Mechanical Behaviour of Materials - 1
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Lecture – 23
Climb Motion of Dislocations

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So, welcome back. We have looked at glide motion of dislocations. We have looked at cross-slip of screw dislocations. Now, we will look at the motion of edge dislocation or particular motion where it moves out of the plane, and this is called climb motion of dislocations. So, this climb is the process by which move out of plane. So, let us look at how this happens. So, for example, let us say we have and to give you just a preview of what is to come, so here dislocations move out of the plane by involvement of vacancies.

So, we will see that vacancies are also involved in this overall process. So, let us say we have an edge dislocation, and we are looking at it side views and let us say this is a vacancy. So, clearly this is an edge dislocation, and this is the extra half plane, and this happens to be a vacancy. Now, let us say that this particular atom which is over here moves into the vacancy or vacancy moves over here.

So, vacancy moves here, then what will the final picture look like? The final picture would look something like this. Now here there usually had to be atom but now it is a vacancy. So, this vacancy is as good as that this portion of extra plane has moved up. So, from here edge this location has moved up and this becomes the lowermost atom over here. Although it has happened only at a local level, only at this small region maybe one vacancy or two vacancy, but that small region, the extra half plane has moved up.

Now, this process is obviously involving vacancy and therefore it means that it would be supported where vacancy movement is supported, meaning high temperature process. So, these are called thermal processes. So, in this particular one the edge dislocation moved up.

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You can also have a situation where edge dislocation moves down and let me draw it for this one also. So, it would look like this. So, this edge dislocation the extra half plane lies only up to this point, but we can also visualize it as if there is a vacancy over here. So, it is as good as saying that there is a vacancy over here and if there is a vacancy then this vacancy can move out and some atom can take its place.

So, this vacancy let us say moves over here and this atom moves over here and therefore what is the end result? That there is a vacancy over here and the extra half plane has moved down. So, it will look something like this. So, here we have vacancy, so, let us denote it by a vacancy and here is a vacancy and in the process, you can see that this edge dislocation, which was up to here, now it has moved down.

So, the vacancy has in this case moved out and which implies dislocation move down. So, these are the two ways that edge dislocation can move out of the plane. This is climb up so this will be termed, and this will be termed climb down and in this case the dislocation acts as a vacancy sink and, in this case, it acts like a vacancy source.

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So, now if you have some barrier appearing in front of edge dislocation, what it will do is it will move up. So, just I can show schematically again. Let us say this is a precipitate and let us say we have an edge dislocation over here, this is an extra plane, and which happens to be moving along this direction. So, now when it comes to this region, obviously it cannot cross this. So, if there is enough thermal energy that the vacancies can; you know in this case we need the vacancies to move in or if basically the dislocations to act as vacancy sink.

Therefore, in this particular region the half plane would move up and you would have a configuration like this, and the dislocation can keep moving on and eventually it can surpass the barrier. So, climb motion can help dislocations surpass any barriers. So, here we have seen tire dislocation has moved up. So, for example if it were moving like this, this edge dislocation and there was a barrier, it would move up and it can keep moving up in the upper glide plane.

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So, let me again emphasize this idea of the glide plane by drawing another schematic and let us say there was a barrier over here like this and then this dislocation, this was the original glide plane for this, but it can move up and glide in another parallel glide plane. So, this move up will happen when the vacancies are absorbed into this dislocation and then this will become the new glide plane.

And of course, there are atoms all around it, which I have not drawn here and thus this climb motion what I have shown here from another perspective that this dislocation would be able to circumvent or surpass this barrier.

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Now, a couple of important points which I have already mentioned climb involves vacancy diffusion, hence it is a temperature sensitive process which means that it is active only at higher temperature and the activation energy is a vacancy diffusion activation energy for this particular process. So, overall, the activation barrier that the vacancy phases during diffusion that is what you will see in this particular case also. So, we have looked at the glide of dislocations and the cross-slip of dislocations and the climb of dislocations.

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So, we can now summarize the motion of edge dislocations for the screw dislocation we have glide and the cross-slip, for the edge both of which would be considered conservative and what is conservative I will explain in just a moment. And for edge we will have conservative as well as non-conservative motions. So, we have what is called as conservative motion. Conservative motions are like what we have come to know as glide. Why is it called conservative?

Because there is no change in the vacancy concentration and hence that overall volume remains conserved, therefore it is called a conservative motion. On the other hand, we have non-conservative motion and climb comes under this category because we have seen that the process of climb involves vacancy diffusion. So, there is generation of vacancy or absorption of vacancies which would mean that the overall volume is not conserved and therefore the processes called non-conservative process, it should be non-conservative.

So, conservative implies number, so more precisely not the volume but now number of sites are conserved, and non-conservative means number of sites are not conserved. So, we have now looked at the overall motion of dislocations. We will come back, and we will look at the fact that even these motions of dislocations that we know, the glide and climb, are not accurate the way we have idealized so far. So, what is the difference we will come to know in the next lecture. Thank you.