Introduction to Materials Science and Engineering
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Lecture – 52
Burgers vector: Shortest lattice translation

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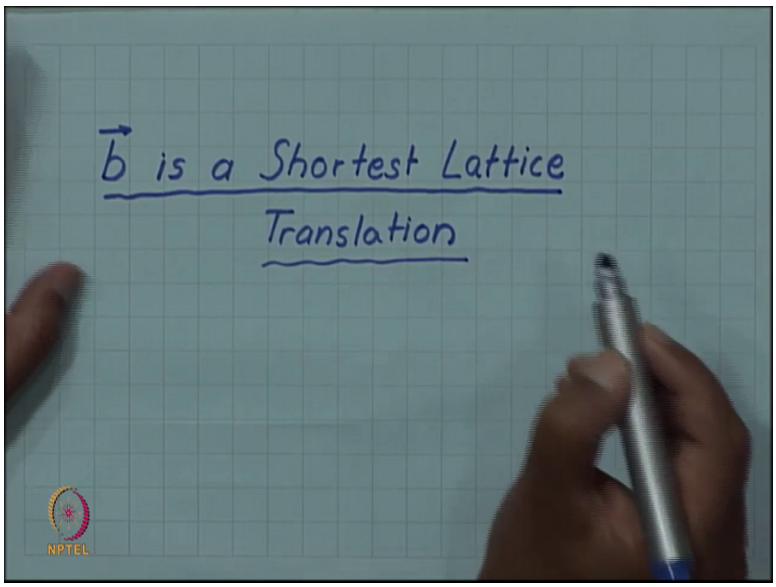

In crystalline material, b is the burgers vector is usually a shortest lattice translation. So, let us look at this particular property of the dislocation line. So, first let us look at the b is a lattice translation; b should be a lattice translation.

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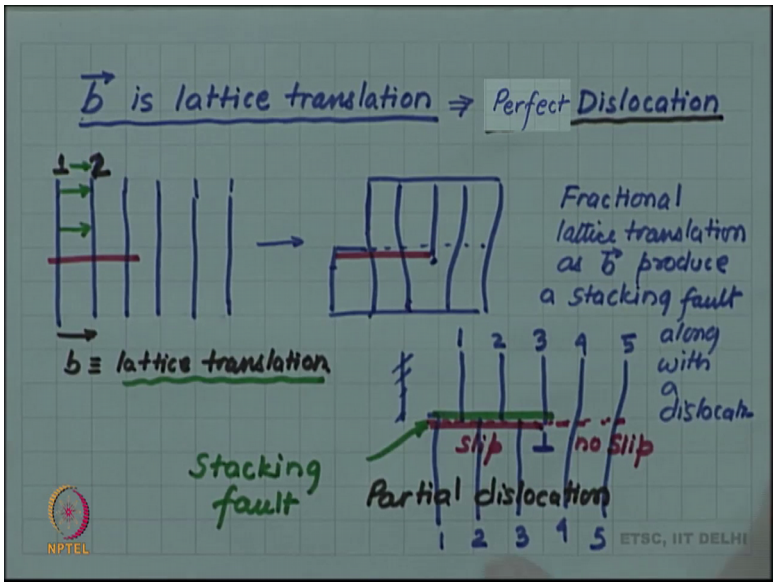

This based on the fact that, if we look at the model which we created for the dislocation line by cut and slip, so we said that we will cut a few planes and then we push the first plane above the slip plane. So, that it joins the 2nd plane.

So, 1st plane was moved to the location of the 2nd plane. So, these are in the simple cubic lattice these planes are separated by a burgers vector and this burgers vector is also a lattice translation. If we do not, so if we create a dislocation line by this process, what we get is that there is a hanging plane from this side, the first plane joins the second plane, the second plane joins the third plane, the third plane remains hanging, then you have fourth and fifth plane, that was the slip plane. This was necessary 1 the fact that, we made a burgers vector as the lattice translation, this was necessary if I wanted the first plane to join the second plane, if I do not do this, what will I have?

If I have let us say a parcel shift, so that the first plane does not join with the second plane, but move somewhere in between sorry, so, this is the lower hanging plane and the first plane has been pushed let us say only half way, is not join with the second plane and the second plane is there, then the second plane from top does not join the third plane from the bottom, there is a third hanging plane, fourth and fifth. If there is a partial slip like this over the slip plane, then you can see if I have not pushed enough such that the first from the top, join second from the bottom and second from the top joins third from the bottom, third is again left hanging, fourth is connected and fifth is connected.

So, you still have the slip side, is the slip side and this is the no slip side, so there is a dislocation. However, on the side of the slip, I have a continuous interface which is disturbed let me show it with green, across this interface we have disturbance or defect. So, what I have created this you can see to the 1, 2, 3 is displaced with respect to the 1, 2, 3 below 1, 2, 3 on the top is displaced with respect to 1, 2, 3 on the bottom and the connectivity is breaking at this green plane.

So, this entire green plane has been created what is called and we will study a little bit more detail later is a stacking fault. So, fractional lattice translations will generate a stacking fault, as b produce a stacking fault along with the dislocation. So, we do have a dislocation line here, but this dislocation line is associated with a stacking fault plane. Whereas, in this case, since we allow the connectivity, so although there is a distortion, there is no fault plane because planes are continuous here above and below this plane.

So, b should be a lattice translation, if we want a dislocation and associated with a stacking fault and that is the kind of dislocation we are considering, these kind of dislocations sometimes are called perfect dislocations, dislocation themselves the defect. So, perfect dislocation is a somebody strange name, but we use it, this is called perfect dislocation and a dislocation associated with a stacking fault, this kind of dislocation will be called partial dislocation.

So, in dislocation theory these partial dislocations associated with the stacking fault they also very important, but in this course we will focus on perfect dislocation which are not associated with stacking faults.

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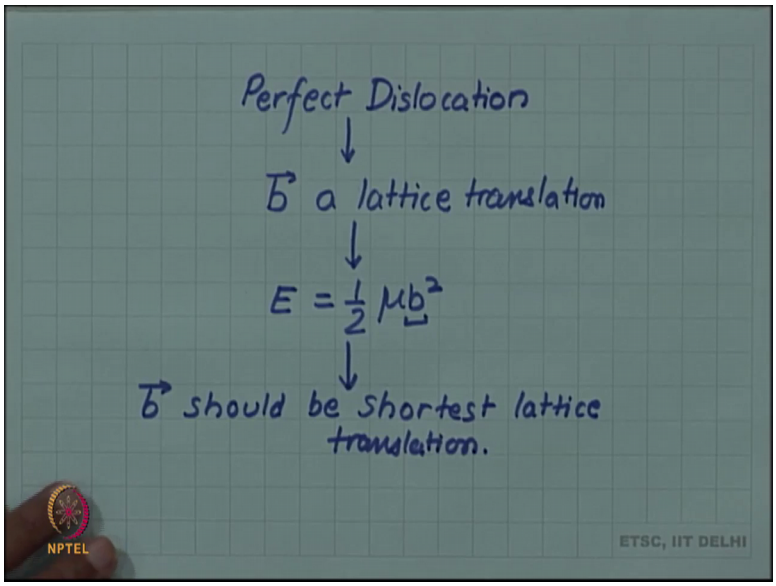

So, we have perfect dislocation, perfect dislocation makes b a lattice translation, but we have also seen that the energy per unit length of the dislocation line is half mu b square, this will then imply to; for dislocations so if b is large; if b is a large lattice translation, then energy will also be higher. So, b should be as short as possible, so b should be shortest lattice translation.

Now, let us look at different a structures.

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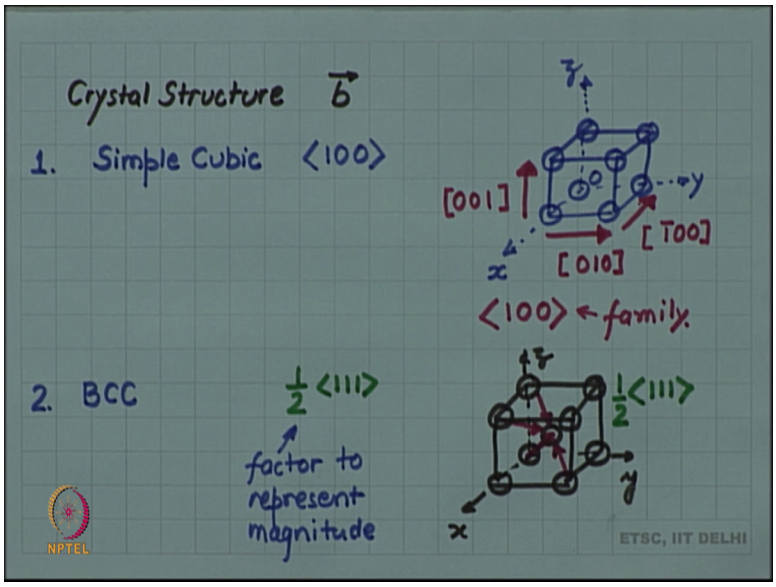

So, let us right here, crystal structure and the corresponding b vector. So, if we have, let us say we have simple cubic; simple cubic crystal that is a simple cubic lattice with 1 atom sitting at each lattice point. So here, the shortest lattice vectors are obviously, the edge of the cube, so these will be the shortest lattice translations.

Now, if we here there is an application of miller indices, which you have learned some time ago, so we will use that. So, if this is the origin, this is the x axis this is y axis and this is z axis. So, this is a vector which is going into the a opposite direction of the x axis. So, this is bar 100, this is parallel to the y axis, this is 010 and this is parallel to the z axis 001, any of these vectors can be the burgers vector for the simple cubic a structure and if you want to represent all of these as a set remember, we use an angular bracket which tells me that it is a 100 direction; family of 100 direction, symmetry related family of 100 directions in the cube.

So, any edge of the cube and any sense all are included in this. So, for a simple cubic a structure, the burgers vector becomes 100. Let us look at a body centered cubic crystal, so in this, we will have a cube, atoms will be sitting at the corners as well as 1 atom sitting at the body center. Now, in this case the shortest distance between the lattice point is actually along the body diagonal.

So, half the body diagonal, this becomes the shortest distance. So, any of these vectors from any corner to the nearby body center is a possible burgers vector. Now, as you know the body diagonal, the entire body diagonal vector is the 111 vector, but since we need half of that, we apply a factor half in front of that. So, this is the half is a family of 111 vectors and half of that is the burgers vector.

So, we can write for BCC half 111, notice that although we are using miller indices, we are modifying it slightly for this context, that we are allowing such factors half to be written because when we used miller indices they were for the entire line. So, we canceled out any such factor because we were interested in the entire line, but since now we are interested in burgers vector, which has a certain magnitude. So, a particular length is important, so this is not representing the entire 111 line, but a specific 111 vector and half tells half of that vector, so we need this factor to represent the magnitude.

So, there is slight modification in the original convention for this miller indices, which we had proposed initially, where we had said that we will cancel out any such factor, but now, we will keep it.

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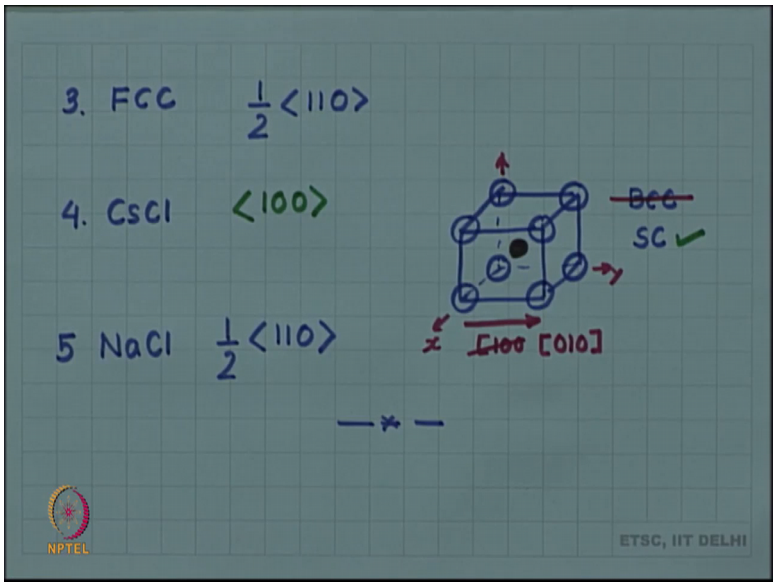

So, if we continue similarly for FCC, the shortest lattice translations are along the face diagonal. So, you can write it as half 110, for cesium chloride structure, this will interesting case, you know that in cesium chloride, there are atoms of chlorine on the corner and there is an atom of helium sitting in the middle.

Now, because these atoms are different, we have discussed this in detail when discussing crystal a structure, because the corner and center atoms are different, the unit this unit cell or the lattice is not BCC. So, this is not BCC, just to emphasize that and recall this is simple cubic. So, only the corner atoms cycle will in and corner atoms are forming a simple cube.

So, similarly here although the shortest atom to atom distance is along the body diagonal, shortest lattice point to lattice point distance is still along the edges. I am taking x this way, this will be 010. So, just like for a simple cubic we had seen, for cesium chloride also it could be 100, similarly if you recall, when we discussed sodium chloride structure although the shortest distance will be along the edge, but this is an FCC and the burgers vector will be just like FCC.

So, perfect dislocations in any structure will have the shortest possible lattice translation and this is to reduce the energy and you can write those burgers vector in terms of miller indices of the corresponding crystal. So, with this we finish this topic of a shortest lattice translations and we will continue, but we are still on the topic of dislocation, several other properties of dislocation we have to look at some geometrical properties, which we will continue in the next video.