**Power Metallurgy**
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**Lecture - 16**
**Crystalline and Amorphous structures**

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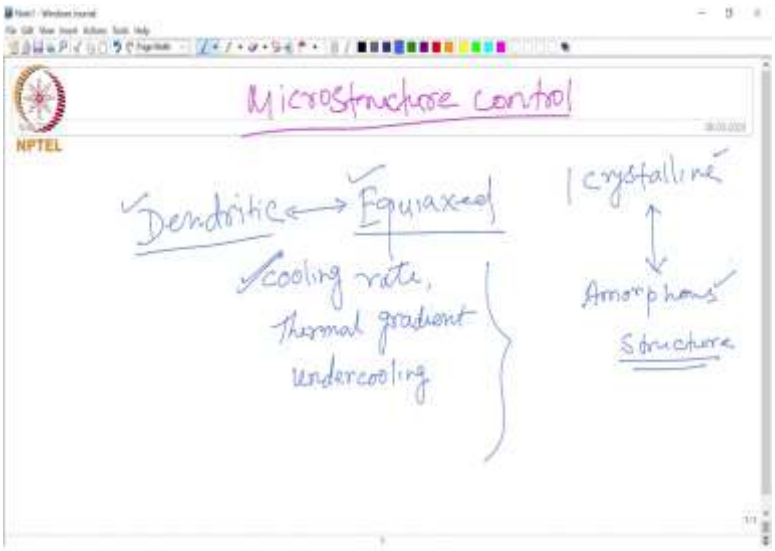


Hello and welcome back again. So, in the past few classes we have been talking about this Microstructure, controlled in the atomization process. And so, far we have had a great deal of discussions as to how the microstructure can change depending on the process parameters in this atomization process. Now, what we have seen so far is that as far as the microstructure is concerned, we have seen this kind of microstructures; dendritic and equiaxed right.

And the transition between these that depends on the process parameters, as I said and these process parameters are the cooling rate, the temperature or the thermal gradient and also, the under cooling.

And in the previous class, I was mentioning that this microstructure control or this change of microstructure is not only between dendritic and equiaxed, there can also be a possibility of transition between a crystalline and an amorphous structure and in the last class, I briefly told you as to what could lead to this transition between a crystalline solid to an amorphous solid as far as the process conditions are concerned.

And we had seen that the cooling rate has a great influence in this particular transition ok. But before we proceed to this microstructure transition between crystalline and amorphous, at this juncture, it is also important to understand what is crystalline and what is amorphous.

So, for the benefit of everybody, especially you know people from non-metallurgy background. Let me first briefly describe these two kinds of structures so that we have a better understanding of what we are talking about and what kind of transition, we are talking about in this case ok.

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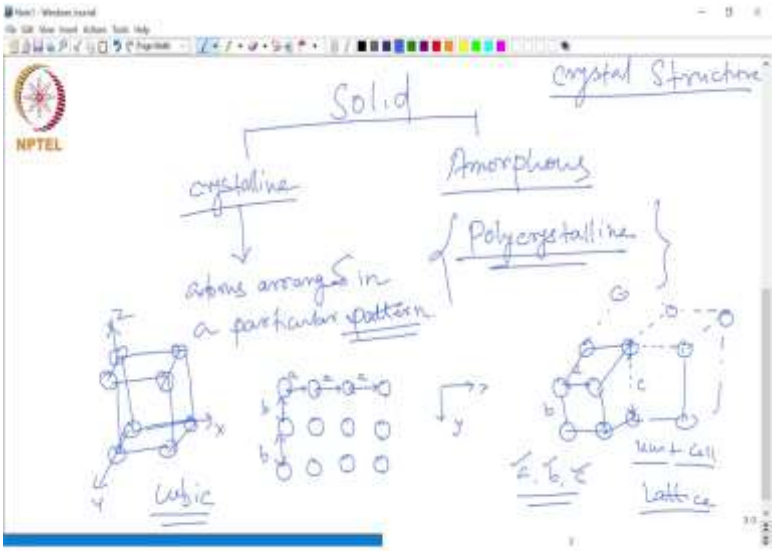


So, if you talk about a solid material in terms of its internal structure which is also referred to as the crystal structure, there are two kind of solid materials, two categories that the solid can be broadly categorized into depending on the crystal structure; one is a Crystalline and another is Amorphous.

The crystalline material will have atoms arranged in a particular manner or in a particular pattern and this pattern in fact, can be defined by a small unit, which can be then repeated in three dimensions to generate the entire crystal structure.

For example, in a given material, the atoms may be arranged like this. So, in this 2D schematic, you can see that in both the directions, this distance if we call that as **a**

remains the same. Let us say this is x and this is y direction. So, in x direction, this distance repeats; it remains the same.

Similarly, in the y direction also the repeat distance will be same, if the material is a crystalline material with a particular crystal structure ok. So, therefore, this kind of structure can be defined by this one unit itself; where, along x, the repeat distance is **a** and along y axis, the repeat distance is **b** and this can be repeated in all the three directions.

Now, if I add the z direction also, then in that direction also, it is going to repeat with a particular distance between two adjacent atoms. So, on the z axis, this can be written as **c** for example right.

So, this a, b and c, these are the three parameters which will repeat themselves in the x, y and z direction respectively and this small unit or this the smallest cell that now we have constructed is known as the unit cell, which can be repeated in all three directions to generate the crystal structure or generate what you also call as the lattice.

So, it can be repeated again like as I said and this distances along each of this axis will remain same as a, b and c. So, this kind of material is a crystalline material and, in this case, you have seen that this unit cell has taken the form of a cube ; where the atoms are in the corners of this unit cell.

So, this is an example of a cubic solid or a cubic metal let us say ok. So, like that metals can have other kind of crystal structure also. For example, they can also be hexagonal, so in each of this kind of structure, the atoms are arranged in a particular pattern or in a particular order ok.

And in most of the cases, the metals will have several of these crystals. So, a metal as such or a crystalline solid as such therefore, can be defined as an aggregate of these crystals right. And in that case, when you have several crystals together forming the entire structure will be known as a polycrystalline material , which is an aggregate of several crystals .

So, this is what most of the metals are generally, they are poly crystalline in nature and for a poly crystalline solid to form from the liquid phase, these atoms have to be sorted out in that particular arrangement, when this solid crystal is going from the liquid.

So, just remember that we are going to come back to that as to how that is going to happen and what role the process parameters will have in that process of atomic sorting or atomic arrangement, in order to form a crystalline solid . Now, the other category is the amorphous one.

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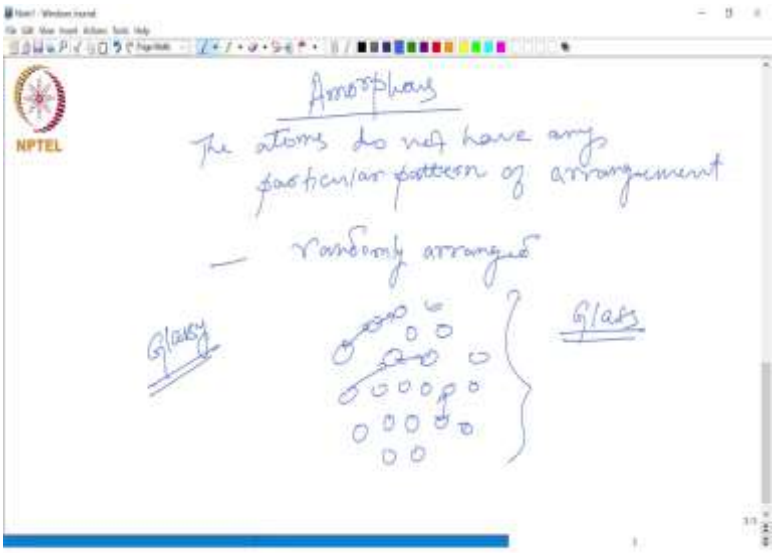


In this case the atoms do not have any particular pattern of arrangement or in other words, patterns are arranged randomly right. So, these atoms, they may not have to follow any particular order like what we have seen in case of the crystalline materials. So, there is no repeating of any of these features or distances in a periodic manner, when the structure is amorphous .

So, this kind of structure you will generally find in the common glasses that we see around us and therefore, an amorphous structure is also known as a glassy structure right. So, in terms of the atomic arrangement or the crystal structure as we call it, solids are of two types; one is crystalline and another is amorphous or glassy .

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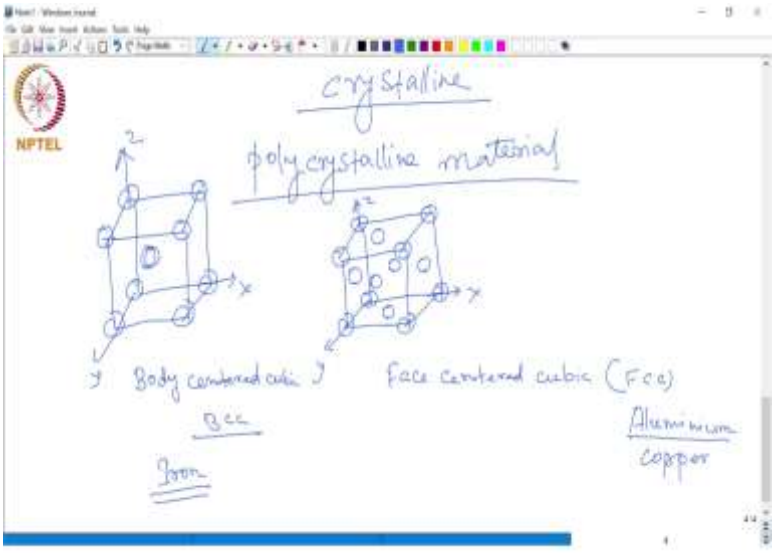


And in a crystalline solid, as I mentioned before also, there are more than 1 crystal, making it a poly crystalline material and the structure of a poly crystalline material can be defined by a unit cell, which actually corresponds to a particular crystal structure or a particular lattice structure. We have seen the example of this cubic structure; wherein, the atoms are in the corners of a cube like this , which will give rise to a cubic metal or a cubic crystalline solid.

There can be other variation on this, like for example, you can have patterns at the center of each of this 6 faces that you have; like this. And therefore, that kind of crystal structure will be known as face centered cubic or FCC in short. An example of an FCC metal is aluminum or copper which is also FCC . One more variation can be like this; where apart from the corners, there is one more atom at the center of the body of this cube , and therefore, that is known as body centered cubic or BCC in short. An example of BCC metal is iron.

So, like that in a particular crystal structure, there could be different variations also like this and depending on that a particular type of a crystal structure or lattice will arise. And like that you know like how you have in cubic starting from simple cubic, where only corners will have the atoms. You have FCC and BCC also. Similarly, in other kind of crystal structure, we will also have their own variations .

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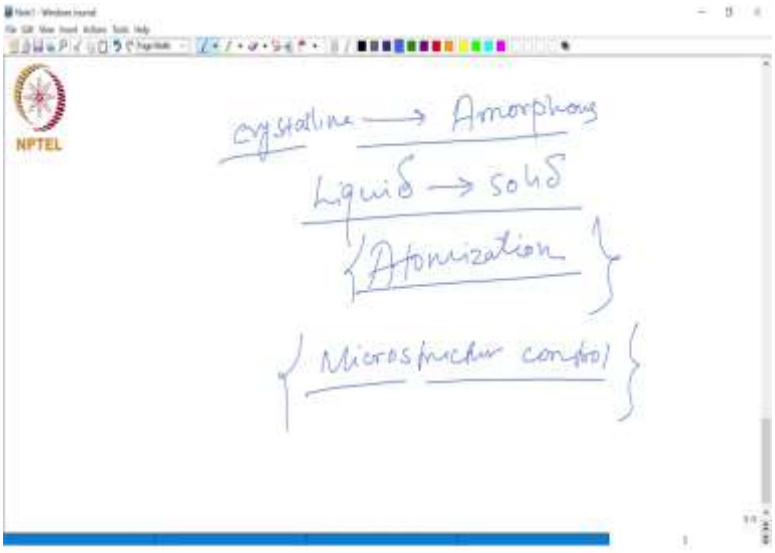


Now, the original question in front of us right now is to how this crystalline structure can change to an amorphous structure in the liquid to solid transformation? And in this case, we are talking about this particular process atomization; where, the liquid stream after it is broken into droplets solidify as solid powder.

So, during that solidification process, we are trying to understand as to how the microstructure can change or what are the roles of these process parameters of this process on the microstructure so that we can exercise some control on the microstructure and generate a particular type of microstructure which is needed for certain type of properties.

So, that will be the main discussion with regard to this process that we need to understand. But for today, this is all I will have and like we generally do before, we close the class let us try and summarize it.

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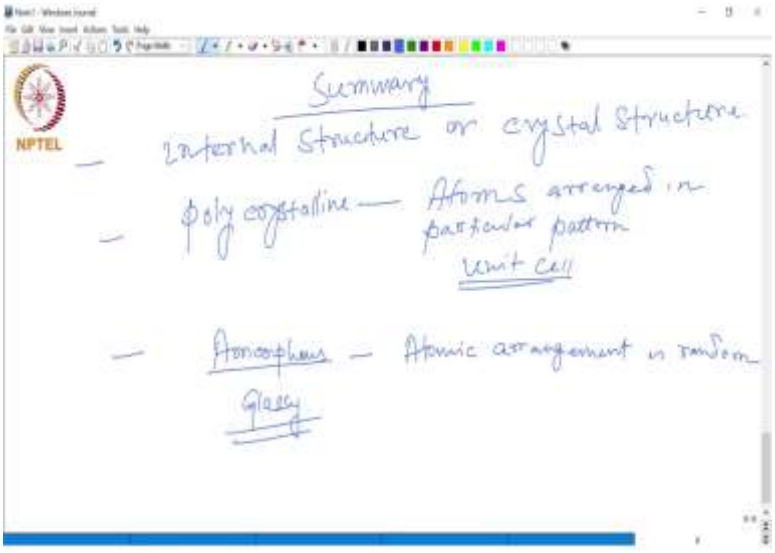


Today, we have discussed about the internal structure of a solid material. The internal structure or the crystal structure and with regard to that, we have seen there are two types; one is crystalline or polycrystalline, where atoms are arranged in a particular pattern which can be defined by a unit cell, which is the smallest unit that can be repeated in the three-dimensions to generate the crystal structure .

And the other one is amorphous, where the atomic arrangement is random. In this case, there is no particular order for the arrangement of the atoms, they are arranged randomly. So, there is no unit cell or you know no crystal structure that can be defined in this case and this kind of structure is generally found in the glasses.

And that is why this kind of material or this kind of structure is also known as glassy structure right. So, this is what we have learned today in today's class and going forward in the next class, we are going to see how this crystalline can change to amorphous during the solidification process.

So, today I am going to stop here; I will see you again soon.

Thank you.