Introduction to Materials Science and Engineering
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Lecture - 22
Solid solutions I

Hello, today's topic is Solid solutions. This is a very important topic in material science till now we have been discussing the structure of pure metals or elements so that we describe in terms of close packed crystal structures like hexagonal close packed structure or cubic close packed structure also some metals we said have body centered cubic structure.

However, we have not yet discussed the structure of alloys, if we put more than one element if the material consists of more than one element what will be the structure. How those elements will distribute in the structure? So, one of the important phases of the alloy is solid solutions which we will discuss in this lecture.

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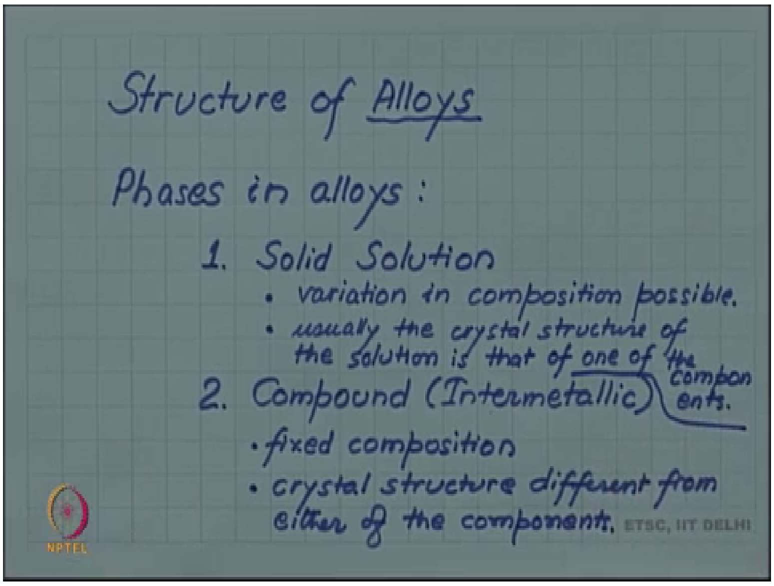

So, solid solution as we said is important in the structure of alloys and 2 important phases are there in alloys so let me say phases. One is solid solution and another is compound sometimes called Intermetallic compound or simply intermetallic, we will be call intermetallic compound both of them since they are structure of alloys they consist of more than one element.

So, in the compound the composition is fixed. So, compound is made up of fixed composition whereas, solid solution will have at least some variation in the composition, variation in composition possible and in terms of crystal structure compound can have a crystal structure different from either of the components. Solid solutions usually will have a structure crystal structure of the solution is that of one of the components.

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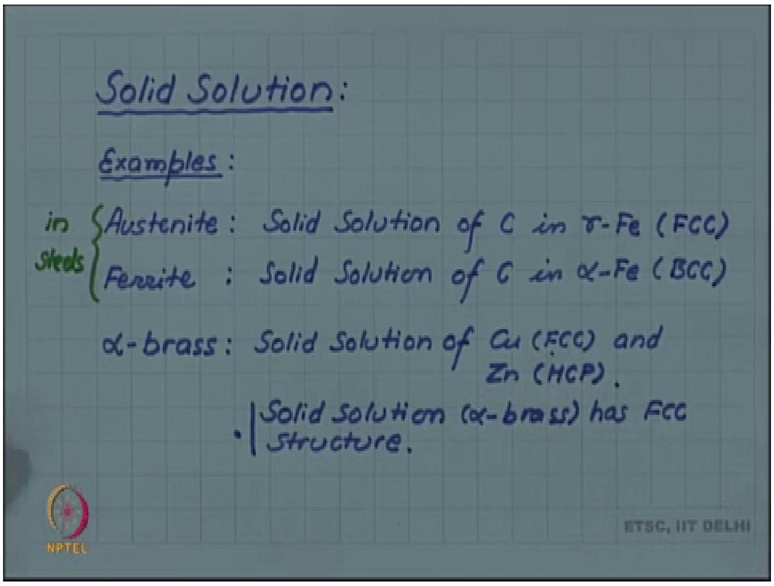

So, let us continue to discuss this phase solid solution in a little bit more details. So, let us consider solid solution first so we have already said that solid solution can be of variable composition and has a crystal structure which is that of one of the components 2 kinds of solid solution have been identified.

Before we discuss that classification let us discuss some examples. In steels we have an important solid solution called Austenite and this is solid solution of carbon in gamma iron, gamma iron means FCC iron, iron has more than one crystal structure in particular FCC, gamma iron and BCC alpha iron

So, we are talking austenite a solid solution of carbon in gamma iron. There is also ferrite this is solid solution of carbon in alpha iron which is BCC, so depending upon whether the solution crystal structure is BCC or FCC we call them either ferrite or austenite. So, both of these phases very important in the structure of a steel so we will discuss steels at some point of time in this courses so when we discuss this we will meet these phases. Again in steels we also have another solid solution alpha brass, alpha brass is solid solution of copper which is face centered cubic and zinc which is hexagonal close packed. So, you can see that the elements have different crystal structure.

So, what is the structure of solid solution? So, the solid solution that is the alpha brass has FCC; FCC structure. So, as we noted in the previous in the discussion that solid solution will have structure of one of the components. So, in this case one component is face centered cubic another is hexagonal close packed and solid solution happens to have the structure of copper face centered cubic.

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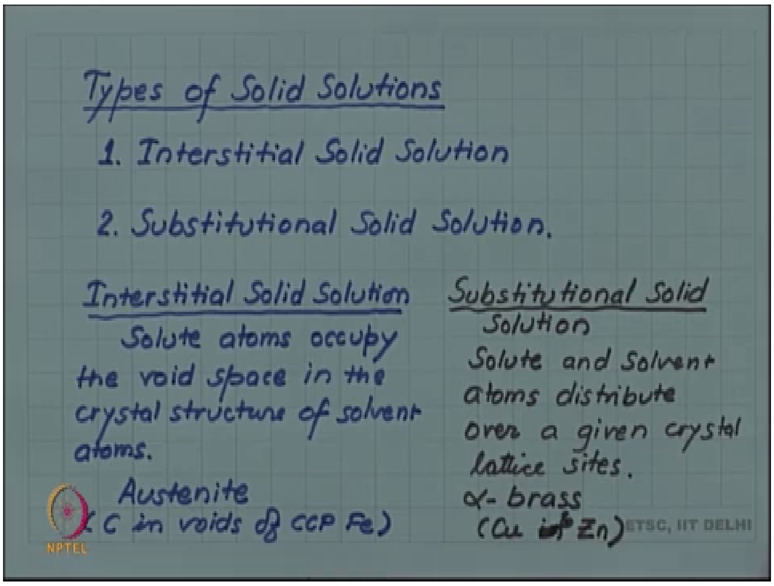

So, we continue with our discussion now on the types of solid solution we distinguish 2 types, one is called Interstitial solid solution and the another is called Substitutional solid solution.

So, let us look at what is the difference between them? So, in interstitial solid solution solute atoms occupy the void spaces in the crystal structure of solvent atoms. We have seen that in cubic close packed structure for example you have a kinds of void tetrahedral void or octahedral void and the solute atoms. So, a solvent atom can have a crystal structure like that and solute atom can go and sit in these voids. If it does that what you have is an interstitial solid solution and from our example which we gave just now austenite is an example of interstitial solid solution, austenite carbon in voids of cubic close packed iron.

In substitutional solid solution solute atoms occupy the same sites as the solvent atoms. So, solute and solvent atoms distribute over a given crystal lattice sites. And here our example will be alpha brass, copper in zinc. Let me use it copper and zinc.

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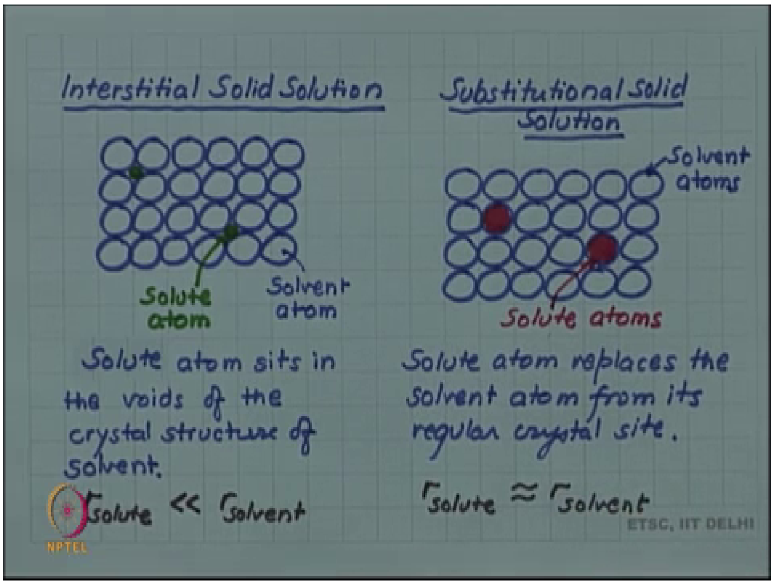

Let us look at this little bit pictorially what we mean by interstitial solid solution. So, when we say interstitial solid solution. Let me make a cartoon 2 dimensional example of a solvent crystal structure. So, these are my solvent atoms making some sort of crystal structure, 2 D square crystal structure we can call it and we can see that in this crystal structure there are many voids and a solute atom solute atom can be located in one of these voids.

So, there is one solute atom located there another solute atom located here. So, I will call this solvent atom and call this a solute atom and you can see that solute atom sits in the void of the solvent atom in the voids crystal structure solvent. But when we have substitutional solid solution let us make one because they are going to start with a basic crystal structure made up of pure a atoms.

Now as I do the alloying. So, these are now my solvent atoms solvent atoms and as I do the alloying process some of the atoms of solvent are replaced or substituted by the solute atom. So, let me replace this by a red solute atom another red solute atom. So these are solute atoms.

So, in this case the solute atom replaces the solvent atom from its regular crystal site one thing from this picture also is obvious and is true in reality is that the radius of the atom the radius of solute atom let us say r solute since the solute atom has to fit in the voids the radius of the solute atom has to be much smaller significantly smaller than the radius of solvent atom. Whereas, in this case you can see because the solute has to substitute the solvent at the same site they are of comparable size. So, the solute atom and the solvent atom should be of comparable size.