Introduction to Materials Science and Engineering
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Lecture – 107
Plastic deformation and crystal structure

So, let us continue our discussion of the mechanical behavior of materials. A in the last video we saw the uniaxial tensile test and we saw that the initial part was an elastic deformation, but that was followed by plastic deformation.

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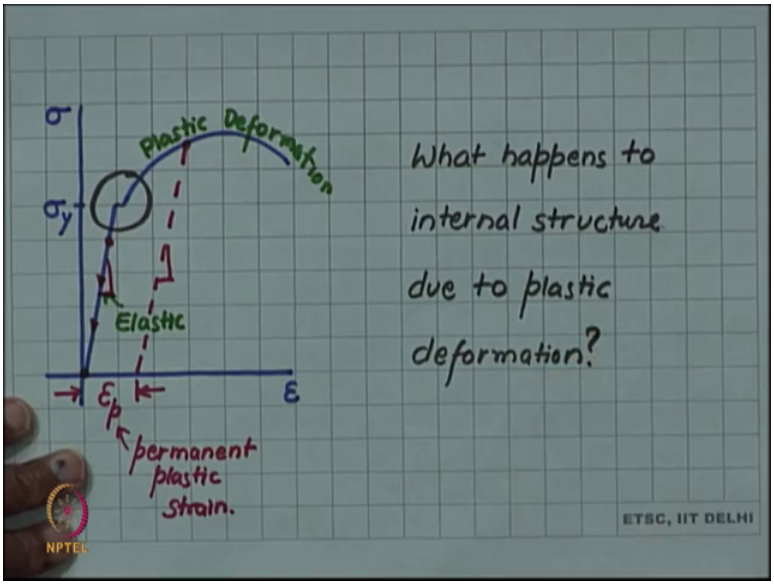

So, if we plot the initial if we plot the stress strain curve of a ductile metal, then it shows a yield strength up to the yield strength the deformation was elastic this part was elastic, but then plastic deformations happened. So, if we if we start unloading at any point in the elastic part of the curve, then there will be no permanent deformation, but if we after we have deformed let us say up to a certain point in the non-linear regime and from there if we unload, then it will follow a line parallel to the initial part of the curve that is the Youngs modulus the slope is not changed that is the same which means; even at 0 stress so much of strain is left. So, this is the plastic strain which is left in the material this is permanent plastic strain. Now let us focus let us focus on this part of the curve the transition from elastic to plastic.

So, what really happens what is in terms of the internal structure of the material what really happens when it undergoes a transition from elastic to plastic deformation? So, what happens to internal structure due to plastic deformation?

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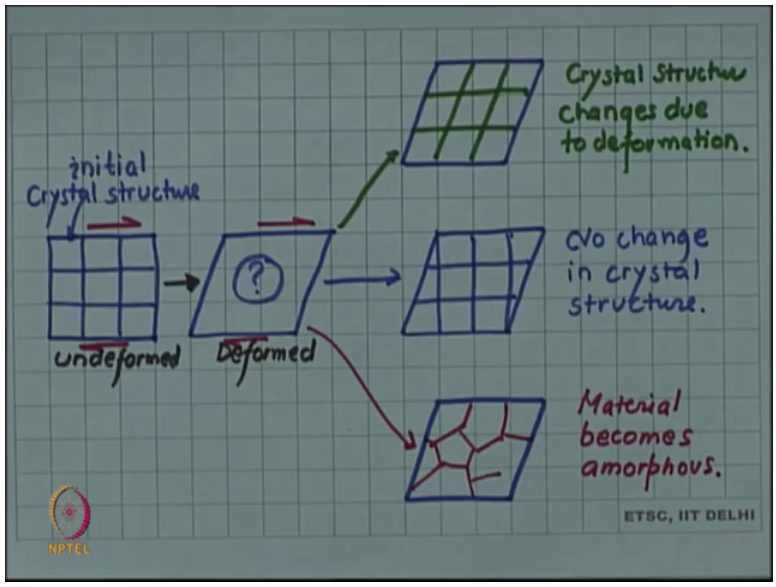

Let me make my question a little bit more precise. So, let us think of that we have a block I have shown you here in 2 d, but you can think of a 3-dimensional cubic block. And I am saying that this material is crystalline we know that most metals are crystalline for example, copper is phase centered cubic. So, the initial block which I am going to deform is crystalline. So, by these squares I am trying to show some sort of crystal structure of this block. So, this is undeformed, and now it is going to be deformed.

So, suppose it is deformed now the question which we are asking what happened to the crystal structure, it had some initial crystal structure before deformation the question is, what is the final crystal structure? Or is it crystalline at all. Now we can take several stance or several views about it. So, one view could be that as the material is deforming the crystal structure also changes according to the deformation this quite natural to assume. So, I think that the deformation has changed the crystal structure, notice that in this case I am considering a very simple kind of deformation which is a sheer kind of deformation of the material.

So, so one option can be the cry crystal structure changes due to deformation I can take another view and I can say that no the crystal structure is some sort of inherent material

property. And this does not change due to plastic deformation the crystal structure remains intact. The given material will have a given crystal structure irrespective of whether it is deformed or not. If I take this view and say that the crystal structure has not changed.

So, then I am saying no change in crystal structure. Yet another option we may think, we may think that the deformation can be quite aggressive in certain cases and due to deformation, due to plastic deformation the material actually breaks down the internal structure breaks down and the crystal structure is lost. So, it sort of becomes I am drawing this to just to show that the unit cell has broken down and some sort of amorphous structure has evolved.

So, no crystal structure is left material becomes amorphous. I have given you these 3 options you may even think of yet another some other new option other than these 3, but the question is; how do we decide? How do we decide between these 3 alternatives or any other alternative that you think of?

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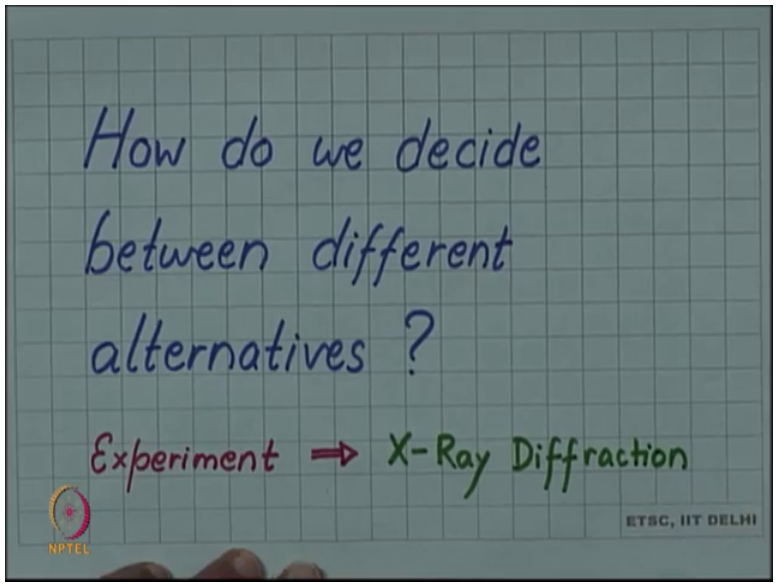

What is the basis for decision? How do we say whether the crystal structure changes or does not change or the material becomes amorphous? So, how do we decide between these different alternatives this is where a great scientific distinction comes from the ancient scientists like Aristotle. So, Aristotle in thinking would have been to just by pure thinking decide which of these 3 alternatives appears to be right or logically consistent

with previously known knowledge, but in the modern science we let the nature decide the question and to let the nature decide we do experiments.

So, we will have to do experiments. So, the correct way to decide between the alternative is experiment. Now if we want to if we wish to decide whether the crystal structure is changing or not changing or crystal structure is totally getting lost, what experimental tool we have if? You recall from your previous study of the structure the experiment which we need to do in this case is X ray diffraction.

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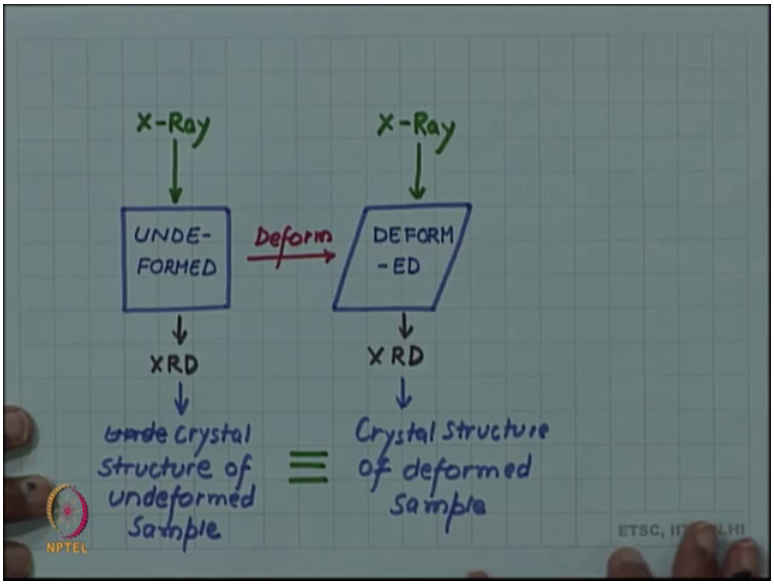

So, let us subject our undeformed and deformed material both of them to X ray diffraction. So, I sign X ray on undeformed material and I also sign and then I deform it. And I do the experiment again I sign X ray on the deformed sample both will give me the fraction pattern the X ray diffraction. And when we analyzed the diffraction pattern we can solve the structure and we can find, what has happened to the structure.

So, if when we analyze the X ray diffraction of undeformed we will get the undeformed crystal structure or crystal structure of undeformed material. And this will give me the crystal structure of deformed sample. When this experiment was done with this view in mind to check what kind of change or what kind of a structural change or crystal structure will change a material is undergoing when it is being deformed. So, the when these 2 X ray diffraction patterns were analyzed to our surprise it was found that the to give you the same crystal structure, the 2 crystal structures are identical. So, this is a

very, very important information about the deformation process that crystal structure does not change during deformation.

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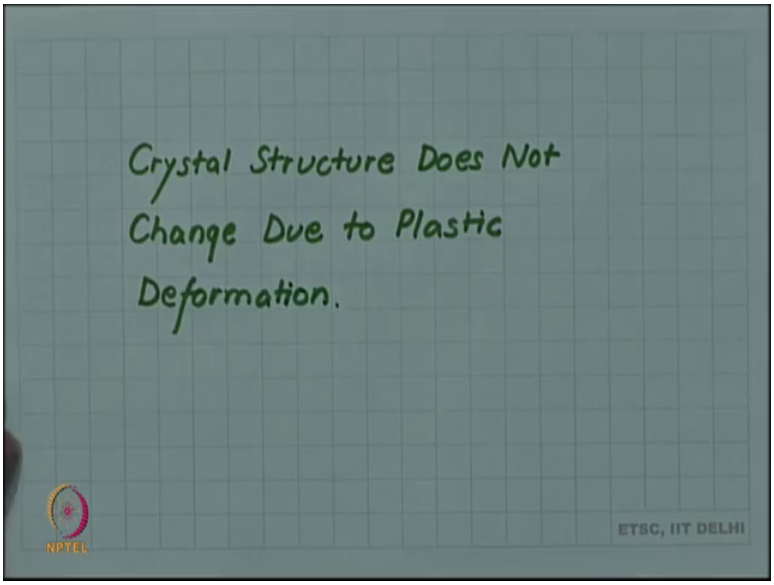

Let us write that out crystal structure does not change due to plastic deformation.