Solid State Physics

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Lecture - 11
Crystal Structure (Contd.)

So, in last class we were discussing about the crystal planes, how it is represented using miller indices.

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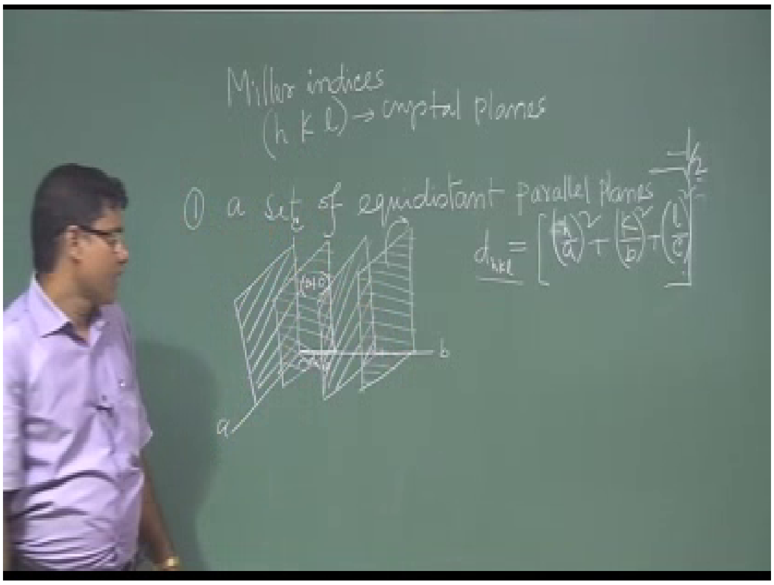

So, we have represented crystal plane using miller indices h k l. So, when h k l put in a first bracket. So, it represent the crystal plane. So, as I mentioned that that h k l that which we represent for a plane it is it is represent a basically a set of equidistant parallel plane. So it is if I show so it is a; it is a plane say pass through the origin and then. So, this so these are the planes they are parallel and they are equidistant. So, this if this plane is represented by say which plane. It will be basically you can see (Refer Time: 03:46) a axis, it is b axis and this is c axis. So, this plane it cut at b axis, but parallel to a and c axis. So, it will be 0 1 0 plane.

So, h k l value is 0 1 0, and then this all parallel planes equidistant parallel planes will be represented by this miller indices 0 1 0. Now that distance that equidistant basically you can this is the distance. So, this d h k l. So, this they are equidistant right. So, that I have discuss the how to find out the planar spacing of a plane say h k l plane. So, that we have seen that d h k l that is equal to that is h by a whole square plus k by b whole square plus l by c whole square and that is minus half, that is minus half. I think you cannot see this one this is basically minus half. So, for so; this is the how you found this one. So, you took one has to take normal on this plane from the origin. And then from so any line if we draw from the origin. So, that line have a direction cosine.

So, basically it makes angle with this 3 axis, and direction cosines is basically it is cos of those angles. And that follows this some rules cos square see I wrote phi a plus cos square phi b plus cos square phi c equal to 1 and cos phi a cos phi b cos phi c that is basically that if normal is d h k l.

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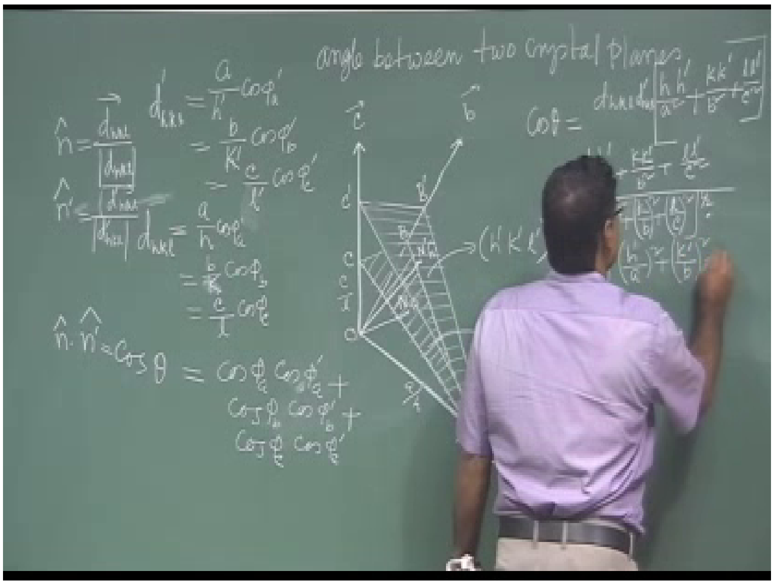

So, this d h k l it is will be that we have seen angle between this this direction, normal direction and the a axis if it is phi a. So, then we have seen. So, this d h k l will be a by h cos phi a, a by h cos phi a. And that along the b axis if angle is phi b. So, b by h cos phi b this will be c by l, sorry not this is h this will be k c by l cos phi c. So, from here one can get cos phi a cos phi b cos phi c in terms of d h k l and a b c. And the miller indices and from this relation one can find out this. So now, today would like to find out what is the angle between 2 crystal planes. What is the angle between 2 crystal planes? That we want to find out. So, just let us consider to axis system. So, this is a axis, this is b axis and this is c axis. So, angle between 2 crystal plane angle between 2 crystal plane right.

So, say this is one this is 1 planes, this is 1 planes. So, this the origin o and this plane say a b c plane. So now, if we draw a normal on this plane the foot of the normal on this plane, you say n and see this is that o n is d h k l right. And this length is we have seen a by h this is c by l, and this will be b by k. Now if you draw another plane. So, a if you draw another plane as it is not straight line, it seems this not straight line think still it is not (Refer Time: 12:14). So, it is now better one. So, this is the another plane. So, we would like to find out what is the angle between these 2 planes. So, you know that is angle between these 2 planes will be same as the angle between the normal of this 2 planes. So, this is one normal of this plane this is n.

So, another normal on this plane other plane. So, this is a dash b dash c dash plane. So, normal that foot is n dash. So, it is that planar spacing is a d h k l dash. And then we can similarly for this plane a dash b dash c dash plane. So, you can write a by h dash or phi a dash. So, if direction cosine of this normal o n dash, if this is cos phi a dash phi b dash phi c dash. And this a by h dish. So, basically this miller indices of this plane h k l and miller indices of this plane is h dash k dash l dash right. So, this is the. So, this d h k l and d dash h k l. So, this basically for this distance for other plane where I could write h dash k dash l dash, but instead of that I have given d dash. So, this angle between this 2 planes if it is theta ok.

So, we will get we will get cos theta. So, if we take the cos theta is basically, if we take the dot product of unit vector of this to o n and o n dash, if it is unit vector of this one is n this normal direction is n and for this normal direction is n dash. So, dot product of this 2-unit vector will give you the will give you the cos theta. So, that n basically unit vector for this. So, n I can write for this n I can write unit vectors, that is basically d h k l vector and this magnitude of this one right. So, that way we define the unit vector, similarly n dash it will be d dash h k l, this vector magnitude of this vector, d h k l dash, right.

So, that n unit vector n and unit vector n dash of the direction cosine is basically cos phi a cos phi b cos phi c. And for other one cos phi a dash cos phi b dash cos phi c dash. So, then some direction cosine itself one can write angle between these 2 (Refer Time: 18:16) cos phi a cos phi a dash plus cos phi b cos phi b dash plus cos phi c cos phi c dash. Then one can find out from here also from here also because you know the relation of d h k l and this cos phi or cos phi dash. So, using this one can find out this relation or this also known that angle between 2 direction cosine is if it is cos theta. So, in terms of direction cosine of each one. So, this will be the relation with the angle between this 2 direction. So, from here if you just put this cos phi value. So, cos phi value right. So, this is basically in this h by this d h by d by a or b by d k by d by b.

So, if you put this value here, if you put this here. So, cos theta will be. So, cos phi a cos phi a will be d h k l h by a, and that phi dash phi dash we get basically h dash by a. So, a square, and d h k l dash right. So, this 2 will come in each term. So, if you tack take common in similarly, other term k dash by b square by b square plus l dash by c square right l dash by c square. So, that you will get basically. Now that d h k l that we have seen what is the value. So, that if we put h dash by a square plus k dash by b square plus l dash by c square right. Divide by d h k l value. So, what was that? Just write that expression. So, that explicitly if we write. So, d h k l value what we have seen? I think this d h k l something wrong, the cos phi is dash d h k l by a, right.

So, d h k l value. So, it will go off (Refer Time: 22:57) h by a right. H by h by a d h k l value h by a whole square plus k by b whole square plus l by c whole square right. And then to the power half, to the power half into h dash by a whole square, plus k dash by b whole square, plus l dash by c whole square into half right. So now, in crystal plane. So, what is the planar spacing? What is the angle between these 2 planes, for that we have expression. So, one can easily find out. So, for if I ask you to find out the planar spacing for a for a plane say 1 0 0 plane. So, planar spacing h k l is equal to 1 by h by a whole square plus k by b, whole square plus l by c whole square to for the power half, right.

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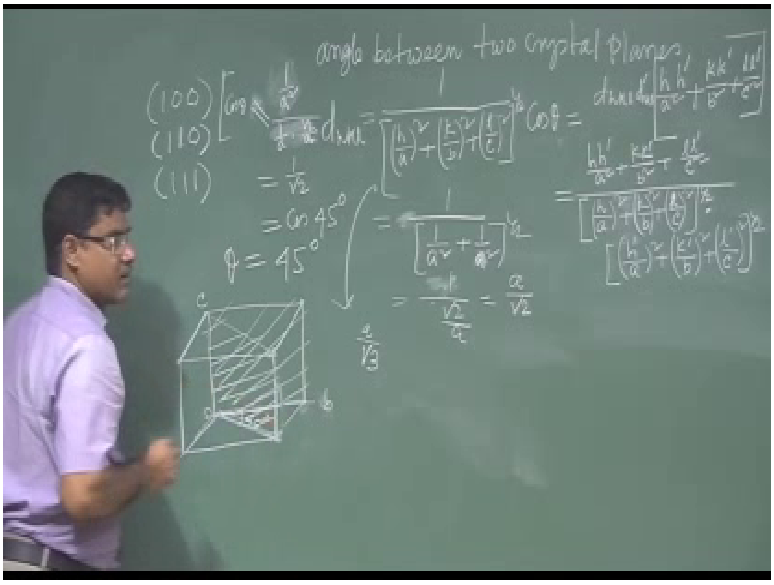

So, for just putting value here putting value here. So, immediately can say that that will be that value will be a right these are 0s. So, these are 1 by a whole square. So, square root of that 1 by a. So, it will go up you see right. And one say 1 1 0, 1 1 0 what will the value? So, this will be 0 this 1 by h square plus 1 by b square right. Now in case of cubic crystal a equal to b right. So, here as I mention these relations are valid for the orthogonal system.

So, at the axis (Refer Time: 26:47) mutually perpendicular to each other. So, for so basically for cubic system tetragonal system (Refer Time: 26:57) system. So, this relations are valid. So, simplest one is cubic. So, in case of cubic most of the example we are we will give in terms of cubic crystal, whether I mention or not, but it is mainly for cubic crystal. So, for this what will be the value? So, this basically 1 by 1 by a square plus 1 by b square. So, b will be a. So, it is basically 2 a square. So, square root is there. So, it will be 2 a square, means 1 by root 2 a. So, it will be a by root 2 right. Similarly, for 1 1 1 plane.

So, it will be for 1 1 1 plane, it will be a by root 3 planar, spacing will be a by root 3. And if you find out angle see this 2-plane angle between this 2-plane cos theta. So, we can see here only this term will exist. Other will be 0. So, basically h dash by a square right. And here basically you will get this for 1 0 0, you will get basically it will if I write this way.

It will be d value right. D h k l d 1 0 0. So, that is basically a and for this one other plane this plane. So, it will be a by root 2, it will be a by root 2 right. And this 1 1.

So, it is will be 1 by a square. So, this will be 1 by a square right. So, 1 by a square here a square something wrong? So, it will be basically this this is basically 1 by d, this is basically 1 by d. So, you will get here 1 by a and here root 2 by a right, root 2 by a. So, this will give you 1 by root 2. So, that is nothing but cos 45 degree right. So, theta angle 45 degree right. So, it is if you draw 1 1 on plane sorry, right. So, if you take this the origin, and that is a axis sorry, a axis, this is b axis, and this is c axis.

So, your 1 0 0 plane 1 0 0 plane is basically this plane, this plane, this plane. So, passing through the origin. So, this will be the plane this will be the plane passing through the origin this will be the plane, and 1 1 0 plane basically this plane right this and this. So, angle between these 2 it is just a from here you can see just this is a phase diagram right. And this is what is the angle between these 2. It is obviously, 45 degree.

So, thank you. So, will continue in next class.