Defects in Crystalline Solids (Part-I)
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Lecture - 18
Characteristics of Dislocations

So, hopefully I have tried and if not then I would suggest you do not start with this lecture until you have tried. But, hope if you already tested, it you have already tried how to draw this, it will be much more useful for you this part of the lecture. So, let us start with this, now assuming that we have already tried it out.

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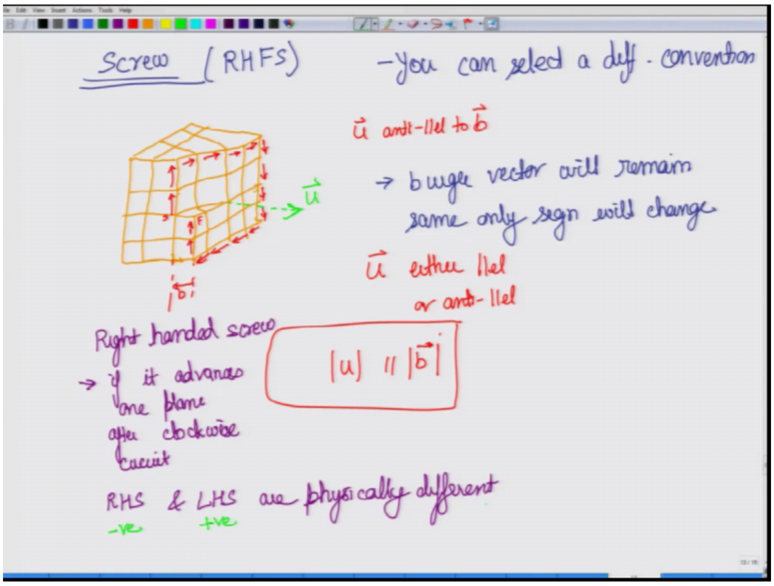

So, how it this look like? So, now without lose of generality what I will do is start from this point. So, this will be my start, I will draw 2 vectors up, I will draw 4 vectors right and then I will draw 4 vectors down and then I will draw 4 vectors left. So, these two are already cancelled with respect to a perfect crystal and the up and down have also been cancelled out.

So, we have F to S, there is still a gap and that gap as you can see is out of the plane, is not in the same plane as it was happening in the case of edge dislocation and that is where it becomes very difficult. So, here this is the gap and hence your Burger vector would be this again using the RHFS. So, finish to start this gives us the Burger vector.

So, in this particular case what you see is that u is anti parallel to b. And now that I have described it here, let me just go back and talk about this Edge dislocation, over here what you observed was that the Burger vector was perpendicular to u.

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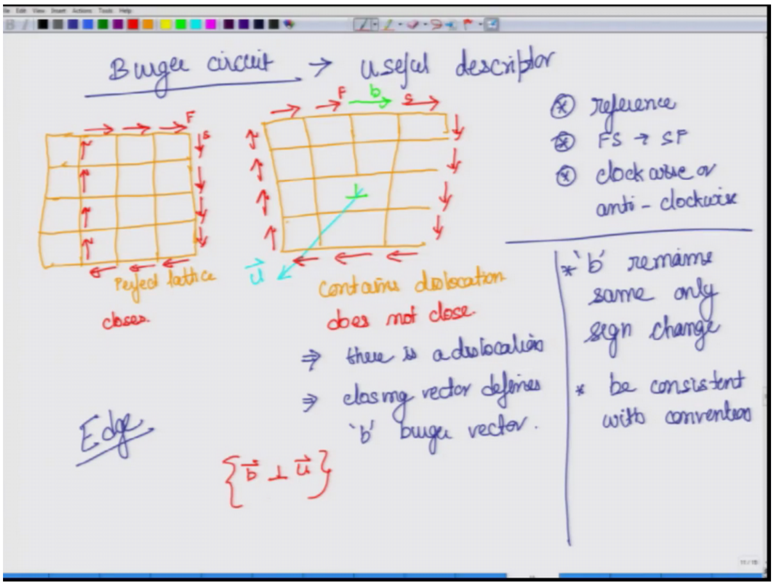

So, this is something common, you would always realize that this is what will also distinguish between edge and screw. So, coming back to our current topic which is screw dislocation, so here u is anti parallel to b or it will, the Burger vector will remain again the Burger vector will remain same only sign will change depending on the convention. So, if that is the case, it means that u will be either parallel or anti parallel always, but it cannot be anything else. So, in general terms u would be parallel to b.

So, this is another understanding that we have been, when I say parallel it means in the signs of being in the same direction, the sign can be different. The sign can be different that is all that is possible depending on the difference convenience or a different kind of screw dislocation. So, here also if you reverse the sign if for example, if you take the u direction going into this you can realize that you will draw this Burger vector opposite. And therefore, the Burger sorry the Burger circuit as opposite direction and therefore, you can start from here, finish would be here and then finish to start the Burger vector will also be different or Burger vector will be now opposite sign.

So, depending on what u direction you will take, you will you are always getting u as anti parallel to b. So, that is also another interesting aspect. And, another thing that we have to realize here is that this is called a Right handed screw. What is a Right handed screw? So, let us look at the screw along the axis. Now, whenever if you draw a clock wise and if you then, if you come out of the plane, one plane if the after drawing going through one clock wise revolution, if you come out one plane then it is called a right handed screw.

On the other hand if you take a clock wise direction and you go 1 layer behind or 1 layer low below the original plane, then it is called an left handed screw. So, right handed screw is if it advances 1 plane after clock wise circuit. So, the question is here, is, it that this same screw which we are looking at is RHS from one side and LHS from other side. So, now let us imagine, if you are looking, right now we have nothing to do with what is the convention, what is the line direction only all we have to worry about is the axis. So, if you are looking at this axis then along with this axis you have to see whether on rotating you are going one plane ahead and one plane back. So, from this direction we have already seen when you go clock wise and you came one plane ahead then it is right handed.

Now, look at let us imagine going, looking at it from the back side. So, again from the back side you have to draw clock wise, do not again like I said do not worry about the conventions are not we are just trying to describe a right handed screw. So, even from the back side if you go clock wise you can imagine that you are coming one plane ahead in that direction. So, that is still a right handed screw, in what is the bigger implication of this is that right handed screw and left handed screw are physically different. Now, that I have described this I will have to go back and talk this something about positive and negative edge dislocation.

So, if this is the positive edge dislocation, how will a negative edge dislocation look like just this and what it would mean is that you have just rotating the crystal upside down. So, positive and negative crystal are not physically different, but right handed screw and left handed screw are physically different and right handed screw and left handed screw can also be said as positive and negative. See if one you has described as, it is not necessarily right handed is positive, but depending on your convention if right handed screw comes out to be positive then the left handed side will be negative. What is this sign in your particular case? In your particular case right handed screw is coming out to be negative. So, let us be consistence and write this as negative and this as positive. So, now we are we have seen the convention, we have seen 2 different type of dislocations. Now, what else can we understand about this. So, let us move on to understand what is called as Mixed dislocation.

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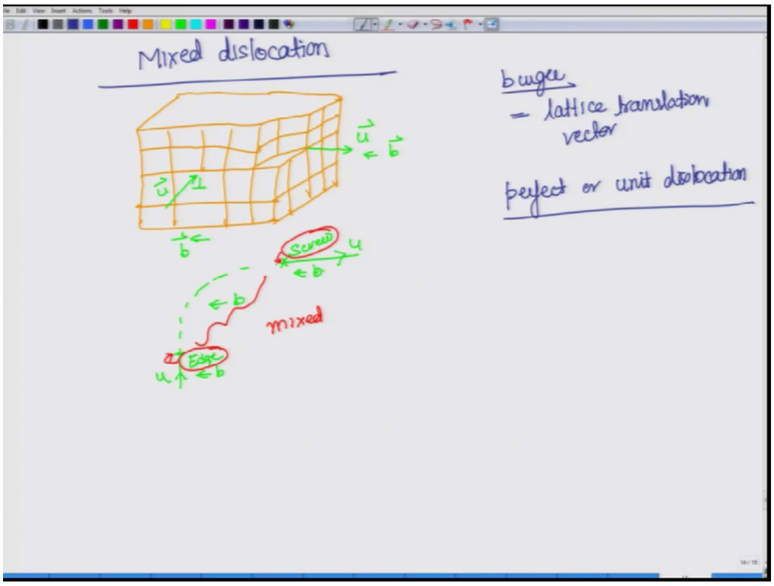

As we will discuss later that in reality what you have is neither a pure edge dislocation nor a pure screw dislocation and most of the time what you will have is only a mixed dislocation. Therefore, let us see what a mixed dislocation implies. So, again let me draw this and it will be little bit more complicated then what we have already drawn. So, again you must follow it closely. So, we are showing over here 1, 2, 3, 4; 4 different layers of atom.

And what you see is that when you look in this set of material, what you see is that on this side you have a edge dislocation and when you go over here we have what we see here is what we have already described as screw dislocation. So, something like this let us describe the line vector like this. So, that it is going in and coming out and accordingly there is a edge dislocation and there is a screw dislocation over here. So, inside it something like this is happening. So, we have and this is the point where we are seeing screw dislocation and this is the point where we are seeing edge dislocation. And if you look at it carefully what you would realize is that if you have described the u like this then the Burger vector would be, it will we have to draw the anti clock wise and therefore, from finish to start the Burger vector would be like this.

So, the Burger vector over here would also remain like this. If you go through this you will realize that the Burger vector is still the same. And now, here you have a Burger vector like this, here you have Burger vector like this. So, it seems that the Burger vector remains constant whether you are in a Edge dislocation or in a Screw dislocation, it is a matter of fact that Burger vector would remain constant for one given dislocation. No matter what location you have looking at, no matter where what is the orientation the Burger vector will remain constant which mean that each of this point Burger vector is like this. However, the line direction as you can realize is not the same. The line direction was like this, now line direction over here like this.

And we know that when, when u and b are parallel or anti parallel only then it is Screw, when u and b are perpendicular only then it is Edge which means that at this point only it is Edge, at this point only it is Screw and at rest of the point what it is a mixed dislocation meaning it has partially edge character, it has partially Screw character and this is what we call as mixed the remaining portion is mixed. And I we will again come back to this, but you will realize that the pure edge and pure screw are actually present only at single or basically at some few points, but rest of it is mixed dislocation.

Another aspect before we move on is to understand about Burger vector is that you have seen that so far, the Burger vector is equal to the lattice factor, lattice translation vector a dislocation which contains dislocation with Burger vector is equal to lattice translation vector is called a perfect or unit dislocation. As you would see that since we are describing something as perfect or unit, it means there are some dislocations which do not have perfect or unit dislocations.

So, there can be imperfect dislocations or partial dislocations, but in, but in this particular cases what we have seen so far are only perfect or unit dislocations. So, now, we are in a position to talk about some important characteristics of dislocations. We have see n the fundamentals of dislocation I would not say that we have gone thoroughly through the dislocation, but the very fundamental characteristics of the, of the dislocations. So, what are these fundamental characteristics, let us look at it.

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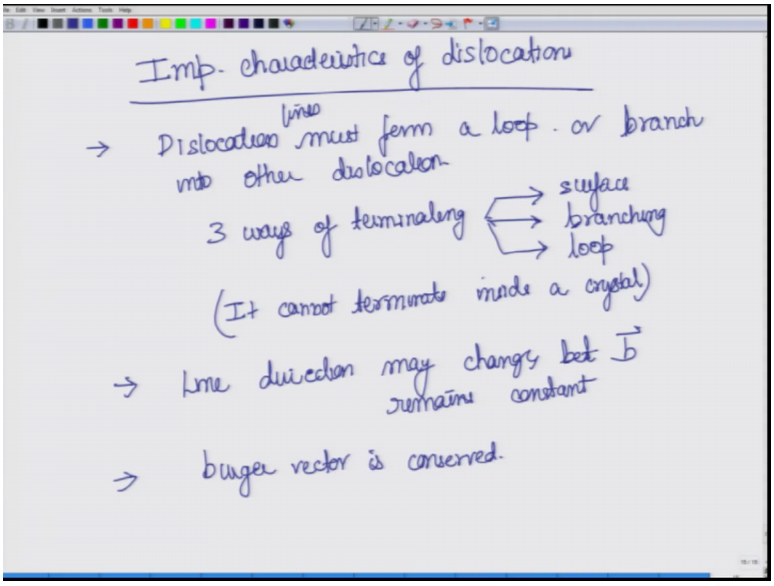

Important something some of this you would see that you may have not realized all though just by the definition that we have given these must be true for them. First and foremost we have to realize that, we saw that the dislocations are actually a line, now you have to realize that dislocations lines cannot start and end separately inside a point, inside a crystal, inside a if you take a crystal then the dislocation line cannot start arbitrarily any point and at arbitrarily at any point, they must either form a loop or they must terminate either or at a surface or a grain bonding.

So, the first and the most important characteristics for dislocation is that, dislocation must actually lines, must form a loop or another way that it could, it could branch or branch into other dislocations. So, the basically there are three ways that dislocations can terminate. One is either it has to come to the surface. So, the end again the start and the finish both of them have one of the have to come to the surface or one of them can at surface the other can be in branching or start and finish can combine together to form a loop.

So, these are the only three ways that the dislocation lines can end inside a crystal. Now you would think that we are seeing. So, many dislocations, dislocation lines the edge dislocation line and the screw dislocation line and we saw the start point and the end point that is a perfect crystal on top of it and that what would that mean that the dislocation start line has finished inside a crystal, but you have to think a little bit more carefully that there is a extra half plane in case of a edge dislocation which would mean that the dislocation is again coming out all the way to the top of the surface on one side

So, it is still form, it is still going to follow this rule that dislocation line will either form a loop or it will branch into other dislocations or it must end at the surface even before I go there. So, now, I have said this which what we are explicitly saying is not possible is that it cannot, it is a corollary of what we have already said, it cannot terminate inside a crystal. You can, you can try doing several thought experiments and you would realize that it is true, it cannot terminate inside the crystal.

Another important characteristic we which we have said is that line direction that can, line direction can change like, like you saw in the case of mixed dislocation. However, when we are talking about the Burger vector Burger vector you would see remains constant. We have not explicitly shown it for the mixed part, but you saw that the Burger vector for the screw component and the Burger vector of the edge component for the same line dislocation line remains same.

And in between also we are not showing it explicitly, but that is the fact where the Burger vector would remain constant. So, the line direction may change, but Burger vector remains constant. Now that we have already also talked about other characteristics in terms of dislocation line forming a loop, a corollary of this is also that the Burger vector must be conserved.

Now, like we say it can branch out, when it is branching out it would mean that the total Burger vector in the 3 sum the whatever 3 or more branching that is taking place, it must remain conserved. So, the, we will see or look at it what exactly this means. So, Burger vector is conserved, we will look at it in a moment, but before that.

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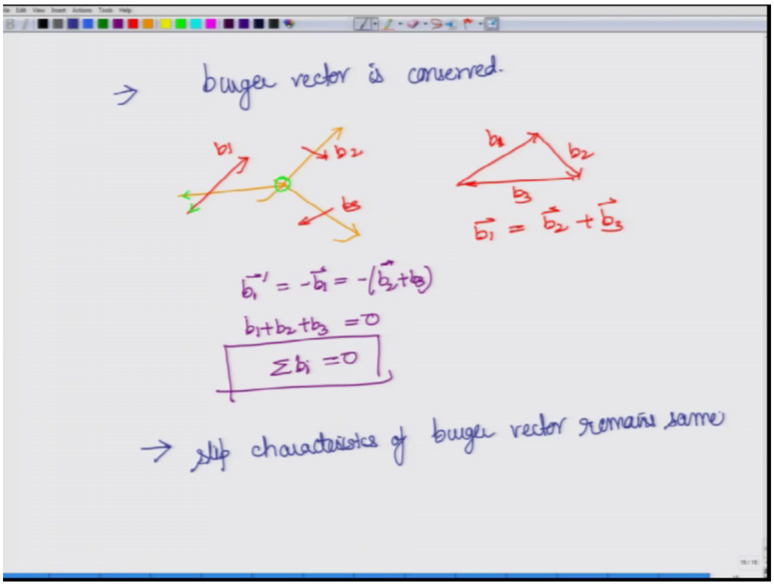

So, let us say this is one Burger vector or one dislocation line which has some particular Burger vector b. So, this is another dislocation line. So, it has branched out. So, there must be another dislocation line going like this and I have drawn it straight it need not be straight line, but the Burger vector would remain the same for those. So, let us say for the original 1 Burger vector was b 1 and for the branched out b Burger vectors are like this b 2 and b 3. When we say it is conserved what we are implying is that b 1 should be equal to b 2 plus b 3.

So, all though we have not drawn it to the scale over here, but this is how it should look like b 1 equal to b 2 plus b 3, this is what is what we imply by conservation of Burger vector and again a corollary of this is that if you take all the direction going out from the node. So, this is node over here. So, if you take a Burger vector in a way that the line. So, that all the lines are going out from it meaning, now we will describe this line vector in this direction which would means that the Burger vector of this will also change and therefore, this Burger vector will become.

So, b 1 prime would be equal to minus b 1 would be equal to minus b 2 plus b 3. And therefore, what we have here is b 1 plus b 2 plus b 3 equal to 0. So, now, (Refer Time: 20:25) or in other words bi equal to 0. So, this is another way to represent that there is conservation or Burger vector. Over here we have assumed again some convention that the line directions have to be taken in a way that from a node all of the line lines are going out.

And one last important characteristic is that slip characteristics of Burger vector remains same. What we are trying to say here is that if you move from screw dislocation to edge dislocation the type of slip that this will provide will remain same no matter whether you are in the screw dislocation part or in the edge dislocation part, but since they have the same Burger vector they will provide the same type of slip.

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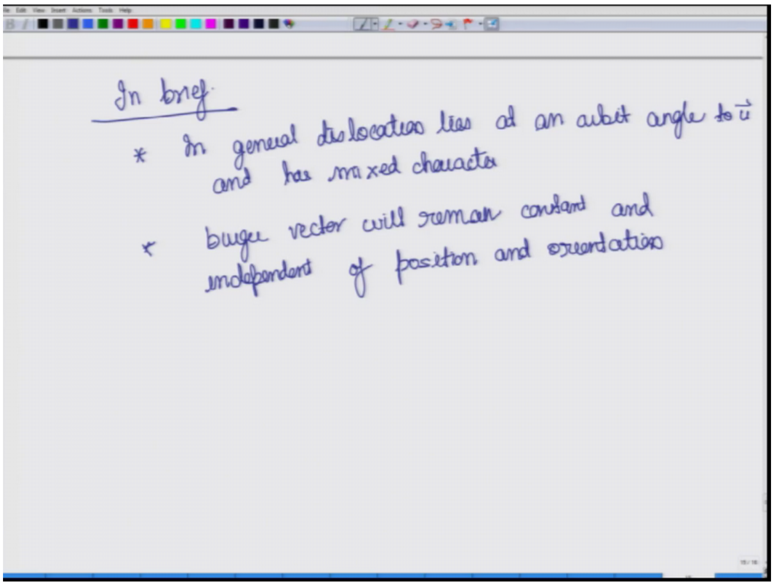

In brief what we have understood is that in general dislocation lies at some arbitrary angle to a Burger vector and has a mixed characters at an orbit angle to u, u is the line vector and has mixed character. Another important aspect is that Burger vector will remain constant and independent of position and orientation.

So, these are the 2 just important just of what we have understood about dislocations so far, but this is very broad understanding about dislocation. We also saw that there are 2 different kinds of dislocations which are the edge and the screw dislocations. So, we will see what are some of the things that we have understood we about Individual dislocations.

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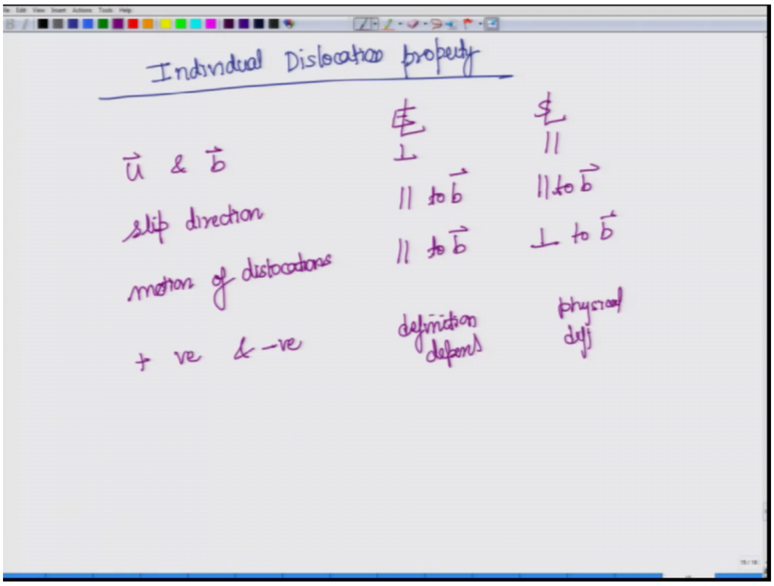

So, what have what are the things that we have understood about Individual dislocation. So, let us look at some properties we should, we can say that what we are looking at now is Individual dislocation property. So, there are 2 dislocations there will be mixed character, but in the mixed character we are in a position to resolve it into either a edge dislocation or a screw dislocation.

So, from the point of view of understanding stress strain and properties and slip we can always resolve them into edge and screw. Although way we know that in screw dislocation they will lie, they will be always in the form of dislocation. So, once you resolve it as screw dislocation and edge dislocation then you can also say this is the characteristics, it will have which we all which we which we will see over here. So, there are 2 dislocations like I said in the pure form edge dislocation which I am writing it like this EL screw dislocation which I am writing like this screw dislocation line.

What do we know about the relation between u and b, for the edge dislocation what would we see u and b are perpendicular to each other, the line signs the signs may change positive or negative. For the screw dislocation they are parallel again signs may change, we need it can be parallel or anti parallel, but in broad sense it is still parallel slip direction. So, we have said that a Burger vector gives a good understanding about the slip direction

So, what is the slip direction? So, you would also under stood, also understand that the slip direction would change when we go from edge to screw. So, in the edge dislocation the slip direction is parallel to b. So, wherever the Burger vector in that direction the slip is taking place and we know that the screw dislocation it must be different because they are it changes the direction changes, the Burger vector remains same, but the screw the relation between Burger vector and the line direction change changes.

So, for example, in b and u they are parallel, in b and u in edge dislocation is perpendicular. So, the slip direction is parallel to b and in the screw dislocation it should be. So, the first hunch that you may get is that it may be perpendicular, but then you realize that no Burger vector is constant. Therefore, this will still be parallel to b. Motion of dislocation; dislocation is not always or not all dislocations are moving in the direction of say this will change from certainly changing from edge to screw. So, the motion of dislocation would be parallel to b for edge dislocation and perpendicular to b.

So, it is the motion of dislocation which changes when we go from edge to screw, but the slip direction will remain same because b is constant and that is what defines the screw slip and that slip will be constant or remain same as long as b is same. What can we say about the positive and negative dislocations? For the edge dislocation what we saw that positive and negative the definition its definition dependent there is not really much change.

For this one it is actually different, physically different. So, we will close at this point with this understanding about individual dislocation property, we will get to know more about dislocations in the next class.

Thank you.