Phase Diagram in Material Science Engineering
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Lecture – 59
Quasi-Peritectic Reaction

Students in the last part of the Four-phase Ternary Equilibria we are going to discuss about the type two equilibria in a ternary phase.

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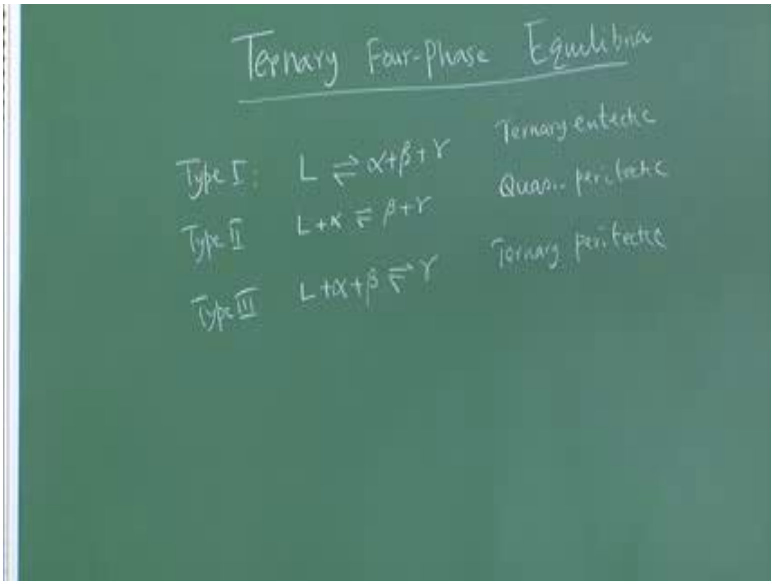

In case you have forgotten let me just remind you what type one is the ternary eutectic where liquid get transform to three solid phases. Type two is quasi peritectic where liquid reacts with alpha for the two phase beta and gamma. And type three is ternary peritectic where alpha beta and liquid reacts and form gamma. So, this we call ternary eutectic, and this is called quasi peritectic I will tell you why it is quasi peritectic and how we can analyse it today in the lecture, and third one is known as ternary peritectic.

If you recall I have a detail discussion on ternary eutectic and in the last lecture I discussed about ternary peritectic, so today we are going to discuss about the quasi peritectic. As you know this is reaction that is liquid plus alpha going to beta plus gamma is a mixture of eutectic and peritectic reactions. So, what it is? How it is mixture of eutectic peritectic reaction? If you look at this first part liquid plus alpha going to any phase whether beta or gamma or delta is a peritectic reaction. On the other hand when liquid plus alpha react and form two phases it will be a eutectic type. That means, this is the mixture of both eutectic and peritectic type. And that is why it is called a quasi peritectic reaction.

To describe it on a ternary phase plain it is four phase equilibria so that (Refer Time: 02:37) by a trepeziate or trapezium. And the corners of trapezium will be alpha, beta gamma and liquid. That is what is shown in the middle.

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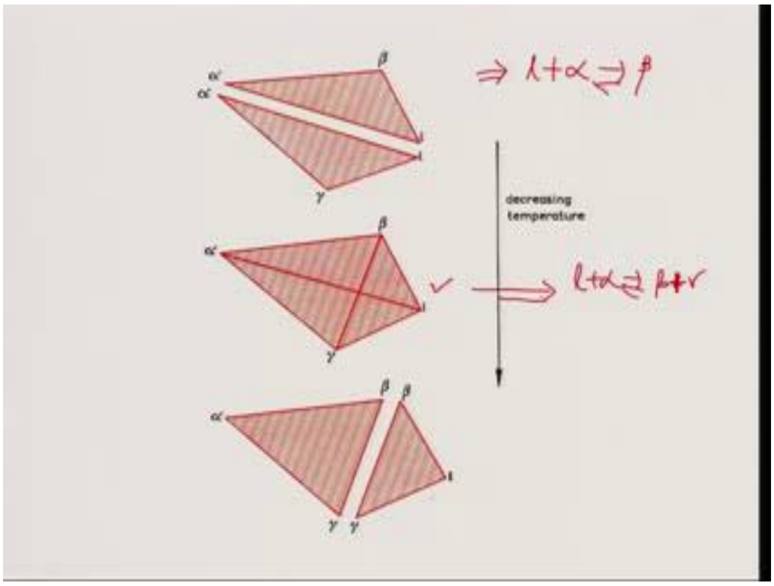

And this happens at a fixed temperature also it is a invariant equilibrium. That means, composition of the all the phases alpha, beta gamma and liquid are fixed you cannot change, because degrees of freedom is 0 in a ternary system when four phases are coexisting. So what happens actually, this ternary four phase equilibria is always preceded by two three phase invariant mono variant reactions or the three phase mono variant equilibria. One is alpha, beta and liquid. Second one is alpha, gamma and liquid. So, these two invariant equilibria must exist prior to the four phase equilibria. And not only that if you decrease in temperature as you decrease temperature the exit for the ternary four phase equilibria will happen with three phase equilibria again; one of them is alpha, beta and gamma other one is beta, alpha and gamma.

So, the important characteristic feature for such a kind of quasi peritectic four phase equilibria is that; there has to be two mono variant reactions which will precede the invariant reactions that are the most important criteria. There has to be two mono variant reactions or equilibria preceded by, and these two mono variant reactions can be peritectic and eutectic type or both of them can be eutectic type. What is the meaning of that? As you see here there are two mono variant reaction represents at the temperature higher than the (Refer Time: 04:45) invariant plain this is the invariant plain these are the two mono variant reactions. One is alpha, beta and liquid another one is alpha, beta, gamma and liquid. What I am saying is that these two can be either peritectic plus eutectic or eutectic. What is the meaning of that? If it is peritectic plus eutectic that means liquid plus alpha will react and form the beta phase for the first three phase equilibria. The second one liquid will transform directly to gamma plus alpha, that is what we are saying. Otherwise both of them can be eutectic also.

Basically, if you look at properly liquid plus alpha going to beta is what; is a mono variant peritectic in ternary reaction, ternary or three components, three phases present therefore C minus P plus 1; C is 3, P is 3 cancel and one will remain so (Refer Time: 05:49) one. Now in this case liquid reacts with some primary alpha and forms the beta. And this reaction that is formation of beta by reaction between liquid and alpha continues till it reaches the ternary quasi peritectic plain. In the space model I will show that and at this temp at this temperature ternary quasi peritectic plain which has the fixed temperature this liquid and alpha will react and it will deposit beta plus gamma.

I hope it is clear. So that is why actually we have alpha plus beta plus gamma below the ternary mono invariant reaction plain and some liquid will remain which will form some other eutectic phase at a lower temperatures. That is the unique thing. So, because you have to have four phase equilibria are reacting like liquid plus alpha going to beta plus gamma, if you can see properly liquid plus alpha going to beta plus gamma.

So, this reaction must be preceded by a peritectic type of reactions at higher temperatures and that is the important characteristics of this reaction. Now let us look at how we can draw that. Well, that is not very difficult to do it let me just draw it and draw it and show you.

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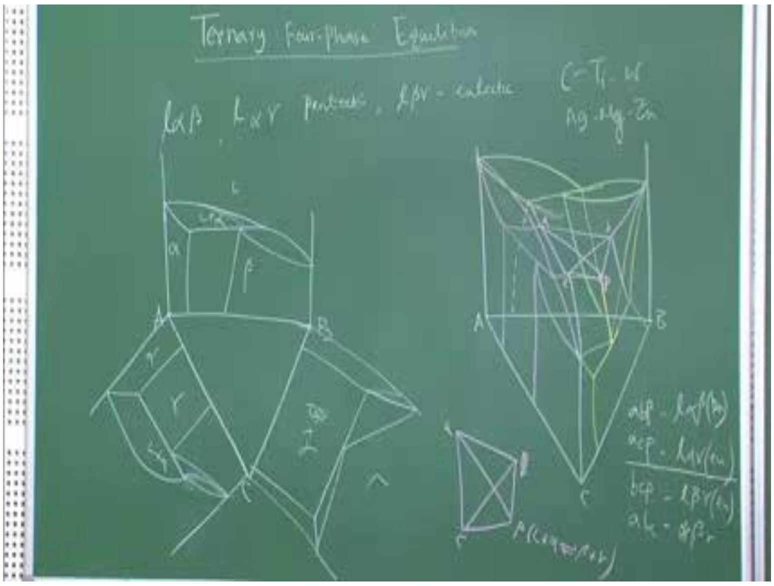

So, first type is what I considering is that let us say liquid, alpha, beta and liquid, alpha, gamma are peritectic type, what I mean to say these are the binaries will see. And liquid, beta, gamma is eutectic type. Let me first tell you what is that, suppose this is my space model let me draw it other way otherwise still do not look nice.

So, between A and B you have a peritectic reaction what is that, that is very simple; liquid, alpha, beta, liquid plus alpha that is the peritectic reaction. Between A and C also there is the peritectic reaction that is the liquid, alpha, gamma. So what is that let me just draw it sorry, am I clear so this is the peritectic reaction. This is alpha, this is gamma, the liquid plus alpha. But on the other hand between E and C are eutectic reactions. This is the eutectic reaction, this is beta plus gamma. So, what I am asking is that if this is the two phase sorry binary systems then what will be the ternary space model that is what we are going to do.

So, let us draw it first it is not going to do a difficult task. I am going to use colour chalks to tell you that. So, I am going to draw between A and C; first A and C using a red colour chalk, this is what it is between B and C is in eutectic that is easy, and between A and C another peritectic reaction. I think it should draw it little above otherwise you cannot see it properly. That is how this thing will look like let me just draw what is inside. Inside thing is not very difficult to draw. This is one point this is another point, so I get this one point, this and this is another point and this another point, so connect it. And point P will be this peritectic point ternary inside like, this which is this is another peritectic and this is another peritectic.

So, then you can connect this triangle you can see the trapezoid that is the trapezoid I am trying to talking about it. It is basically like this is the trapezoid. This point is P, this is A, this is B, this is C right. Little bit complex but still understandable. So, what you see here that if there are two peritectic reactions on the two binaries and the eutectic reaction it actually generates a ternary peritectic reaction or ternary four phase equilibria kind of reaction. This point P, this is the point P, this is A sorry this is the point P, B, C, this point P is basically corresponding to liquid plus alpha going to beta plus gamma. That is what I am saying there are many many system which actually follows this reactions.

Before that let me just tell you if you look at properly there are four triangles here and this four triangles can be represented like this A, B, P is basically liquid, alpha, beta this is nothing but peritectic type I have written P and peritectic P let us write peri peritectic type then A C p this triangle. First one is A B P this triangle, second one is A C P this triangle this is also sitting above. So, this is liquid, alpha, gamma, this is eutectic. And then below they all lying above. Bellow this we have B C P this is be lying below this ternary four phase plain this is liquid, beta, gamma, this is also eutectic type looks like and A B C is alpha, beta, gamma.

So, these are the three phase equilibrium plains which are sitting there on this triangle, so everything on this trapezoid. Everything solidification all the alloys will be depends on how this triangle or the how this trapezoid will behave. And I do not want to go into details of that that will be quite bit complex. In the sense that we have to look at how this triangles are lying on the four phase plains and also we have many compositions of alloys which will undergo this four phase reactions remember that. And depending on the four phase reaction composition temperature on the composition basically the solidification path phase will change.

So, there are many many many such systems where this can happen. I am going to show you another case or actually same things here whether you can understand better way.

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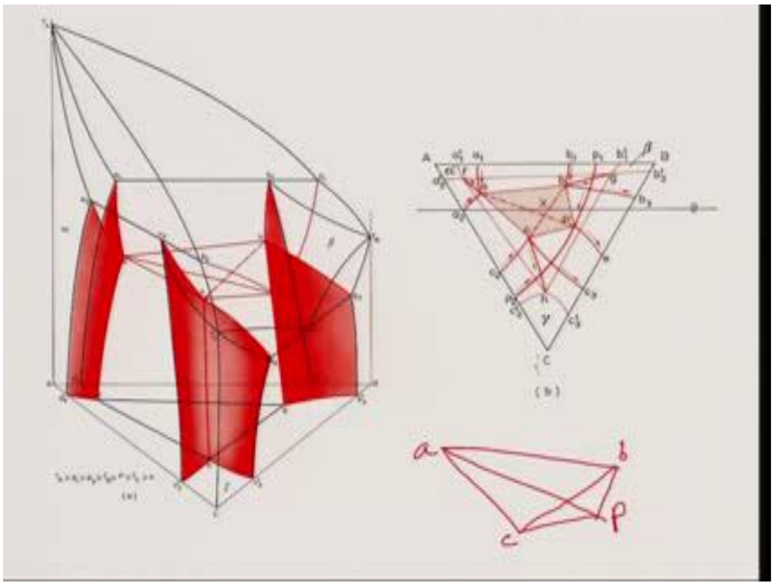

So, see if you look at that A B C, A and B a forms peritectic and this peritectic is represented by P 1. Then AC forms the peritectic that dependent by P 2 you can clearly see this is a peritectic. Other hand BC forms the eutectic which represented by E.

Now, this points which I have drawn inside A B C and P correct this points are coming basically from A is coming from the solid solubility limits A 1 and A 2 for the AC binary and the AB binary. If you exchange that they form the point A. Similarly, B is also formed very easily from B 3 and also B 1 they are joining and forming point B. Point C is also form what once it is getting form from the it is lying on this C 3 a point, but from C 2 and from this line which is C h that is how the point C forms. And this P is basically form by joining E P and P 2 P and P 1 P. If you join that is what is shown on the board, all the peritectic reactions are joining at the point P. 2 are coming from the two binaries and 1 is coming from the eutectic of the binary at BC.

Now, it will be very easy if I project everything on to the Gibbs triangle. That is what is shown on the right side. If you see here alpha, beta and gamma phase which are shown and then this points A 2 and A 1 extended and then you get a point A. Similarly, B 1 and B 3 extended B 1 is here, B 3 is here, they are extended we are getting point P. And C is carrying from C 2, C 2 is this one and also coming from C 3 C 3 is coming from the terminal solid solution of (Refer Time: 20:19) eutectic on B C that get C. And P is basically connected between P 2 and P 1 and also E this three points that is how. So, this is what inside plain is what I have drawn. From there I am drawing again this is the trapezoid you can see here carefully trapezoid correct. So this is point P, this is point A, this is point B, this is point C. So, here you have all this plains line, that is much is very clear to you right. That is how the things actually happen in this in this phase field.

Now, one can actually draw even much complex diagrams where you have two eutectic and one peritectic that is also possible. Having we one can draw that or systems, systems which follow this kind of things are carbon, titanium, tungsten, aluminium, magnesium, zinc. These are the two system alloy they form carbon, titanium, tungsten, and aluminium, magnesium, zinc. These two ternary systems are widely observed to follow this phase (Refer Time: 21:36). And the ternary reaction for the first system a ternary reaction is like this.

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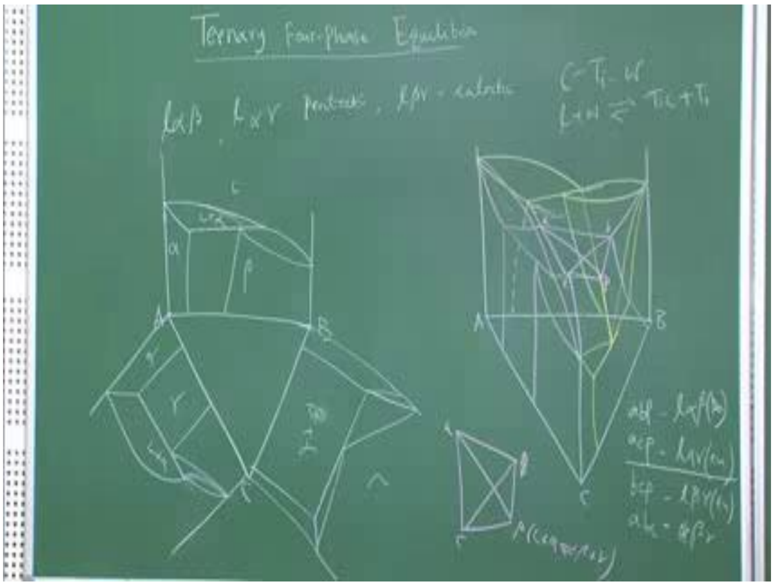

Ternary four phase reaction liquid plus tungsten plus TIC going to; yes TIC it forms a compound and this going to titanium this is the reaction. This is not the reaction sorry; something else I have written no this is the reaction correct. That is actually quite a bit small description of this ternary quasi peritectic reaction and in metallic system this is this has been observed by (Refer Time: 22:34) eutectic or peritectic reactions in the metallic systems.

So, I do not want to get on details of those metallic reactions because this will open up a new chapter. And if you look at properly in the text books there are few phases used to describe this reaction, because for ternary is the most important reaction is the eutectic reaction. And in many cases you find peritectic reaction, but this one as it is between eutectic and peritectic so that is brings lot a complexity. And many cases even we do not understand research level also this reactions. That is why we seemed to or look the importance of this reaction in the ternary phase diagrams.

So, if you want to know on the details of these phase diagrams little bit of topology needs to be understood. Topology means how these plains are appearing like this trapezoid which I have drawn. It is very difficult for you to conceive that how A B P and A C P are lying above the you know top of the plain and B C P and A B C is lying on the bottom of the plain, it is not easy. So, let me say trapezoid is lying at the inclined angle that is why you see some plains are top and some plains are bottom, but it is actually four phase equilibrium plain. Unlike eutectic or peritectic this is completely different.

With this I like to conclude this lecture. So, next two lectures which will be the last two lectures of this course, we are going to take few case studies of the ternary phase diagrams. Obviously, all important phase diagrams will be ceramic one, aluminium oxide. I do not remember what is the phase diagram I asked, I have given in the syllabus and I will discuss two metallic one; one is stainless steel other one is super alloy.

So, in the next class will start with stainless steel. Stainless steel is nothing but the ternary phase diagram between the iron, chromium and nickel. And nickel with super alloys a ternary phase diagram of nickel, chromium and aluminium. So, these two ternary phase diagrams will discuss first and the final we will discuss the ceramic phase diagrams which is based on aluminium oxide.

Thank you.