Solid State Chemistry
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Lecture – 18
Glide Planes

Now, I will start the third lecture of week 4 of this course. In this lecture, I will discuss another translational symmetry operation which we refer to as glide reflections and the corresponding symmetric element is referred to as a glide plane. So, week 4 lecture 3 will be on the topic of Glide Planes.

Now, we have already seen one translational symmetry operation which is the screw axes and this is another symmetry operation called the glide plane.

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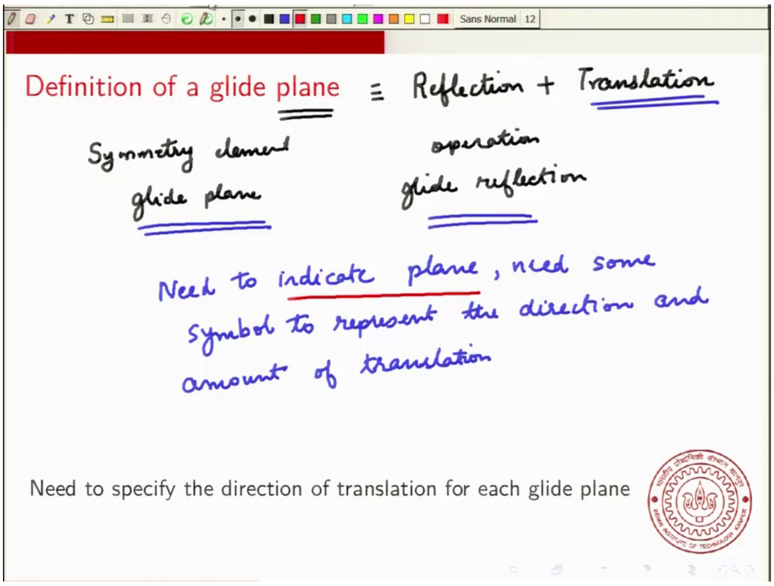

And it is a combination of a reflection and a translation. So, you reflect about a plane and then you translate in some direction. So, you need to specify the direction of translation for each glide plane. So, usually you show the plane. So, the glide plane so, it is a plane. So, you show the plane on the on your crystal or your lattice and then you indicate the direction of translation that makes it a glide reflection, ok.

So, the symmetry element it is a plane and this plane is referred to as glide plane and the operation which is the symmetry operation is referred to as and glide reflection, ok. Now, clearly so, you when one is specifying the glide plane in a crystal, so, you will be representing the plane using whatever symbol for the plane you will be indicating the plane, and you will need to indicate the direction of translation, ok.

So, need to indicate both plane indicate the plane, ok. So, you have to show where the plane is, and you need some symbol to represent the direction the direction and amount of translation, ok. So, what we will do; we will follow the practice that actually the plane will be indicated on the on the depiction of the crystal, the glide the appropriate plane and in the nomenclature of the glide plane we will indicate the direction and the amount of translation, ok. So, let us see how it goes.

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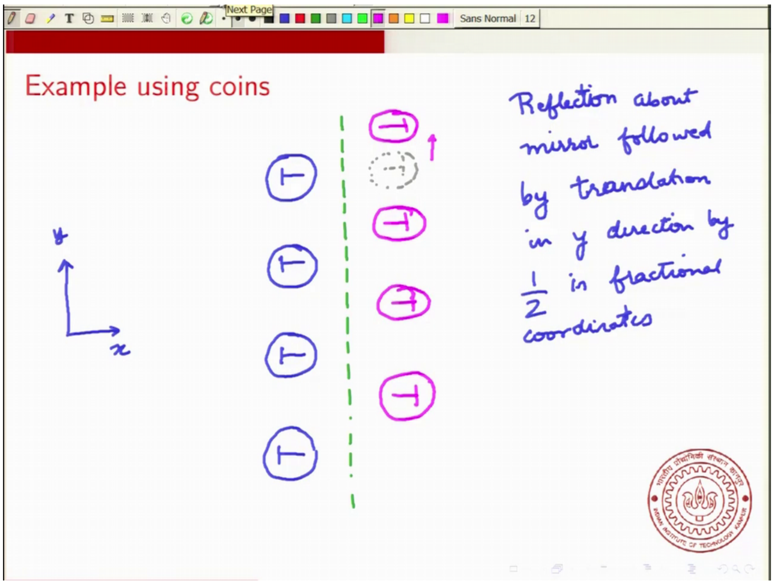

Before that let us take an example of a glide plane, and again we will use our favorite coins to show the glide plane. So, suppose you have a bunch of coins which are all facing tails and let us say the tail is pointing in this direction. So, this is a sideways T, ok. So, you think of this as tails which, but it is pointing sideways.

Now, if I imagine that this is a glide plane draw this more accurately these two are supposed to be they are all supposed to be equidistant. So, all the coins are supposed to be equidistant from each other and they are supposed to be identical. Now, let us do we will do a reflection about this mirror followed by translation in let me say let me call this direction the y-direction in y direction by half in fractional coordinates, ok.

So, what will happen when you do this operation? So, when you reflect it this T will look like. So, when you do the first reflection you will get something that looks like this I am just showing it in dots it will look like this; the T will now be reflected. So, it will face the other way and then you translate it by half, then you will end up with something and I will use a different color. So, you translate it by half upward, you will end up with a T that looks.

Similarly, this T will be reflected here and translated up so, you will get now that this T will be reflected here translated up. So, you will get another T and this T will also be reflected and translated. So, we will get a fourth T ok. So, the effect of this glide reflection is to take the blue T's and give you the purple T's and the purple T's are shifted by half with respect to the blue T's, and again keep in mind that the lattice is infinite, ok. So, whenever you are if you are looking for glide planes and crystals you should remember that your crystal is infinite ok. Now, what are the different types of glides that are known in that are seen in 3D crystals.

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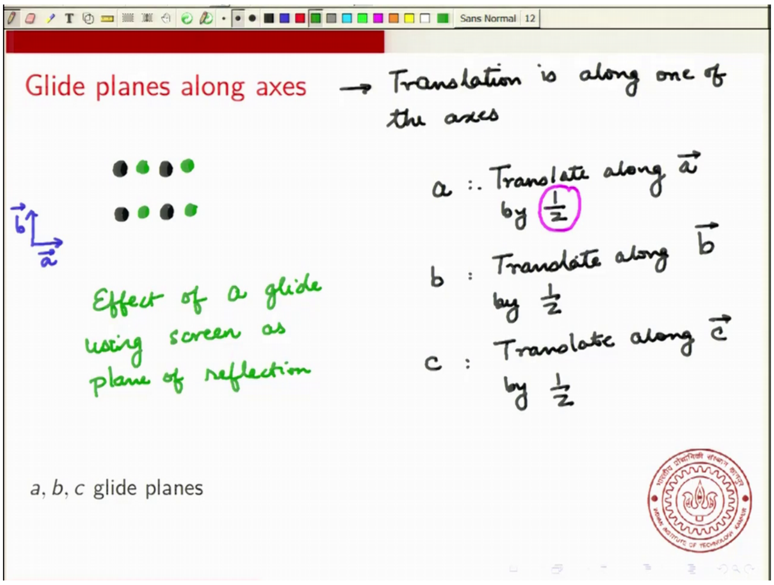

Now, it turns out that there are only certain kinds of glides that we need to consider the first are glide planes along axis; that means, the along axis. So, the translation is along the axis is along one of the axis, ok. So, you could have three possibilities you could have a three possibilities. So, you have some plane and so, you reflect about that plane and then you translate the whole system along one of the axis, ok.

So, the three possibilities are I would are a where you where you translate along a along a by half ok. So, it is a very specific translation you are translating only by half, only by half ok. So, it is a very specific translation, it is not some arbitrary translation. So, if there is a plane such that you reflect about that plane and you translate the whole crystal along the a direction by half, and if that turns out to be a symmetry operation then that plane is referred to as a glide as an a glide plane, ok.

The other kinds of guide glide planes you can get are b where the plane. So, you have the regular reflection about the plane and then you translate along b axis by half and c you translate along c axis by half, ok. So, just to take a simple example if we let us, I will just consider a simple square lattice ok.

So, if you have and now let us so, let me label my axis. So, this is b and this is a axis. So, you have the you have the crystallographic axis a and b, and let us say c is coming out of the plane of the of the paper of the of the screen; now if the screen were to be if we consider the screen as the mirror as a mirror plane and then ask what will happen when we do an a glide using the screen. So, we are looking at effect of a glide and use a green color effect of a glide using screen as plane of reflection.

So, if you do an a glide then you reflect these points about the above the plane and now and now since all these points lie in the plane, nothing will happen to them when you reflect them and then the only effect is to translate these. So, you translate them along a along this direction. So, this will get translated along a and you will get this point this will get translated along a to this point and you are translating it only by half of the half of the lattice parameter, ok.

So, that is what you will end up with, ok; clearly it is not an equivalent position. So, clearly this is not a symmetry element ok. But, this is how you define this a glides b glides and c glides and these are fairly simple to see, ok. Now, you have to say which is the plane that you are considering, and then and then the name of this so, what you will say is that this screen that we considered is not a glide, ok. It is not a glide; that means, it is not a glide is not a symmetry operation ok.

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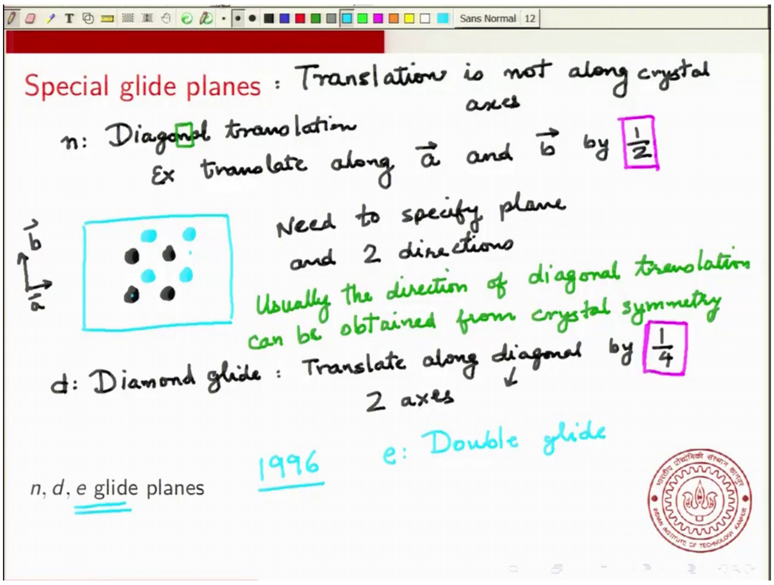

Now, let us look at some special glide planes, ok. So, in addition to the a, b and c there are some special glide planes, and they are special in the sense the translation is not along the axis is not along crystallographic axis, ok. And, in this regard there are three glide planes that are defined; one is called the n plane and the n stands for diagonal translation and here for example, you could have an n translation corresponding to change so, example translate along a and b by half, what is also relevant is that we are translating by half.

So, here if you had I will just show this effect by acting on a single point, ok. So, suppose you had the same I mean we could we could do this with the same square lattice. So, the square lattice that we looked at in the last example so, you have a square lattice and let me draw my axis this is the b axis and this is the a axis, ok.

And, now if I do if I imagine doing an n glide what the n glide will do is it will reflect and reflection if you consider an n glide using the using the plane of the screen, ok. So, using the screen as using this plane of the screen as the n glide, n glide, ok. So, there will be a reflection which will not change anything then there will be a translation by half along the a direction and half along the b direction. So, this point will go here; this point will go here; this point will go here and this point will go here. So, this is the effect of a n glide on this, ok.

Now, notice that how do you we have to specify the specify the need to specify the plane specify plane, and there are two and two directions. In other words, how do I know which two? I mean how do I know whether to take along a and b or a and c or b and c how do I represent that, and usually this is where the glide planes get a little tricky.

So, usually the direction of diagonal translation can be obtained from crystal symmetry, ok; that means, in other words, if you know if you know what kind of crystal it is, and you say that some plane is an n glide plane, ok, then once you look at the plane and you look at the crystal then it will become obvious in which direction you are you have to do the translation. This is n is diagonal and you can you can think of this n as coming from the n of the diagonal ok.

There is another glide plane which is referred to as the diamond glide. So, d for diamond glide, and as the name suggests it is seen in the diamond crystal which will diamond lattice which we will see in the which we will see soon. And now, you here you translate again along the diagonal along diagonal and here by 1 by 4, and we will see an example of this.

So, this was so, here you only do a quarter translation, unlike the half translation that we were doing in the case of a diagonal translation and in the case of this diagonal glide, ok. So, and again this should be a this should be a diagonal means two axis, ok. So, it is not a full body diagonal, it is one of the face diagonals. So, in the sense that you translate along both a and b along any two axis by one quarter, ok.

So, we will see examples of this soon. So, I would not talk more about it I will just mention this there is a new type of glide that was introduced called the e glides, ok. So, these were introduced in 1996, they were introduced into crystallography, ok. Now, the e glide I will not be describing it in detail. So, e is refers to a double glide ok, where you essentially do two glide of glide operations, ok.

So, you reflect about two different mirrors, and then or reflect about a mirror it is a combination of two glide operations, and this was recognized as a symmetry operation and it was introduced into the language of crystallography in 1996. I will not be talking about this. This is only for very very only for very specific systems you see this e or a double glide, ok. So, these are the glide planes. Now, let us look at our favorite example, ok.

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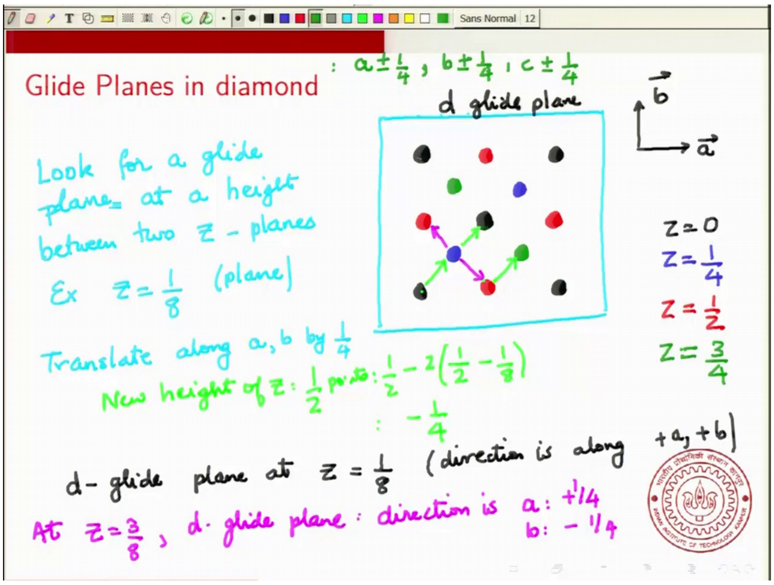

This is diamond; diamond lattice, and let us try to see if we can if we can recognize some glide planes, ok. Now, let me draw it in the usual way that we have been doing and draw it slightly bigger. So, this is at Z equal to 0, and then you have Z equal to one quarter, then you have Z equal to half, then you have Z equal to three quarter, ok. So, this is our diamond lattice, and again it is not a Bravais lattice, we keep using the term lattice, because we are saying that all the atoms are identical.

Now, are there any glide planes in this diamond lattice? Now, I can see a glide plane you can see that if you translate along this direction, along any of the diagonals you will end up; you will end up at another lattice point, but some different height, ok. So, can you have a glide plane ok, can you have a this is a question can we inspect look for a glide plane at or rather I will say between; so, at a height between two Z planes, ok.

So, that means, so, for example, you can look between Z equal to 0 and Z equal to 1 by 4. So, example you look at Z equal to 1 by 8. So, Z equal to 1 by 8 is a plane this is a plane Z equal to 1 by 8 is a plane that is parallel to the screen, but it is at a height 1 by 8 above the screen, ok. So, it is parallel to the screen ok, but it is, not in the screen of the it is not in the screen, but it is at a height 1 by 8 above the screen, ok. And now so, you can take what you let us take this corner atom, and then and then let us say you translate along if we call these axis as a axis and b axis, ok. So, translate along a comma b by one fourth, ok. So, what you can see is if you do this reflection ok, let us look what happens to this point to this corner black point.

So, if you do the reflection about Z equal to 1 by 8 plane that will come to a height of Z equal to 1 by 4 and it will be right above this, ok; then if you do this translation along a by 1 by 4, then it will get translated over here and if you translate by b by 1 by 4 you get translated and will sit directly on top of the blue atom, ok. So, the black atom black point will go to the blue point and you can similarly see that the red point will go to the green point the blue point will go so, the blue point will now when it is since it is we will actually should it should be a little more careful.

Red point will not go to the green point, ok, when you when you do a reflection about this red point ok, now you are reflecting it about Z equal to 1 by 8, ok. Now, this is a red point is at Z equal to 1 by half ok. So, it will when it is at a height half above the plane of the screen. So, when it is reflected about Z equal to 1 by 8, this will go to a height of. So, it will go to half minus 1 by 8 into 2 half minus.

So, it will go to a height of; so, the new height of this new height of this new height after reflection of Z equal to half at points is half minus this, and you can you can easily see that this is minus half plus 1 by 4 that is minus 1 by 4, ok. So, this will go to a height of minus 1 by 4, and which is translationally equivalent to this point which is translationally equivalent to height of 3 by 4, ok. And, then you do the translation you will get a point that is translationally equivalent to this green point. So, it is exactly one unit lattice below this point, ok.

And, you can you can do the same thing similarly the blue will go to a blue will actually exactly go to this point, ok; blue is at height of 1 by 4 when its reflected about 1 by 8 it will go to it will go to Z equal to 0. And, it will exactly go to this black point and you can show that all these points will go into each other by this operation.

So, this is an example of a glide plane in diamond, and. In fact, this is called a diamond glide, ok. So, the diamond glide. So, this is a d glide plane, ok. So, diamond has a glide plane at Z equal to 1 by 8, and what I want to emphasize is that the direction of the translation is obvious you can get it by inspecting the crystal, ok. So, the direction is along plus a plus b, ok. So, you go along plus a and plus b by fact by a distance of 1 by 4, ok.

Now, if you take if you think of other glide planes; so, if you have a glide plane at 1 by 8, you would think that there should be another glide plane at Z equal to 3 by 8, ok. So, at Z equal to 3 by 8, there is another d glide plane, and what will the direction of that translation b ok. So, Z equal to 3 by 8 is between 1 by 4 and half, ok. So, it is between the blue and the red, ok.

So, if you do a glide if you do the reflection, about Z equal to 3 by 8 you will see that the that the height of this blue atom will go from will go from 1 by 4 to half, and now once it goes to half you know that there are two possible directions of translation; you can either translate this way or you can translate this way. They are equivalent I mean whether you translate forward or back it is the same, but essentially you have to translate along these directions. You cannot translate along these green directions, ok.

So, now the direction is along is along you can take either. So, it goes to a by plus 1 by 4 and b by minus 1 by 4 or vice versa or you can take it the other way, ok. So, the direction of the glide is actually obtained by inspecting the crystal, ok, the exact direction as to which along which axis you will translate and by how much. And, typically what you do is you either go you either go from typically you go to a plus minus 1 by 4, b plus minus 1 by 4 and c plus minus 1 by 4, ok. That means, you go along each of the any of these axis you go along any two of these and you can go with any one of these signs.

You can go either go by plus 4 along a and plus 4 along b or you can go plus 4 along a or and plus 4 along c or a plus 4 along a and minus 4 along c and so on, ok. So, with this I will conclude the discussion of glide planes and in glide reflections and this will conclude the discussion on the translational symmetry operations. In the next class, I will try to summarize all these symmetry operations and try to give a give some understanding of why we are looking at these symmetry operations and what is the advantage of looking at these symmetry operations.

Thank you.