Introduction to Materials Science and Engineering
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Lecture – 54
Dislocation cannot end abruptly in a crystal: Free surface

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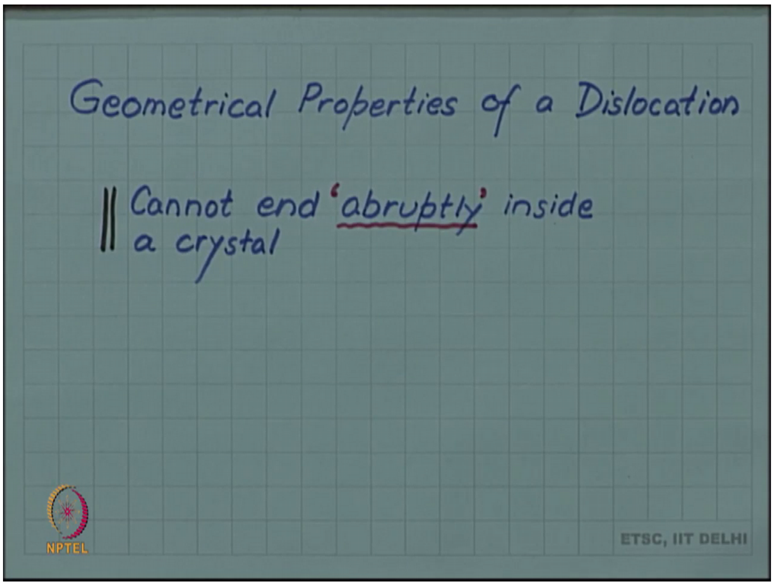

We have discussed some geometrical property like the burgers vector of a dislocation line in the last video. We will continue with other geometrical properties of a dislocation line. And one of the important one is that a dislocation cannot end abruptly inside a crystal. This is a very important property. And we will spend some time on this, and we will explain as we go along it will become clear what exactly is meant by this phrase abruptly.

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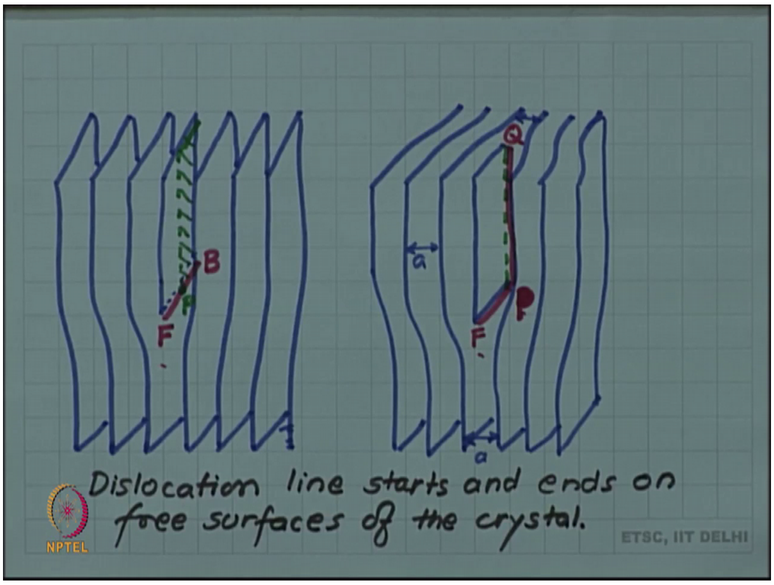

So, let us try to look at an edge dislocation and let us create an edge dislocation, if you recall edge dislocation we have described as an edge of an extra half plane. So, let us start with the extra half plane, and then nearby planes are continuous, we may bring planes are continuous like this, and one plane in the crystal is a half plane, and we said that the bottom edge of this half plane, is the dislocation the edge dislocation line. I am not showing the atoms I am only imagining the atomic planes.

And the bottom edge of this half plane was the dislocation line. So, the dislocation line exists here, and you can see that the way I have drawn this is the front face of the crystal. So, the dislocation starts from the front face, and reaches the back face, it is a dislocation line which is running right from front to the back. So, the end that we can see that this dislocation is not ending inside the crystal, it is running from the front face to the back face, now is there a way to stop this dislocation in along it is line somewhere in the middle.

So, let us select a point somewhere in the middle the point P, and let us say that we want the dislocation to run only up to P, from F to P rather than from F to b. So, if the dislocation runs from F to P that will be a dislocation which is starting on the front face, but is ending in a sense abruptly inside the crystal. Now if we have this half plane the full half plane as shown here then the dislocation line, which is the bottom edge of the half plane will; obviously, run from F to B from front to back if I wanted to end at P then maybe one way we can imagine, that is try to chop off the back part of this half plane.

So, suppose I cut this part off, then since the half plane does not exist beyond P, the dislocation line will also not exist beyond P, and we will have a dislocation line running from the front face and ending inside the crystal at P, but let us try to redraw the geometry which we will achieve by cutting the this half plane into further half. So, I draw the green line here to indicate that I have chopped off the back part, but if I do that on the front face I continue with this configuration, which was seen before, but you now see, that we have lost this part of the half plane. So, in a sense we are now left with a quarter plane, the back half of the half plane is also lost.

So, on the top the configuration will again change to accommodate this loss, and the planes will look something like this. So, what you are see what you are seeing on the front face here, what we were trying to manage to achieve the same spacing a the normal spacing of the crystal despite the loss of half plane, the same relaxation will happen on the top face also that these planes will now curve. So, that this is spacing is maintained this does not become twice to a, but remains a. So, you can see then that this green dashed line, which was the cut line for the half plane in this figure.

So, this green dashed line now becomes like a dislocation line, which is coming which is oriented in the vertical direction, and is coming out of the top face. So, although our goal was to try to get rid of the back part of the dislocation, which we which we did succeed in getting rid of the dislocation PB. So, PB is not a dislocation, but then we were not successful in forcing the dislocation to end at B because now I have another dislocation line running from sorry this is P. So, I am not successful in stopping it at P, but the dislocation line from P turns up and ends at Q.

So, all that has happened that a dislocation line FB running from front to the back face of the crystal, has got converted into a dislocation line FP Q which is starting from the front face takes a turn at P and then emerges out of the top face of the crystal at Q. So, you can see that this sort of thought experiment, did not help us in succeeding to end the crystal end the dislocation line abruptly inside the crystal. So, in this both the cases dislocation line is ending on the surface, the dislocation line we can say starts and ends on free surfaces of the crystal, free surface means external surface free surfaces of the crystal.

But is this property true only for this particular drawing and this for this particular edge dislocation, that is not true because this property holds for all dislocations in all configurations, and this is because the very definition of the dislocation.

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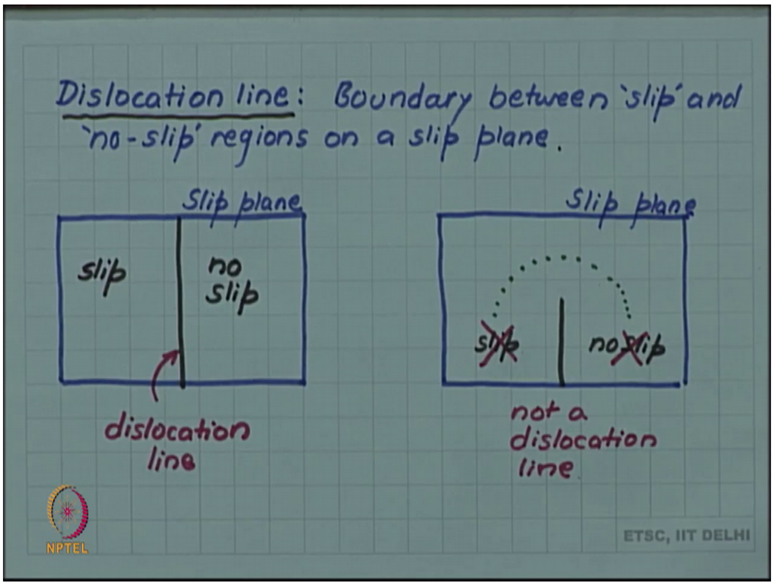

Let us remember one of the definition which we gave of a dislocation line was as a boundary between slip and unslipped region, boundary between slip, no slip regions on a slip plane.

So, if you look at this definition. So, the abrupt ending of a dislocation line in the crystal is excluded by this very definition let us see why so, suppose I draw a slip plane, and I want to define a boundary in this slip plane. So, let us say that there is a boundary, and if I want this boundary to be a dislocation line, all I have to do is to create a slip on one side of the crystal, and leave the other side un slipped. So, in this case this will be a boundary and this will be a dislocation line.

So, this is a general definition of a dislocation line depending on the slip, where the slip is perpendicular to the dislocation line in which case we will create an edge dislocation, or the slip is parallel to the dislocation line in which case we will create a screw dislocation, or slip is at any angle to the dislocation line in which case we will have a mixed dislocation. So, this picture of slip no slip boundary as a dislocation line is a general definition of a dislocation line.

now if I try in a similar picture, I have another slip plane picture, and if I try to make a dislocation line which starts on the front face, but ends inside the crystal, something like this then you can see that in this kind of picture the slip plane is not divided into 2 regions the entire region of the slip plane is continuous and a line is hanging in this way. So, a hanging line of this sort a line which is starting on the front face, but is abruptly ending inside in rather than going all the way to the back face, will not be able to divide the slip plane into 2 regions which we call slip and no slip, because even if we call this side slip and this side no slip then it will be possible for me to walk all the way from slip to the no slip region, without crossing the boundary and this should not be possible.

if we are saying that there are 2 regions one is slip and another is no slip then from going from slip to no slip, there should be a boundary which need to be crossed. So, this will be there will be no slip and no slip regions unless and until there will be no different regions on a slip plane, if the dislocation line is not continuous from one end of the slip plane to the another so, this is not a dislocation line. The rectangles which I have shown is the slip plane in our discussion.

So, I am looking down on the slip plane. So, if the dislocation line cannot end abruptly inside, there are some suitable locations where it can end, you have already seen that it can end on a free surface.

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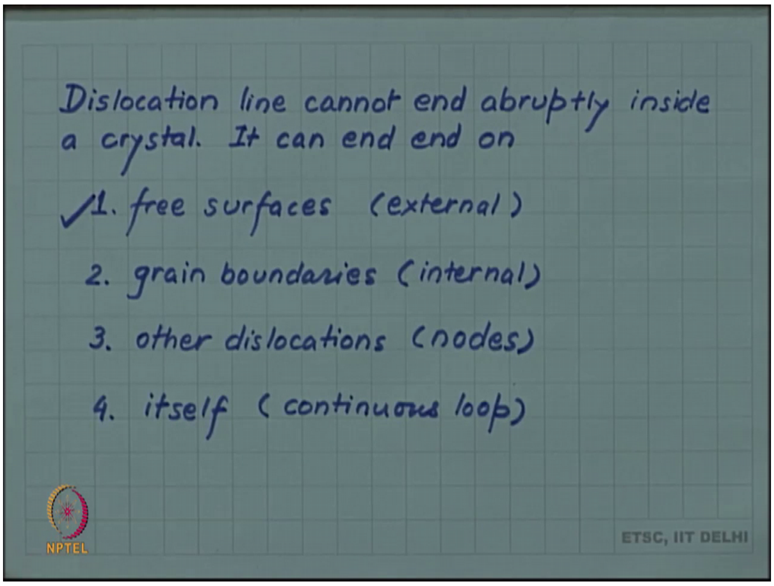

So, let us make a note of what all it can do. So, the dislocation line cannot end abruptly inside a crystal, it can end on and we have already seen that it can end on free surfaces, there are other locations in the crystal also where it can end. So, it can end on grain boundaries.

So, free surfaces are external surface whereas, grain boundaries are internal surfaces, we have not yet talked about grain boundary, we will do that in the next video, but for sake of noting down, we are noting that it can end on free surfaces or it can end on grain boundaries, it can also end on other dislocations, and if it ends on other dislocations it will form what are called nodes, or it can end on itself ending on itself really means that there is neither and really a start or an end, it forms a continuous loop, it is not a line within a start or an end, but it forms a continuous loop. So, we have already seen that it can end on a free surface, these other configurations we will be looking at in the coming videos.