Mechanical Behaviour of Materials - 1
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Lecture – 26
More on Slip Systems

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So, we have looked at the various slip systems. Now it is time to get a little familiarized with this slip systems. So, first let us look at FCC. We said that for FCC, this is the slip system where this is the glide plane, and this is the slip direction. Overall, how many 111 types of planes can you find in a cubic material and the answer is 4. What about 110 direction? And if you look closely then you would see that there are 6 different variations of 110 direction.

And here is a catch or basically any additional information which helps us to make or organize our information. For each of the 111 plane, there are only three directions that lie, three on a given 111 plane. So, for each of these 111, you will have three 110 directions which also means that the sum of these 110 directions would be shared between the 111 planes, and this is best described in terms of what is called as Thompson's tetrahedron.

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And if you do a simple search on Google, you will be able to find some images of this and although I said tetrahedron what we are looking at here is a triangle it is because it is drawn in 2D. Now, if you join the D with the D if you cut this along these somewhere like this, this will ensure that you are able to join it. Similarly, over here, you will have to cut it like this. Now, this is a Thompson’s tetrahedron which is very powerful technique to identify the planes and directions in FCC systems.

Now, once you cut it, you fold such that D comes back to D and from here and over here and therefore what you will have is a shape like this. Now, here you can see that there are 4 faces. So, the 4 faces represent 4 111 type planes and each of the face are bound by 3 edges. So, the 3 edges represent the Burgers vector that are possible on the given slip plane. So, clearly from this for example if you take this particular edge which is shared between these two planes.

So this particular Burgers vector is common to both of these and it also tells you a lot about the dislocations. So, if you have a screw dislocation with this Burgers vector, then you know that the screw dislocation line vector is also along this and therefore this can cross slip into either of this. So if it is moving here, it can also as well move into this plane. So, this is giving you information about the slip plane, the slip direction and what are the possible cross slip that is possible in the FCC system.

So, this way FCC system can be understood fully using this Thompson's tetrahedron. There are some additional information over here, but we will get to understand those more later on. For now, it is sufficient to understand that this tetrahedron will enable you to understand all the planes, slip planes and what the associated Burgers vector. So now let us look at some examples over here. So let us look at this one. So, this is a bar 1 bar 1 1 plane and the Burgers vector possible are ,so you will have to add a by 2 this is just showing the direction.

So, a by 2 011 a by 2 11 bar 0 and a by 2 101 bar and you can see that the dot product of these would come out to 0 because these Burgers vector do lie on this plane. And like I mentioned that this particular any of these Burgers vector you select will lie on two and exactly two slip planes. So, for example, this one a by 2 1 bar 10 will be lying on bar 1 bar 1 1, but also on 111. And therefore, dot product of this with this is 0 as well as dot product of this with this is also 0.

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And therefore, if someone tells you that let us say we try to solve the examples where you are asked that this is the cross slip that is taking place in an FCC system and you have to identify what are the two possible planes, then you can clearly identify. So, let us say you have given cross lip. So, basically this is double cross slip and the only thing this is given is that this plane is 111 and you are asked to identify P 1, P 2, you are asked to identify u 1, u 2.

Now, it is very easy if you go back over here. So, 111 is our plane. So, 111 is over here and the possibilities with which it can cross slip are so it can cross slip onto this one, it can cross slip onto this one or it can cross slip onto this one. So, the planes P 1 or P 2 can be any of these P 1 or P 2 and we will correspondingly u 1, u 2. So, 111 can cross slip onto any of these basically 1 bar 1 bar 1 or bar 1 1 bar 1 and bar 1 bar 1 1.

These are the three possible planes, and you can as well take the negative of this. So, if I say this it is as well equivalent to saying this and when this is the plane then the only Burgers vector which is common to both of these is 0 1 bar 1 and we know that the line vector must be parallel to Burgers vector for cross slip and therefore this must be also the Burgers vector. This is the line vector as well as the Burgers vector where the cross slip takes place.

So the u 1 or u 2 for this particular case, which is 1 bar 1 bar 1 should be equal to a by 2 011 bar, a by 2 0 1 bar 1 or a negative of this, which is a by 2 01 1 bar. When we are talking about the other plane which is 1 bar 1 1 bar so this is the common one and here the Burgers vector or the common direction is 101 bar. But of course the Burgers vector has to have that a by 2 or the negative of this therefore bar 1 0 1.

And for the last one which is bar 1 bar 1 1 which is here, the common vector is 1 bar 1 0. For Burgers vector we have, so this actually for the u 1, u 2 we do not need this, but for Burgers vector we would need this factor. So, this factor first let me write the complete thing. So just to clarify, this is just vector part. For the u 1, u 2 you do not need this part. Similarly, over here. So, when you are given a condition like this, you would be able to identify what is the combination of P 1, P 2, u 1, u 2.

That is possible given this particular plane or any combination of this information and it is all possible, even without the Burgers vector you can do that, even without the consisted pattern you can do this, but then you will need to do a lot of vector multiplication to see and cross check whether this is a dot product or not, dot product is 0 or not and so on that is whether this particular Burgers vector lies onto this plane or not. So overall, this makes the task much simpler for us.

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Now, let us look at BCC slip system. So, here we know that 111 is the closest packed direction. We said this is the closest packed direction and unfortunately here we do not have anything like consisted of pattern, but we do have a something which can give us partial information using a circle. So, if you have 111 as the closest packed direction, then for each of this 111 and we know that 110 is the glide plane, but 110 and yes one more thing that I should now mention at this stage that 110 is the preferred glide plane.

But for BCC there are some more options available like 112 and 123. So, depending on material sometimes 112 and sometimes 123 are possible glide planes. Now, for a given 111 what you would find is that there are three possible 110 planes and similarly three possible 112 planes are possible for one given 111 direction. So, if you 111 direction, there are basically three different 110, three different 112 which can contain this 111 direction and six different 123. Overall, 12 different possibilities.

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And like I said unfortunately we do not have any consisted pattern, but we do have something which serves the purpose. So, let us say you have a 111, zone axis is given as 111. Then you can draw the various planes. So, the normal to this is 111 basically, you can draw the various planes. So, for example this is 1 bar 1, 2 bar 1, this is 112 type of plane, this is 011 bar. Then you have one bar 1 bar 1 2. Then you have bar 1 0 1. You also have bar 211 and then you also have 011. And here I have only included 110 and 112.

So, there are only six different planes that are shown to you and if you were to include 123 type of planes, then it will be a lot denser. So, even just from this you can see that screw dislocation in a BCC system will have so many possibilities. In the FCC system it had only two possible planes to move on to a given screw dislocation. But in BCC with only 110 and 112 you get to six different possible planes. And if you include 123, then there are 12 different planes onto which the screw dislocation can move.

And it is not surprising that because of this variation, this is the trace of a screw dislocation looks as if someone has just drawn by hand and therefore it is also termed as pencil glide. So, I hope that we have gotten enough acquaintance with the dislocations and the slip systems. We have looked at the BCC and FCC system and the particular ways where we can easily identify the slip systems what these two particular crystal systems. So, we will end this chapter over here and then we will come back with a new topic in the next week. Thank you.