Introduction to Materials Science and Engineering

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Lecture - 23
Solid solutions II

Let us look at a little bit more realistic 3 d example of our Austenite. So, we said Austenite.

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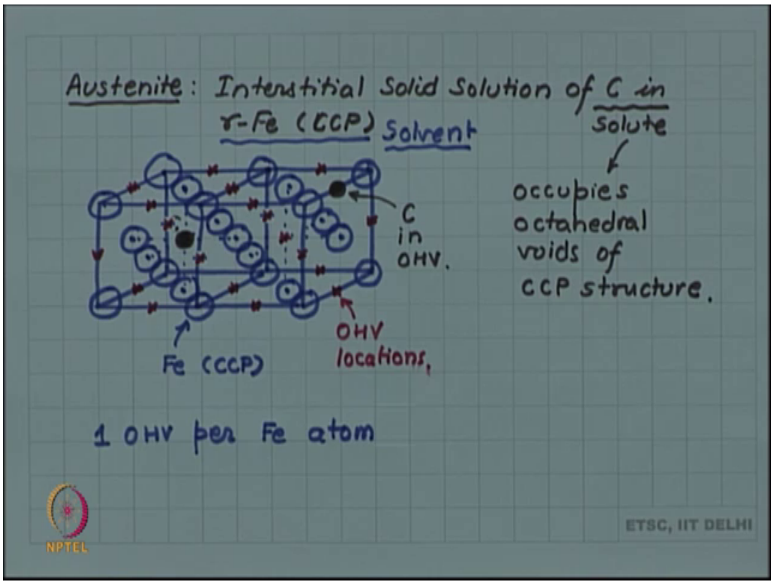

ustenite is interstitial solid solution of carbon gamma iron, which is cubic close packed. So, let me try to draw 2-unit cells side by side, I have drawn of course, in the real crystal structure there will be many unit cells, but as an example we are taking here and demonstrating 2-unit cells. So, the lattice points as you know are at the corners, and also at the face centers. So, lattice points at the face centers.

So, these left and right face centers, and then you will have top and bottom face centers, and also the front and the back-face centers right, and the back-face center maybe we should connect them with dotted lines, otherwise it becomes quite confusing, now these are our locations where atoms will sit and since this is a interstitial solid solution of carbon in gamma iron, gamma iron is the solute sorry gamma n is the solvent. So, this is a solvent. So, these locations the lattice locations are all occupied by iron atom.

So, let me represent them by these blue iron atoms. So, they sit on the corners, they also sit on face centers, front and back of the first unit cell back of the second unit cell. Now the carbon atoms which is the solute this will sit and it is known from the experimental results, that carbon in gamma iron sits in the octahedral voids occupies octahedral voids of CCPthe structure, and we have already seen where are the octahedral voids, if I try to locate the octahedral voids we have seen that the octahedral voids is right in the center of the cube, with little cross I am marking the octahedral voids center of the cube, as well as the face edge center locations are also octahedral void.

Remember our discussion on voids. So, we had seen this that the edge center location is exactly identical to the body center location in ccp, both are octahedral void location. So, I am marking all the octahedral void locations in this pair of unit cells, I have marked the body centered locations and all the edge center location, now carbon will occupy some of these octahedral voids. So, let me in this unit cell put a carbon atom at the body center, that is carbon in the octahedral void in the body center there, and in this unit, cell let me place a carbon atom at this edge. So, this was iron this was making ccp, and this these red locations are the octahedral void locations, and these black atoms are the solute carbon carbon in octahedral void.

So, this kind of structure. So, the overall structure is cubic close packed of iron, it has several octahedral voids. In fact, we have noted that there is may you just recall that, that there is 1 octahedral void per iron atom. So, the number of octahedral voids is the same as the number of iron atoms, and some of those voids depending on the number of carbon atoms will be occupied by carbon, and this gives us a solid solution a cubic close packed solid solution of carbon in gamma iron, and this solid solution in the metallurgical literature foreign material science literature has been given a special name Austenite. We will meet it again when we are discussing the structure of a steel.

So, that is about the interstitial solid solution, let us look at a 3 d example of a substitutional solid solution also, and that example is that of alpha brass.

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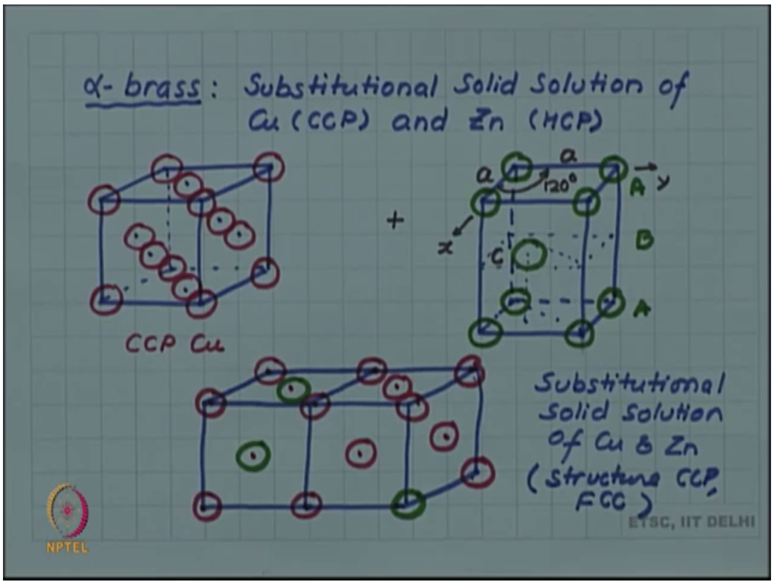

Now let us look at alpha brass, alpha brass is a solid solution of this is a substitutional solid solution of copper, which is cubic close packed and zinc which is hexagonal close packed. So, note that copper is cubic close packed so, if I make a unit cell of copper, the face center locations are also the lattice sites, and let me say a lead copper atom it is sitting at each of these locations. So, all the 8 corners left face, right face, top face, bottom face, front face, the back face.

So, this this gives us CCPcopper zinc, and we are adding this to zinc, zinc has the hexagonal close packed structure whereas, you know it is an ab kind of stacking. So, let me represent the zinc atoms by green. So, this is the a layer atom, this is the next a layer atom, and remember since it is hexagonal, the x and y axes are now not making an angle of 90 degree, but this angle is 120 degree, and these 2 sides are equal, the third side is C which is not equal to a, and in the mid plane we will have one more atom, and that would be the B atom.

So, 2 kinds of triangle are there the B and C triangle, if you take the centroid of the B triangle, and go up half the way up in the unit cell, that is the location of that mid B plane. So, A B A stacking of the zinc atom now we are mixing these 2 and we are forming a solid solution, the question is and the solid solution also is crystalline, but the question is, is the solid solution forms cubic close packed structure or the hexagonal close packed structure, or maybe a totally different structure it. So, happens and experimentally we have found that alpha brass has this structure of cubic close packed or a CCP structure.

So, let me again draw another 2-unit cells. So, this is structure, which will now represent the solid solution, maybe for clarity I do not show the invisible faces now, and only show the visible faces and these are the sites. So, the corners and the face centers are sites where atoms will be sitting, and if it was pure copper all these sites were occupied by copper, but now we are saying that on some of these sites copper is replaced by zinc. So, let this face center go to zinc and let this corner go to zinc.

So now we have a solid solution, where some of the location where I expected to find copper is now being occupied by, let me place one more, some of the locations have been taken by zinc, and in the process, zinc has sacrificed it is hexagonal close packed structure the solid solution. So, the substitutional solid solution has the structure, copper and zinc, and the structure is face centered cubic the lattice. So, the structure is ccp, lattice is fcc.

So, we can see here that the difference between interstitial and substitutional solid, solution interstitial solution like carbon in gamma iron it go carbon goes into the voids, substitutional solid solution like in the zinc in copper it replaces copper from it is regular lattice site. So, I think with this we will end this discussion, and we will continue this discussion an important question which we will ask is that, is there a solid solubility limit, what is found that in some solid solution there is a solid solubility limit, that is you can not put in more than a fixed amount of solute, more than a maximum amount of solute whereas, in some other solutions, we will find that 2 elements can be mixed in any given proportion.

So, let us write that down, because that is the question which we will take up in the next lecture.

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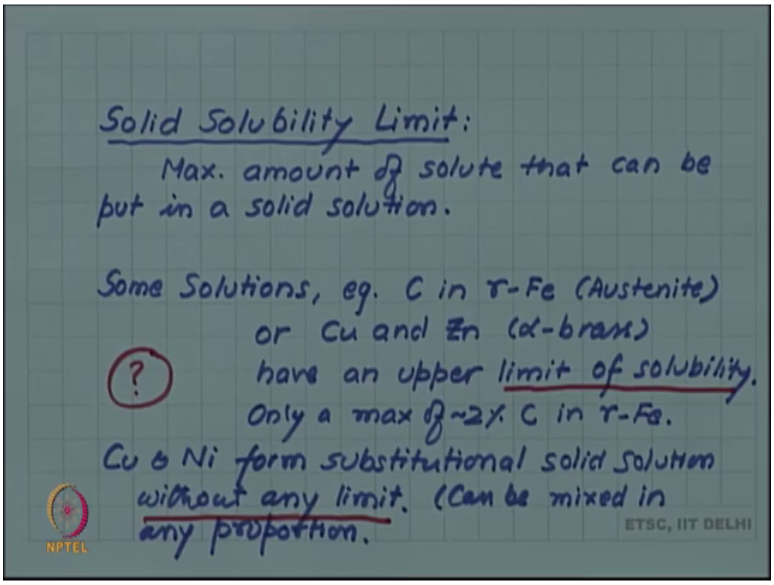

So, let us say solid solubility limit, there is the maximum amount of solute that can be put in a solid solution. So, some solutions for example, carbon in gamma iron our Austenite, or copper and zinc, our alpha brass, have an upper solubility limit, and upper limit of solubility. So, for example, only about 2 percent carbon, approximately about 2 percent carbon can be dissolved in gamma iron.

So, these solutions have solubility limit whereas, we let us give an example, copper nickel copper and nickel form substitutional solid solution without any limit, means they can be mixed in any proportion. So, we will take up this question that why some solid solutions have limit and upper limit, limit of solubility, and why some have no limit without any limit this is the question which we will take up in the next video.

So, thank you very much we will meet next time addressing this question.