intersect at infinity. So, 1 by 1, 1 by infinity, 1 by infinity so that will give 1 0 0.

Now if there is a plane who is intersect at the middle of this set a by 2, if it is intersect a t a by 2. So, this this figure you see this figure.

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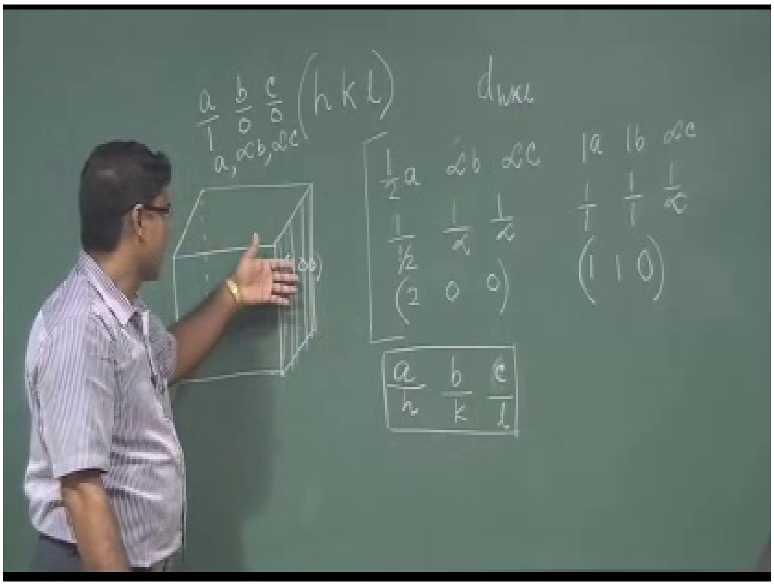

So this is 2 0 0 how it is coming. So, it intersect actually half a infinity b infinity c right. So, you have to take the reciprocal of this 1 by half, 1 by infinity, 1 by infinity right. So, that is describe 2 0 0. So, this will be the plane and here that side left 1 2 0 0 plane this the 2 0 0 plane. So, I think here this d 2 0 0 it is not 1 0 0 the inter-planar distance d 100.

So, this is the miller indices generally inter-planar distance writes d h k l. So, h k l or inter-planar distance is d h k l. So, here it will be d 2 0 0. So, this plane is 11 0, plane so that also easily we can find out because this is the; a axis. So, this plane intersect at 1 a and this is b axis. So, this plane intersect at 1 b because this is the unit cell. So, it is this this distance between these 2 corner like this point here.

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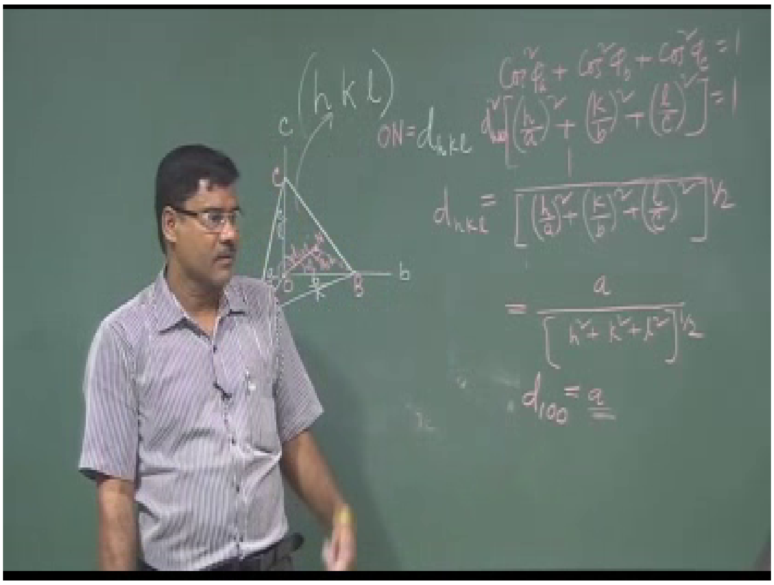

So, this will be a; this will be b and this other 1 c axis. So, this plane is did not cut or intersect at c. So, it is parallel this plane is parallel to c. So, it intersect at it infinity for that 1 1 0 1 1 0 planes. So, what is that it is intersect at 1 a, 1 b and infinity c. So, to reciprocal of this simplify it. So, it will be 1 1 0. So, this is 1 1 0 planes. So, this as I told is 1 bar. So, this is the a axis, this is the b axis no I think this we have shown see if I consider this one just it is rotated it is rotated this one. So, axis is one axis is this another is this and another is this. So, this is a axis. So, this is b axis and this is c axis this is. So, in this case it is we are telling 1 bar 0 0. So, as if this it intersect as the negative side of the negative side of this a axis. So, that is why it is we are telling as I mentioned already. So, a bar ok.

So, this represent. So, this we represents the different planes of the crystal and one can find out the miller indices of this plans. So, this, let me go back to the unit crystal unit cell for cubic crystal unit cell of cubic crystal. So, this one thing is clear that that how we are getting h k l. So, wherever intersection intersect, this h basically coming from reciprocal of that one, from h k l value if I want to find out the interception of the planes with axis, then how to find out how to find out? So, of it is h k l, where it intersects on the axis. So, this, you can write this it intersects at a axis at distance a by h right it because h is basically from here you can see. So, it was half a intersect as half a, but to get the h we have taken the reciprocal and simplified it.

Now from each if we want to get the intersect, again we have to take reciprocal of this h 1 by h times a. So, that is this it intersecst at a axis at a by h, b axis b by a and c axis l by c by l. So, this h k l plane it intersects at axis a axis b axis c axis where at a by h, b by k and c by l distance from the origin. So, that is what here it is shown here. So, this is the plane this is the one plane it this is the h k l plane, this the h k l plane if it is h k l plane. So, it intersects at a axis the a by h, that at b axis b by k. So, this the distance intersecting at this length and along the c axis this is c by l.

So, that is what I explain here. So, if I know the plane then I can get the intersecting length on the axis and these from here for this plane if I take this the origin this the origin. So, this plane intersect at; if I tell this is the 1 0 0 plane. So, how it will intersect on the axis it will intersect on the axis a by h means a by 1, b by k k is 0, c by l, c is 0 this l is 0. So, c by l. So, here we are getting just a a by 1 a 1 by 0 infinity b, 1 by 0 infinity c right. So, this 1 0 0 plane intersects at a infinity b infinity c.

So, this intersect length on the axis is verified with our crystal planes which we found from the procedure of miller indices. So, this plane when you find out the miller indices at that any concept that it intersect at a infinity b infinity c from there we found the miller indices. Now from miller indices itself we can found find out the intersecting point intersecting length and that is the (Refer Time: 15:51).

So, this way we can get the get the interesting points on the axis from the miller indices of the planes and this I need to calculate basically the inter-planar distance. So, h k l plane is not a one plane it is a one set of parallel planes. So, it represents a one set of parallel planes . So, say suppose this h k l this is a plane h k l plane. So, let me draw it I am considering slightly different axis. So, this is a, this is b, this is c, this is a plane, this is a plane. So, this is h k l plane, this is a, this is a h k l plane this is h k l plane. So, that makes it intersect. So, this length will be. So, this the origin. So, this length will be a by h this length, this is b by k and this is c by l.

Now, I want to find out the inter-planar distance. So, as I mentioned that this is h k l plane, but it represents a set of parallel plane equidistance inter-planar distance will be same between 2 planes. So, this inter-planar distance for this plane h k l plane we represent by as I told d h k l right. So, this d h k l is the inter-planar distance. So, a set of a set of h k l planes a set of planes parallel planes, which is basically h k l plane now what is the inter-planar distance of h k l planes. So, that we want to find out. So, here we can consider that this through origin there is a, this is h k l this parallel planes are there and this again this other side the back side. So, lot of parallel planes. So, one planes passing through the axis passing through the origin of the axis parallel to this parallel to this. So, inter-planar distance, then I can consider that the if I take normal on this plane from the origin. So, this a if I take normal I think I should take slightly off. So, (Refer Time: 20:25) this point slight. So, this is the normal on this plane from the origin, origin is o and this is N normal on the on this planes. So, this O N.

So, this O N will be basically d h k l as I told that this a parallel plane of this h k l plane on parallel plane passing through this origin. So, then normal from the origin on this plane is basically, then this O N is perpendicular distance between 2 parallel planes. So, that d h k l and then what we find out we want to find out the d h k l value. So, this is d h k l d h k l right . So, you have plane and this the normal O N is the normal on this planes right. So, if this normal have angle with a axis, b axis and c axis say phi 1, phi 2 phi 3 or let me write phi a, phi b, phi c. So, this are the angles of this normal with the crystal axis. So, then this angle. So, this O N having angle phi a with the a axis. So, I think basically this angle this angle right and with the b this have angle this 1 phi b and with c this the angle with c this the angle. So, that is phi c. So, if you take the. So, this the. So, if I consider this. So, it is a bit easier one.

So, this dotted line on the plane this dotted line on this planes and this one is normal to this plane. So, this angle is basically ninety degree right this angle is ninety degree this angle is 90 degree. So, if it is 90 degree here you can see this cos phi b because this angle is phi b. So, cos phi b is equal to this by this d h k l or I can write O N this O N by o (Refer Time: 25:12) we can give name b in consider a basically c. So, O N by O B, O N by O B right O N is basically here d h k l d h k l divide by, O B is b by k b by k right. So, cos phi b is equal to this, this I can write k by b d h k l right. Similarly we can find out cos phi b yeah phi a is equal to this is h. So, h by a d h k l and cos phi c will be l by c d h k l, right.

So, here basically this cos phi a cos phi b cos phi c these are the cosine directions of this normal it follows cosine rules. So, that cos square phi a plus cos square phi b plus cos square phi c is equal to 1 direction cosine rules. So, just if you put value of phi a cos phi a cos phi b cos phi c. So, h you are getting, h by a square d h k l. So, I will take this outside d h k l. So, this square; because it is everywhere in three cases, it will be this plus k by b whole square plus l by c whole square is equal to 1 . So, I can write that d h k l equal to; So, 1 by this 1 by this and square root of that 1. So, it will be 1 by h by a whole square plus k by b whole square plus l by c whole square right to the bar half right. So, what can write this just as you minus half just taking off? So, these expression for the inter-planar distance of h k l plane. So, if it is cubic crystal. So, a equal to b equal to c right.

So, a square. So, all will be a square will (Refer Time: 29:19). So, it will. So, square root is there. So, basically 1 by a. So, for cubic you will get basically a by. So, h square plus k square plus l square right half a by this. Now for 1 0 0 plane 1 0 0 plane. So, 1 0 0. So, it is one. So, it will be for d 1 0 0 plane this inter-planar distance is a. So, that when you derive this miller indices you have seen this 1 0 0 plane it intersect at on a axis at distance a right and b and c axis is intersect at infinity. So, just here also you verified that our expression is correct and for 1 0 0 plane see inter-planar distance is nothing, but it is let this constant a. So, for today will stop here and next class I will continue this direction of the crystals and other things. So, for represent the direction of the crystal, we need basically miller indices. So, in next class we will continue.

Thank you very much for your attention.