Introduction to Materials Science and Engineering
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Lecture – 55
Dislocation cannot end abruptly in a crystal: Grain boundaries

So, we will discuss Grain Boundaries and Dislocations. In the last video we saw that a dislocation line cannot end abruptly inside a crystal.

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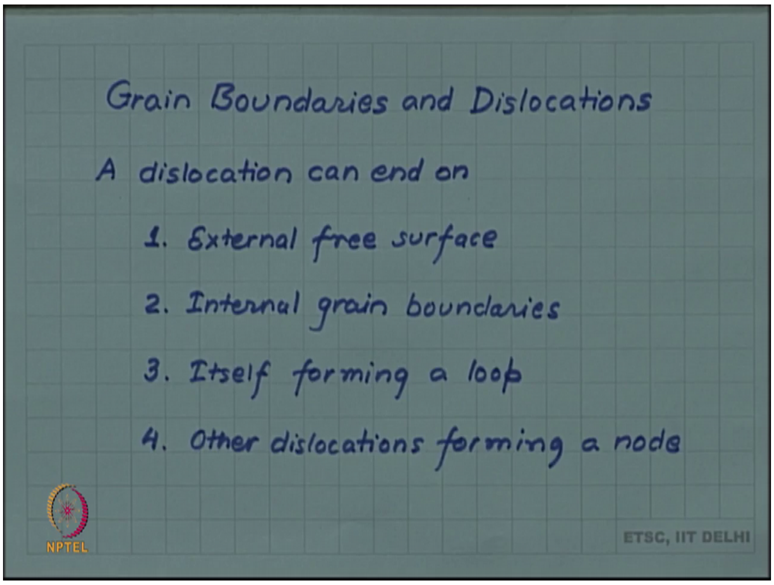

But, it can do one of these things it can end on external free surface or it can end on internal grain boundaries or it can end on itself forming a loop or it can end on other dislocations forming a node. We have already discussed in the last video the external free surface. We should now look at how it can end on internal grain boundaries.

So, let us look at, what is the meaning of grain boundaries?

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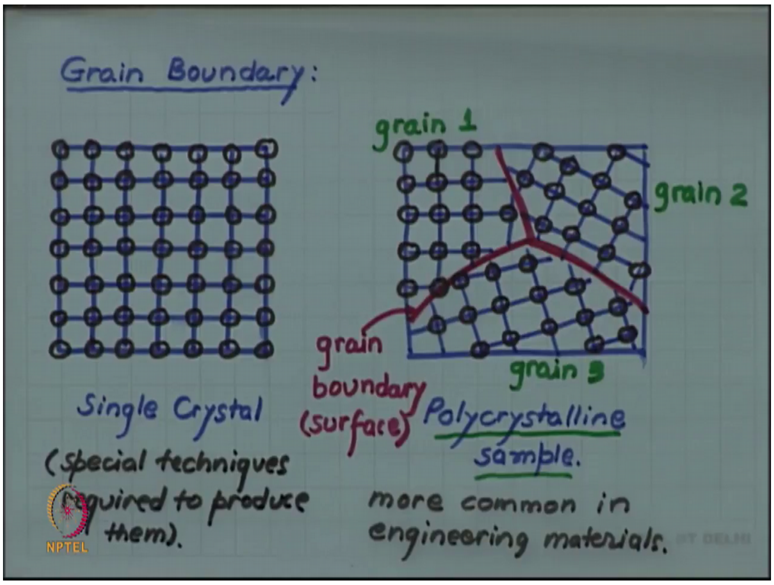

Grain boundary is an important micro structural feature in a crystalline sample and we should have understanding of the grain boundary. Let us assume, that we have a crystal and the crystal which we have been talking till now are what will be called a single crystal, we have not used this phrase again, but basically, we have been assuming that all our crystals were single crystal. By single crystal we mean that all the unit cells in the crystal in the sample are in identical orientation. It should be that by our very definition of the crystal because we require periodicity. So, we have all the unit cells in the same orientation.

We called it crystal, but now we are calling it single crystal, because we want to distinguish it from a more realistic situation where in the same sample we have more than one crystal orientations. So, such samples will be called polycrystalline and they will have more than one orientation of the unit cells within the same sample. So, to contrast it from polycrystalline the standard crystalline material or crystal with nice periodicity from n to n is what we have called single crystal.

So, let me try to now draw what will be meant by a poly crystal. So, then I will draw my sample box this is the external face, but this sample I divided in into more than one regions by some lines. Let me divide it into regions like this and then in one of the regions draw my crystal in a given orientation. But I am not extending that orientation throughout the sample you can see I have ended this particular orientation on the red lines which I have drawn. So, I am not extending this particular orientation beyond the red lines. In the other side I will draw the same crystal, but in a slightly different orientation.

So now, I change the orientation. And so, this is also the same the square crystal. Let us say in 2d or a cubic crystal in 3d. So, unit cell size and shape is the same; however, the orientation has changed and similarly, in the third region I can draw with another orientation. So, the idea is that in the same sample we have the same crystals, but in different region the crystals are oriented differently.

So, the unit cell size and shape is the same, but as I cross these red lines the orientation changes. Orientation is no more the same and these kind of samples are more common in engineering and in practice and these are called polycrystalline. One has to make a special effort to get single crystal. So, this is a polycrystalline sample, and the lines which I have drawn across which the orientation changes, these are called the grain boundaries.

In 2D it is a line, but you can imagine in 3 dimensions if I want to separate regions with different orientationsso you will need surfaces. So, grain boundary is a surface. It may not be a flat surface it may be a curved surface, but it will be a surface in 3D in a 2-dimensional picture like this I have shown it as lines and different regions which are divided by the grain boundary there are themselves called grains.

So, this is a grain, this is another grain and this is another grain. So, in my picture there are 3 grains. So, I can call them grain 1, grain 2 and grain 3. So, this particular boundary, this particular boundary which I have labeled as grain boundary is a grain boundary between grain 1 and 3, this one is a boundary between 2 and 3 and this one is a boundary between 1 and 2.

So, there can be several grain boundaries and several grains in a same sample and this kind of samples will be called a polycrystalline sample and as I stated more common in practice, more common engineering materials. This will be less common and we require extra a special care is required a special techniques are required to produce single crystal.

Now, if we look at this and try to relate it to the dislocation we can see that a dislocation line cannot cross a grain boundary.

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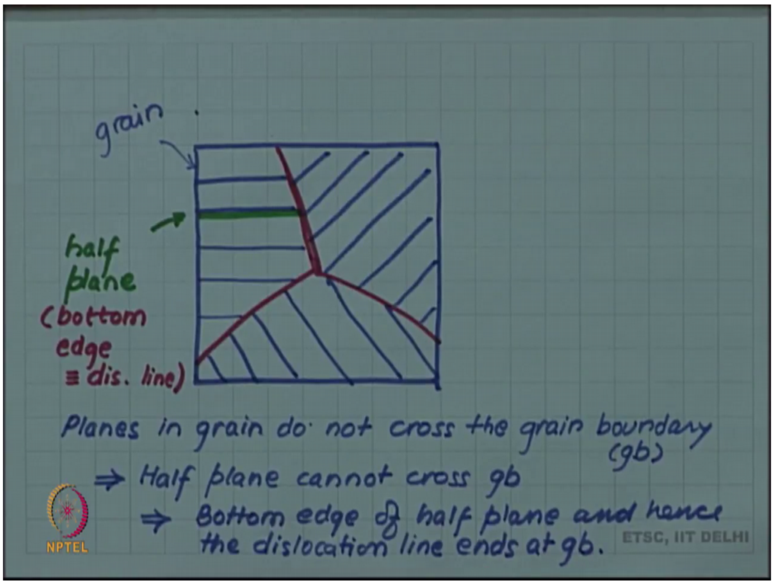

So, let me again draw a grain boundary and let us consider some plane let us say 1 0 0 plane of the crystal and let me draw it in each of the grain.

Now, since the across the grain boundary grain changes the orientation. So, the plane which I am drawing will also change it is orientation. Now you should imagine that these planes which I have drawn a perpendicular to the plane of my drawing plane of a plane of the page and it is going into the crystal. If I want to and if they are going right from the top face of the crystal to the bottom face they are continuous plane and there is no dislocation .if I want to introduce a dislocation one of these planes have to be a half plane. So, let me say that this plane is a half plane.

Now, since across the grain boundary the crystal orientation changes so, these planes do not continue across the grain boundary and that is why half plane also cannot continue across the grain boundary. And so, dislocation line which is the bottom edge of this half plane also cannot cross the grain boundary. So, the bottom edge of this half plane with the dislocation will be a dislocation line which will start on this free surface, but it is not going all the way to other free surface, it is interrupted by this grain boundary. This grain boundary interrupts this dislocation line the bottom edge is the dislocation line.

So, this is quite simple to understand and so we let us write that down that plane in a grain. So, this is one of the grain in our terminology introduced in the last slide, this is a grain. So, planes in a grain do not cross the grain boundary. Let us use abbreviation GB for grain boundary.

So, this will imply that half plane will also not cross the grain boundary. So, this will; obviously, say that bottom edge of the half plane which is the dislocation line. And hence the dislocation line ends at grain boundary. So, a dislocation line can end on a free surface or internally it can end on a grain boundary which is also a surface, but is an internal surface.

So, thank you, we will continue examining the property of dislocation ending at various places in the next video.