Materials Science and Engineering

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Lecture – 09
Microstructure: Understanding

Hello friends, now after going through the microscope and metallography let us talk about microstructure a little bit ok. So, the idea here to while, while we want to discuss microstructure is that we want to understand that what we see in a sample or in a material ok. What are the different features can be possible in a material just to get a hang of the word or the term microstructure and what can be there ok.

So, this is just an understanding again you may feel that some of the terms are not known to you and some of the ideas are still not covered in this particular course ok. So, again after going through let us say phases phase diagram and. So, on later on you can again come back to this lecture to get an idea about that what we were discussing about microstructure here ok. So, just to give you an idea about when we say microstructure, what do we mean by microstructure ok.

Just want to take few examples here and kind to impress upon you that what different features are there in the microstructure ok. So, usually when we talk about microstructure we talk about a term or we talk about a material, which is polycrystalline ok, polycrystalline poly means there are many in crystalline means crystals ok.

So, when you are many crystals and they are together then only you we talk about some micro structure in the material ok. So, it can this crystals can be we can we also call it as grains or grain, and when two grains meet they have some boundary; obviously, like two countries are there ok. So, one country is there the next start for example, from India to Bangladesh there has to be a boundary between the two entities ok.

So, similarly two grains two entities there has to be a boundary between them ok, and normally all engineering materials are poly crystalline again they contain large number of these crystals and, they are kind of and have a these are agglomerate kind of thing and you have features in between them ok.

There can be another class of material this is polycrystalline there can be another class of material which is called single crystal ok. So, now, I do not have large number of crystals ok, I have only one crystal in the whole material and this type of a materials are required or this type of a.

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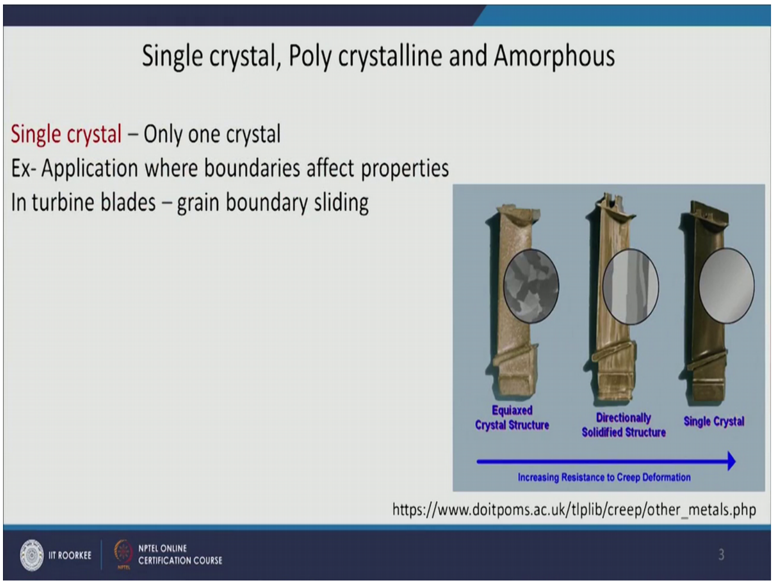

Arrangement is required in very specialized condition for example, your is, electronic material or is silicon vapor this is a single crystal silicon vapor, or you have turbines a high temperature turbines like gas turbines or maybe a jet engine of aeroplane ok.

And there these materials are operating at a very high temperature and you can also understand the rpm of these turbines is also very high ok, so under very high stresses and high temperature condition ok. And in a high temperature when material is at high temperature the deformation starts through grain boundary ok.

So, I do not want grain boundary there ok, so in these cases I want to have a single crystal for example, in this slide also this is taken from a one website which is given here it is university of Cambridge website ok. Now of different material on metallurgy is given there you can go through that also ok.

So, there are three blades are shown here turbine blades one is of course, polycrystalline you can see different crystals are there with different colors the another blade is directionally solidified structure means I want to have the grains in a particular direction only ok. So, in this case now you can see that the grain boundaries are all parallel to the length of the turbine blade ok.

These are called directionally solidified structure, and the third is single crystal now here you see that there is no feature here, because these are all single crystal or only the atomic arrangement will be there and because we are not looking at the atomic structure here; we are looking at the microstructure I would not be able to see those atoms ok. So, what I will see, I will see nothing here because there is there are no feature only one single crystal ok. And you can see with this arrow that what they are saying that it is increasing resistance to creep deformation ok.

So, creep is have a creep happens at high temperature ok. So, a single crystal blade will have least deformation ok, which we actually want we do not want deformation of this blade, but if you have a poly crystal single or directionally solidified crystals, or you have a quick crystal structure then the creep deformation will be more which we do not want ok.

So, this is another class of material which is called single crystals ok, then the third class of material can be amorphous material for example, in a case of crystals we saw that that the atoms are arranged at a fixed position, which is given by the particular lattice ok, but in case of amorphous material the atomic arrangement will be a random arrangement.

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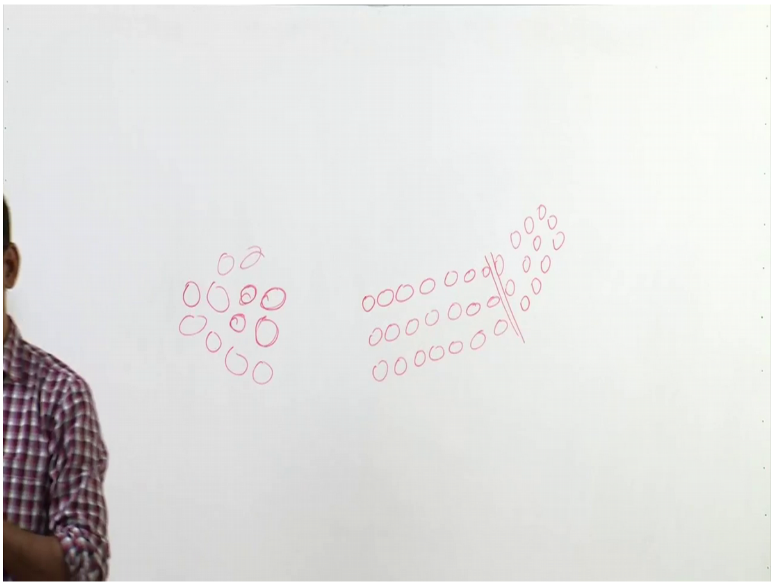

So, it can be anything something like this any arrangement is there ok. There is no kind of a regular arrangement of atoms ok, which we see in crystalline materials ok, so amorphous material where the arrangement is all random ok. So, all these bond lengths are of different type. So, I am just drawing it properly this bond lengths are all of different type ok.

So, it is a random statistical arrangement of atoms and that is how the amorphous materials are defined ok, there is no crystallinity here ok. And glass is a very good example of a this type of a material which has a random arrangement of atom and it is amorphous, glass also is a very good class of material in the sense lot of a development is being done in the glass and one of the most popular example is all your smartphones nowadays ok.

When the advertisement come or a sometime on the TV, there are this home shop kind of thing where they show that they have a gorilla glass ok, or they have a very glass which key you if you drop it also it is not breaking. And there is no there are no scratches on the glass when you kind of put some, so some sharp of the object on that or you just scratch it with you that ok.

So, these are the glasses which are they have a special processing to, to impart a good strength in the good strength hardness and toughness in the glass ok. Our normal glass at home if I just drop it, it will fracture ok, but these glasses are now toughened using different techniques ok.

So, there is a whole class of material development in glass also for example, in case of cars also nowadays if you see, and if you compare with some older cars ok. In case of an unfortunate accident ok, you will see that glass pieces are breaking into very small pieces and those pieces are also not having any sharp corners, these are all very kind of a square shape or something like that ok.

One image you can see in the slide also and it, it breaks into large number of pre pieces and those pieces are of very small size and they do also do not have very sharp corners you can also recall this kind of a scenario from, if you compare the old movies and the new movies. In the old movies like in seventies when hero used to go through the glass the glass particle the fracture when those fragments if you notice of those glasses they are all very sharp. In fact, the stunt man used to get injured in the process ok.

But nowadays, if you see in recent movies all these glasses break into very small pieces also sometime you must have seen in the showroom windows if somebody has thrown a stone those, those glasses break into very small pieces. And sometimes they do not even break they I will stand their fracture may might have taken place I have the failure has taken place, but the star glass is still standing there it is not falling on the ground all these developments are being done, so that people do not get injured during any of these accidents ok.

So, you can understand that a amorphous material also which people used to think of no importance in, in engineering application ok. Now finding with the development in the glasses and they are we are seeing that there is a huge kind of potential for this type of materials also ok, so this is another class of material.

So, you have polycrystalline material single, crystal materials, for different application and you have amorphous material also and they also have a, a very useful application at different places. Now, we will discuss more about polycrystalline because in this you actually see the microstructure ok.

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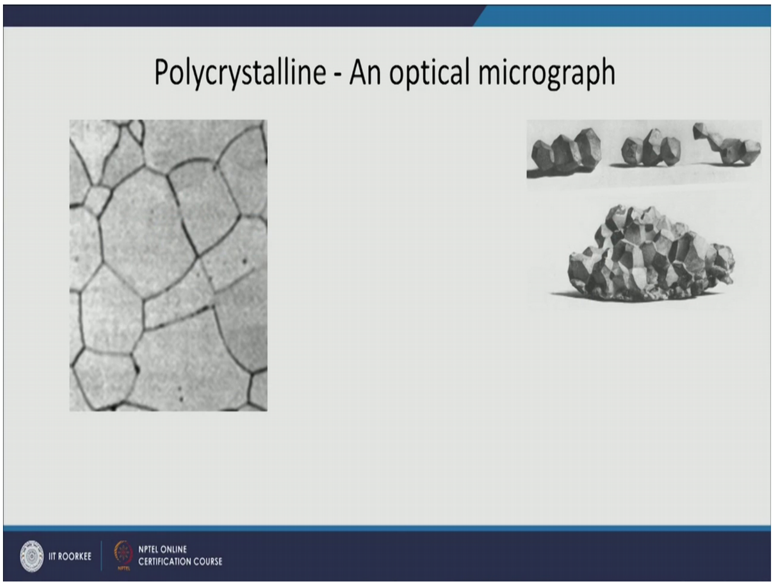

And you would not see the microstructure in single crystal you would not see the microstructure in the amorphous material ok. So, for example, again you can see a microstructure is given on this slide ok, I see something as a bright and something is dark here and in the previous lecture we saw that how we can get this dark feature which is what we called as grain boundary ok. So, this is a grain crystal and this is a grain boundary ok.

Another how in three dimension you see these grains this is a titanium cast, titanium alloy which has fracture through the grain boundary. So, you can see that all these are one crystal joined together at the grain boundary and then there is another crystal and so on ok. Again a very nice arrangement of different crystals an agglomerate of this crystal, which make this polycrystalline material just to give you more insight into this grain and grain boundary and the next slide I have taken.

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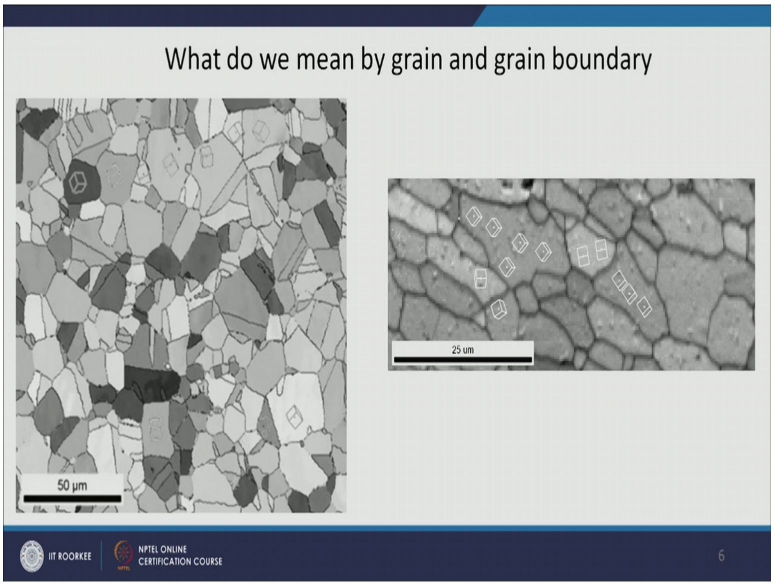

The this is a technique to get a micro structural information in terms of orientation of the crystal ok. So, it is for example, in this second image if you see here this is one grain and it, it is surrounded by the grain boundary ok. So, what I am trying to say is grain is see one crystal ok.

So, I have kind of a highlighted the orientation of the unit cell ok, so this is a cubic unit cell how it is oriented. So, if I see in the given grain you see that all the unit cell at each position are of same orientation; that means, this is one single crystal one single grain having the same orientation of the unit cell ok, but if I cross the grain boundary then the, the orientation of the unit cell has changed. So, suppose it is like this, so it has changed to something like this ok, then if I cross another grain boundary here again the orientation is changed here also if I go from this grain to this grain the orientation is changed again the orientation has come back to what was here ok.

So, in each grain I can say that the for example, atoms suppose are arranged very nicely like this suppose there is some type of arrangement in one grain. Now there is another grain which has a suppose some different orientation let us say I draw it like this ok. Now, when I keep on extending this you will see that somewhere the orientation has change of this atomic arrangement ok. So, how to accommodate this and this is now accommodated by a very small width of grain boundary width is a actually in nanometer range ok.

Now in this the atoms will be some will be having some random arrangement ok, again the proper arrangement will start either here also it will be a proper arrangement and in between them there will be a random arrangement to accommodate the this miss misorientation between the two different arrangements ok, and that is what is grain and what do we mean by grain boundary. So, they just to tell you that in a single phase material you will see this bright feature like this which is a single grain ok, and between two grains there will be a grain boundary then there can be some other features.

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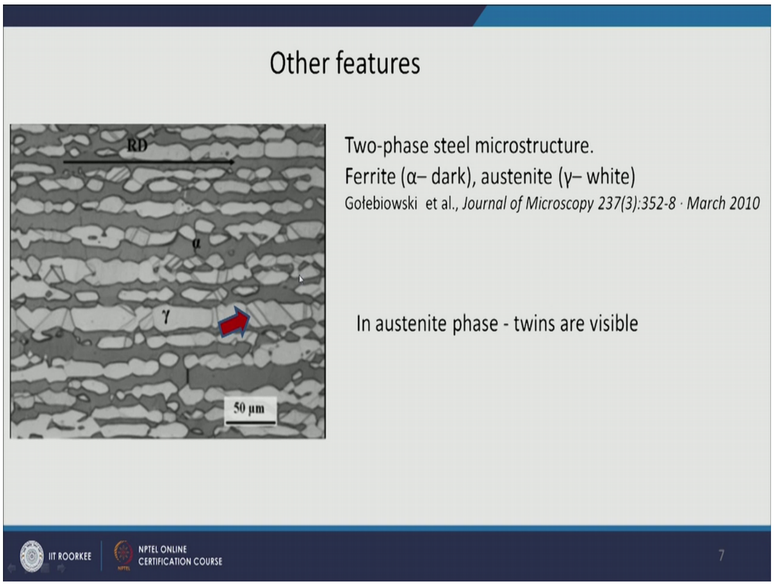

Ok for example, some material may not have only one phase it may have two or three phases also for example, they this is a two phase steel microstructure where ferrite is there again these are names which are not known to you ok, but this will be covered later on. So, you can again come back right now you just take it from me that there are two phases ok, and we have seen that when you have two different phases the phases may react with the etchant in different ways ok, and that can be captured through a microscope.

So, here a ferrite is dark, austenite another type of phase is white it is this particular image is taken from this journal paper ok. So, this all this phase is alpha which is dark ok, and all these phases gamma which is white ok, and in this you see another feature again this will be covered later which we call as twins ok. So, if you see the grain boundary the grain boundary usually has this kind of curved features or curved surface ok.

If you see any grain boundary it will have a curved surface ok, but here if you see this particular boundary, they are very straight boundaries and usually they come also in pairs not always, but most of the time and these are called twin boundaries. So, these, these are a special type of boundaries other than the boundaries which we just discussed ok. So, you, you understand that I am when we see a microstructure there are.

So, many different information you can get from the microstructure about their size, about how they are distributed are there are other features are also visible there and all this also when you get this information you can relate with the properties of the material ok.

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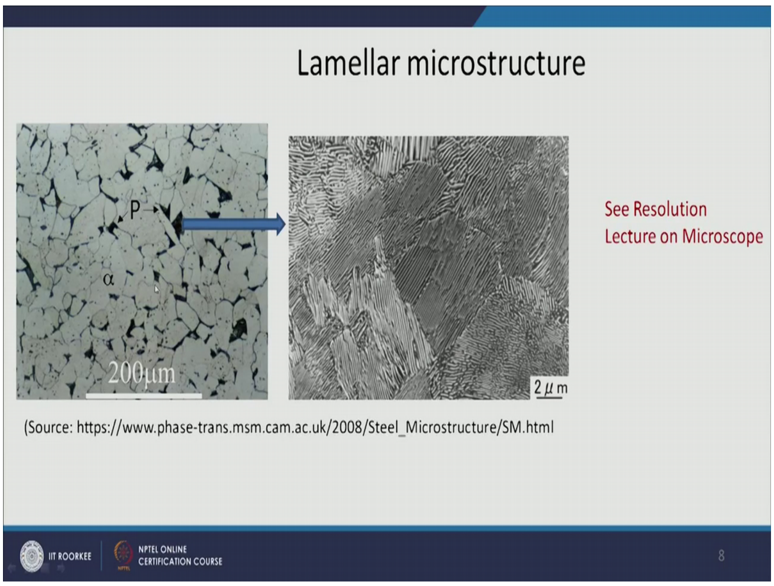

Then this is another type of a material we basically steel ok, where you again have this bright one is alpha phase and this dark one which looks like one phase as a dark phase is a what we call as pearlite ok. Again we will see what do we mean by pearlite ok, and if I want to have information about this that what this dark phase consists actually it consists of this very fine lamellas this is very beautiful arrangement of white bright and dark bright and dark lamellas ok.

So, the again these are all consist of two phases one is alpha another is what we call as cementite fe 3 c. So, one is ferrite another is cementite and these laminas are we are visible here, but it is not visible here ok. So, again you recall about resolution when we were discussing resolution we said that you should be able to resolve two closely spaced entities and you should them see you should be able to see them as two separate entities ok.

So, for example, here you can see one dark line one dark line or you can see one bright line one bright line as two separate lines or. So, two separate features the same thing I in this micrograph I am not seeing that I am just seeing one dark feature ok. So, my resolution is better in this image, and in this image my resolution is not good I am not able to resolve that this particular dark one actually contained lamellas of one bright, one dark one, bright one, dark feature ok.

So, you again related with the resolution which we discussed, when we were discussing about the optical system of a microscope ok. So, this is what we call as lamellar microstructure which, which exists in pearlite and with this I am stopping it here ok. Just wanted to introduce you to the idea of a microstructure and now when we go through phase diagram and we will discuss about phases, then you will be able to appreciate that and you will be able to relate what is discussed there with these lectures ok.

Thank you.