Defects in Materials

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Lecture - 25
Intrinsic Stacking Faults in FCC

Welcome you all to this course on Defects in Materials. In the last class we looked at the different types of defects in FCC lattice that is especially dislocations in FCC lattice we try to look at it. What all the types of dislocations which are possible in FCC lattice and that to what we considered was when the stacking fault energy of the material is high, that is the various types of possible dislocations which it can form; when this and what is the type of interaction which can take place between these dislocations.

Today what we will try to do is that look at cases, where this that is cases in materials where the stacking fault energy is low.

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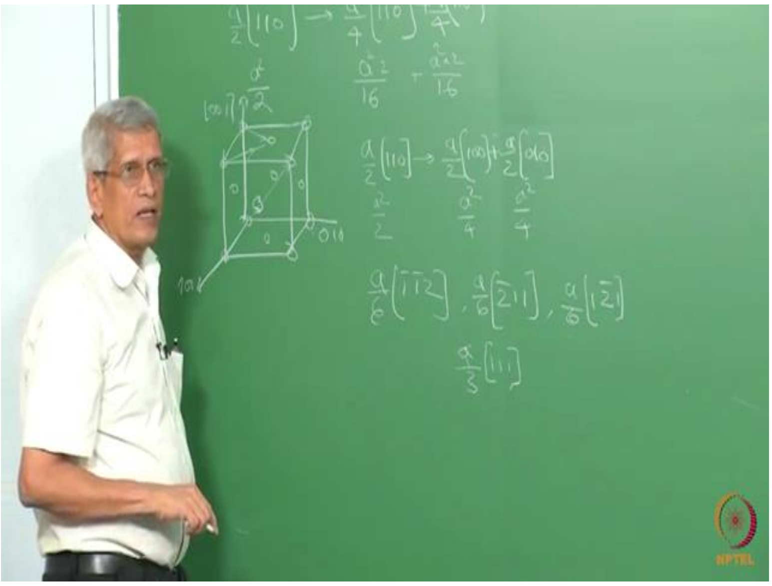

As such if you consider dislocation in a lattice the tendency essentially is that, if a dislocation of the type a by 2 110 which is a perfect translation vector in the FCC lattice. If it tries to split into a dislocation for example, consider a hypothetical case 110, then we will find that here it will be the energy will be a squared by 2 in this case it will be 2 correct by 16 correct this is plus a squared 2 by 16. So the energy here is greater. So this reaction is possible. What it means is that all perfect dislocations would like to reduce their energy by splitting into partials which have got burgers vector which is smaller than that of a. This is an type of reaction which because of reduction of your self-energy dislocations will always try to go through this process to reduce their energy. So this is one inherent property of the, but will dislocation split into partials and creates stacking fault or not that is the question which have to be considered. And another is that will in all material a stacking fault will form or not.

Let us try to look at that case. Here what he had considering it is an FCC lattice. I will just 100 these are all the positions; which atoms are going to occupy in the lattice correct. Let us look at the case of 100 plane or 001 plane, 001 plane means essentially atoms which are arranged in this x y plane which we have to look at it that is what is shown here.

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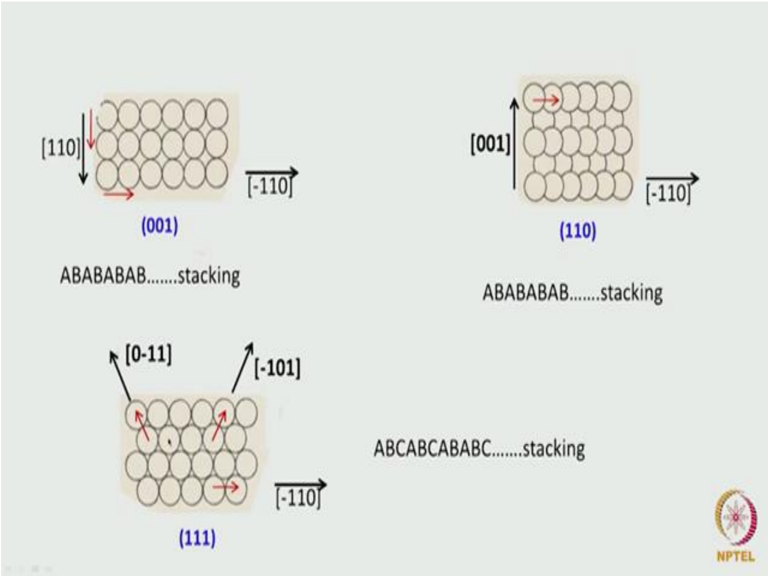

These are all the 2 directions 110 direction and 1 bar 1 0 direction. Because there are 2 close packed directions which are going to be there that is at every plain here this will be one close packed direction this is another close packed direction correct. That is essentially what is being shown here. What is the stacking sequence here in this direction? If you look at it, it is going to be an A B A B type of a stacking sequence. Suppose we consider this plane; this is the B plane.

This is again an identical a plane comes A B, A B type of a stacking sequence here. We assume that the atom on the B plane is sitting at this position which is going to be the low energy this atom by a movement of a perfect dislocation will shift from here to this position or from here to this position so; that means, that the movement of the atom goes from A B position to another B position correct that is what essentially happens in this system.

So there is no other choice which is available. The other choice which is there is that this atom can be removed from here to this position, which will be essentially a partial of the type a by 2 0 or 100. Because we can consider this reaction right this reaction, we can consider if we look energy wise this, will be a squared by 2. Here it will be a squared by 4. Here it is a squared by 4. So that is net gain or loss of energy is going to be there. And, but added to that the atom has be moved from this position to A position which is identical to an A position that is the only possibility. And this vector essentially is like a partial translation vector because this is not a translation vector in the FCC lattice correct. That sort of a reaction in principle can happen, but that moves atom from here to position on top which is essentially looks like a high energy position. Some energy is required to move it here; some energy is to from this position to come back to this position. So you essentially this sort of a dislocation reaction there is not much of gain in energy this need not happen.

Let us take the case of a 110 plane. That same is true in this case also. In this case also the close packed direction is 110 high a by 2 110 is the burgers vector of the dislocation close packed direction is 110. And here also the stacking sequence is A B A B A B so; that means, that A layer and the B layer below this A layer is being shown here. So atom moves to shift from one A position B position by a translation vector of the perfect lattice, it moves to an another translation vector nothing else there is no other possibility where, you can then it can go. If you think of a partial which can move it, like we considered in this case. That partial moves it to A position which is a high energy position, because it is almost like climbing up the hill correct.

What is interesting is the 111 plane. In 111 plane here if you look at it, essentially it is a hexagonal type of a stacking sequence. In this the stacking sequence itself is A B C A B C type, let us look at it in detail here what I had shown essentially is the various close packed directions are shown in this.

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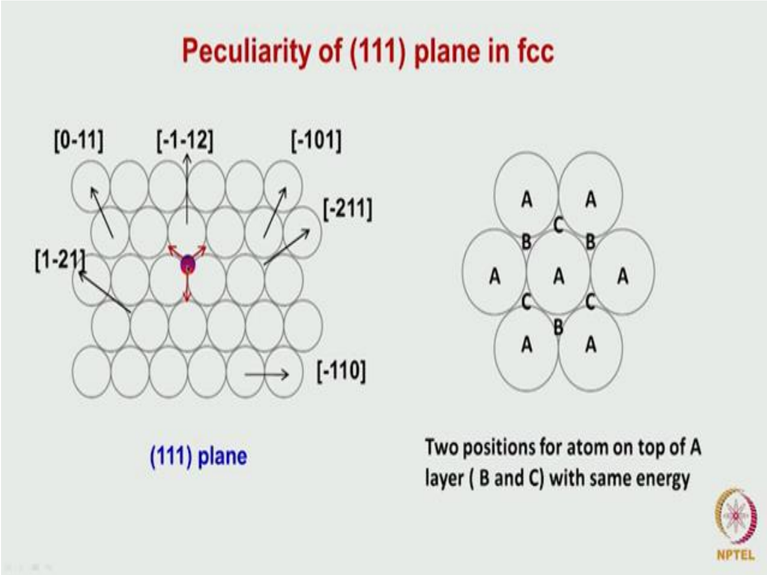

Let us look at the arrangement of atoms in this plane which is shown in this particular slide. Here this is an A layer which is being shown. And this is an atom on the next layer which is A B layer. And there is another position, this position is essentially a C position because which is what is being A and B and C position.

What is interesting about this arrangement that is whether the atom occupies the atom on the next layer occupies B position or C position, essentially it is in the same energy state, by go moving over from B to C, it is reaching a stage which is the same as that which was before. That is because there are 2 possibilities for the position that B position there is a possibility that it can go from B to A which is a high energy position or an another alternative from B not to B, but to A position which is C, that possibility is also there. If it goes from the position B to another B position that movement can be brought about by a perfect translation vector, whereas if we go from here to here, the translation vector is not a perfect translation vector in the FCC lattice, that is essentially what is being shown here.

This is an atom which is occupying this B layer, by a movement of a vector these vectors if you look at it this vector will correspond to essentially a 1 bar 1 bar 2. Similarly, we can find out the translation vectors in this direction is a by 6. It will be 1 2 bar 1 and in this direction if you look at it, it will be a by 6 2 bar 1 1. By a movement of a partial which moves atoms, from atom which is sitting at B position to this position. Whatever be the partial it does not matter which partial use it, it moves from B to a C position.

The stacking sequence essentially changes from B to a C position it does not matter which partial is responsible for it correct. That is one thing which one should understand; that means, that the stacking sequence is altered in a particular way the atom going from B to C, but that can be implemented by a movement of the choice of 3 partials are there to be implemented. Here what I had shown is perfect translation vectors which will move this atom from B layer to another B layer or to another B layer or it moves with an another B layer right. The choice if you look here, now essentially is that any of this perfect translation vectors, maintains that order correct, A B C stacking sequence is not changed.

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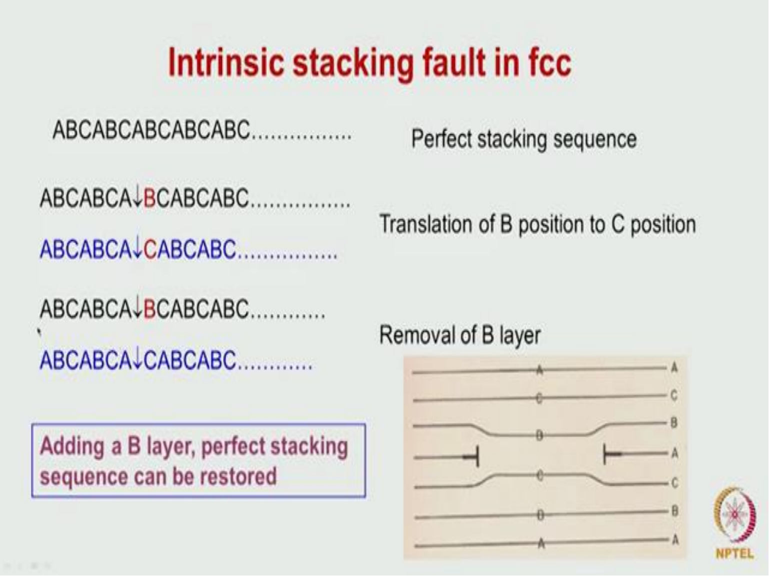

The stacking sequence remains the same the same thing I had just shown in terms of a stacking sequences itself here we have considered with respect to an atom position, that is A layer and how a movement of an atom from B layer by what is the type of partial which will move it from B position to a C position that is what we have considered.

So in a perfect FCC lattice, the stacking sequence is A B C A B C A B C type which all of you know. In this suppose I introduce a fault here by a movement of a partial. The partial which we consider that which I mention that is like this or a by 6 1 2 bar 1 anyone of this partial moves an atom from B position to the C position; correct.

So then the stacking sequence, when this partial moves it not only moves the atom in that layer, all the atoms in that layer above that plane will all be shifted by the same translation vector. So B will be shifted to C that is what is being shown. C will be shifted to A, A will be shifted to B, B will be shifted to C. Now if you look at the stacking sequence which has come because of the movement of a particle, it has become A B C A B C A B then A B C A B C on either side. So here if you look at it in this region which is a C A C A type of a stacking sequence is there that is it is nothing, but an A B A B type of a stacking sequence. That is what it occurs for a hexagonal lattice. When such a type of a stacking sequence occurs in a hexagonal lattice we called that as an HCP, structure hexagonal closed pack structure, so essentially the stacking fault which forms has got the unit cell of HCP there. Before coming to that let us look at what is the other way in which the same stacking sequence can be generated.

In this suppose I remove A B layer, that is this is the A B C A B C perfect stacking sequence. I remove B layer, then what will happen? When the B layer has been removed, then the stacking sequence now becomes A B C A B goes C A. So essentially the same stacking sequence comes, so either by movement of a partial we should move an atom from one position to another position or removing that layer itself.

Both are equivalents right both generate the same type of fault in the stacking sequence. That is what is being depicted here. Where part of the A layer has been removed, when the part of the A layer has been removed then this has become A B C B C A. So this stacking fault we called as a frank fault, so frank fault also the stacking sequence remains that same. But the mechanism by which the fault has been generated in these 2 cases are different. It does not matter, but what is important is as far as the fault is concerned, these type of faults are called as intrinsic stacking fault. Where either one layer is just moved from one position to another or A layer has been removed in the stacking sequence along 111 directions. They give rise to an intrinsic stacking fault. What will be the difference which we will observe is the type of dislocation which is responsible for it. In one case the stacking fault will be attached to a dislocation which is a burgers vector of this type or will have a burgers vector in this particular direction which will be of a by 3 111.

Suppose you wanted to restore order in this alloy. What should be done? Either of this case if I add A B layer here, the order can be restored, correct.

So in a perfect FCC stacking sequence, if A layer is removed, your fault is created. Or A layer is added that same fault can be restored. There is where already a fault has been created we have added one layer, but let us know, we will consider the case where in a perfect lattice we order layer that we will consider it later. So by removal of A layer or addition of A layer if the fault can be generated, or the a fault can be removed this sort of faults are called as intrinsic stacking faults.

Let us take the case addition of A layer or removal of one layer. Removal of one layer is equivalent to what is will be the magnitude of the burgers vector corresponding to that. That vector is going to be a by 3 111 correct. Perpendicular to that direction; for example, in the FCC you look at this case here, from this position this is the position at which the identical position this will be the translation vector for that in 111 directions in FCC lattice correct. With this translation vector we are moving from here to an identical position. In between 2 more layers are there. So this vector is. So if you remove or add one layer it is equivalent to shortening are increasing it by one-third of it correct. So essentially a by 3 111 is going to be the fault vector.

So this information that this is the fault vector, this information will be required when we wanted to find out the nature of the stacking fault using transmission electron microscope. There we should know what is the fault vector. So what we considered. So far was just that a movement of a partial can create a stacking fault can a partial s h p generated in a material FCC material know. We considered the case that all perfect dislocations it does not matter what is the fault energy of the material perfect dislocations always will have a tendency to split into partials.

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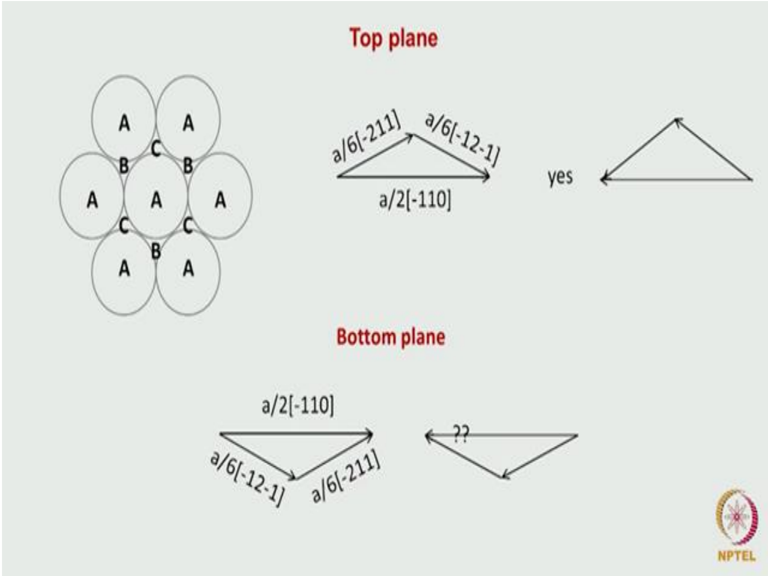

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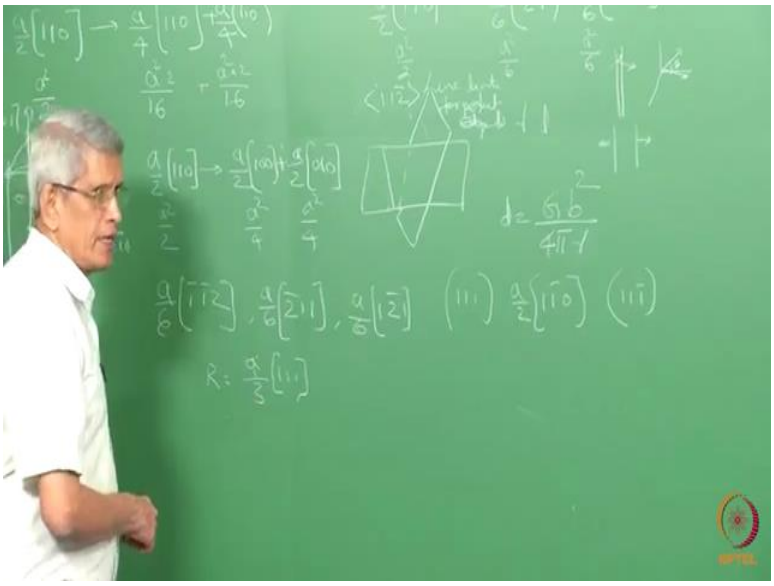

That is for example, if you consider this dislocation a by 2 1 bar 1 0. This can split into 2 partials of this type. Whether this reaction is possible or not we can just try to find out this will be a squared by 2 the self-energy the B squared value here it will be a squared by 6 correct. Here it will be another a squared by 6 correct. So if you add them together then we will find that there is a gain in energy. So inherently this reaction is always results in lowering of the energy of the dislocation.

Now, the question which arises is that whether this reaction will occur or not or the reaction has to occur because there is always a lowering of energy whether we will be able to observe this reaction or not this splitting or not, so one such a reaction takes place. In the last class we mentioned that we assume that the dislocation perfect dislocation has split into a partial of this type. When it was split up into a partial of this type, assume that dislocations are very close to each other.

Now, what is the type of force which will be acting between these dislocations? That we can try to find out since we know the burgers vector directions.

That we have derive the formula also. What we will observe is that these reaction dislocations will repel each other. That is a way in which this could be found out essentially what is being done is that, if we consider the burgers vector of the 2 dislocations, this is a thumb rule which is being used. That is if one dislocation has got a burgers vector like this, another dislocation has got a burgers vector like this. This with respect to a coordinate system which we consider with respect to a origin we can write one will have a burgers vector like this, another has got a burgers vector assume in this direction, if the angle between these 2 burgers vectors is an acute angle. The generally the force between this dislocation will be repulsive.

If the angle between the means obtuse angle, then the force is going to be attractive; that means, that in this case like the example which is being shown here. Here what I had shown is that, let us consider with respect to the atom position, which is being shown here from this B position to this B position a vector a by 2 1 bar 1 0 will move an atom from this B position to another B position correct? The same thing can be considered as from this B position this atom is first moved to a C position by a partial dislocation having burgers vector a by 6 2 bar 1 1 and then another dislocation having a partial burgers vector a by 6 1 bar 2 1 bar. That comes and moves the atoms from this position to this position; that means that this movement has been achieved by moving from here to here and here to here correct. It is the same.

So if you look here what is the burgers a direction of the burgers vector here in this one this burgers vector if we place with this as the origin we will find it is in this position. So both angle between them is acute. So this dislocation will repel each other, right.

So when this dislocation repels this dislocation that is will try to move apart in this direction. Whenever this dislocation moves apart, since between them they have created A layer which is does not have which has created a fault. So a new surface is being created. So that surface requires some energy to create that surface energy. Suppose we assume that the surface energy is gamma, and we know the separation between the dislocation what it is going to be per unit length, if we consider into d the separation between them that will give the force. This force can be equated to the force which is being acting between the dislocations correct.

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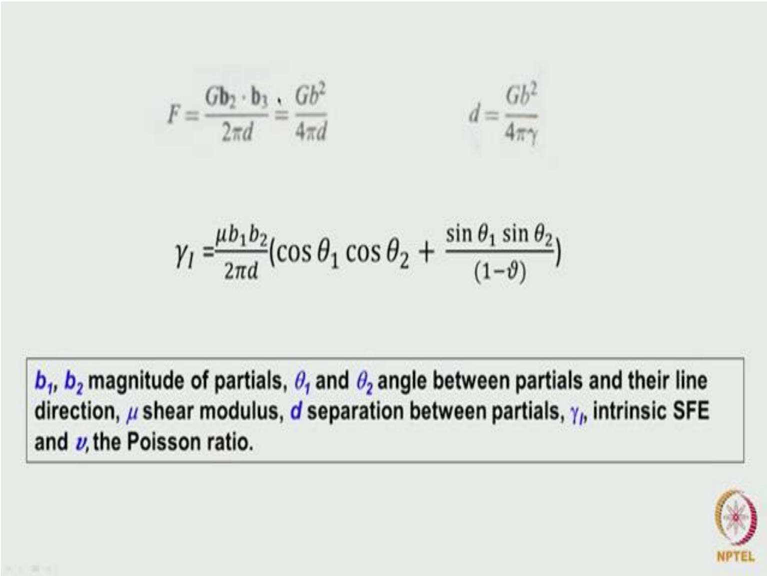

We will now come back. Essentially that is what is being done. Now force equals G into this expression you remember which we have derived earlier G B squared by and this should be equal to gamma into d. So then we will get an expression for the separation between them.

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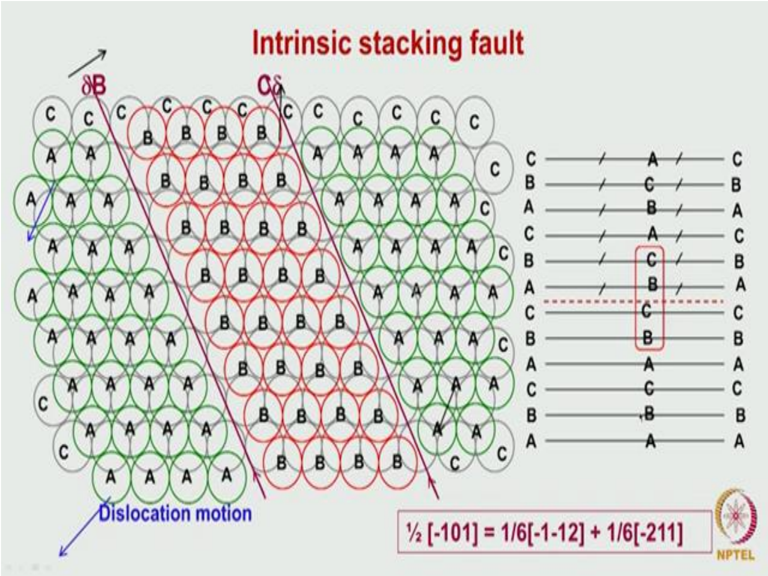

So essentially what is going to happen is that the gain in energy, which you have observed, obtained by the dislocation splitting into the partial that is balanced by the energy which is required to create that a surface, between that is essentially a new surface, which we are creating by moving the dislocations apart, that surface energy we equate it. Only up to that distance the dislocations will move.

What is the consequence of that? Suppose the surface which we are creating has got a very high energy. Then because this formula turns out to be gamma equals G B square. Or d correct or d equals B squared by. If the gamma is very large this separation will become very small.

Correct? Suppose we assume that the gamma is So large that the separation d between them becomes less than the lattice translation vector. Then though there is an inherent tendency for that splitting to take place will occur, but if they try to move apart then the surface energy. So high that the separation between them too small to be observed, so essentially if it is within the core radius of the dislocation, then we assume that the dislocations we are not able to observe it. So we say that the dislocation are not split. We consider it to be a perfect remains as a perfect dislocation correct there is or the splitting it is. So such a small value that it is almost one is sitting on top of a, or the other are close to each other.

Suppose the stacking fault energy is small. Then what will happen is that this dislocation is very small, the separation between them is large, we are able to see this dislocation has 2 distinct ones. This is what essentially happens in low stacking fault energy material, then the next case which we have to consider is that suppose a stacking fault energy is of intermediate value, where there is a splitting is there, but the split sufficient splitting is going to take place, maybe just above the about the size of the core of the dislocation, but we are not able to observe experimentally in such cases what we will find out is that in most of the experiment the dislocations will appear to be present in the planar arrangement; that means, that whenever the dislocation sees an obstacle when the stacking fault energy is high. If it is a screw dislocation it will try to cross slip. Here these dislocations will not be able to cross slip. For a cross slip what is the criterion which a dislocation should satisfy? That is the burgers vector should be lying to slip planes.

Correct. So if we consider a dislocation in 111 plane, which has got a burgers vector assume that a by 2 1 1 bar 0. This dislocation with the same burgers vector can lie on 1 1 bar 1 plane also correct. If it turns out to be a screw dislocation the line direction and the burgers direction is the same, and the line direction is common to both of them, because of that a dislocation which is the moving in this plane you assume that dislocation is there in this plane, which is moving as it reaches somewhere here it sees an obstacle. Since the burgers vector is in this same direction, the screw dislocation with the same burgers vector and l line direction can exist in this plane also. So it will just cross slip on to that plane that can happen.

That is why whereas, for an edge dislocation if we consider, the line direction is always 112 type of a direction. Should write it as 112 type of a direction, this is the line direction of for perfect edge dislocation. And though burgers vector can be common in 2 directions, but the line direction cannot be because of that edge dislocation cannot cross slip. When the dislocations split in partials of these type this partial is lying in only this plane.

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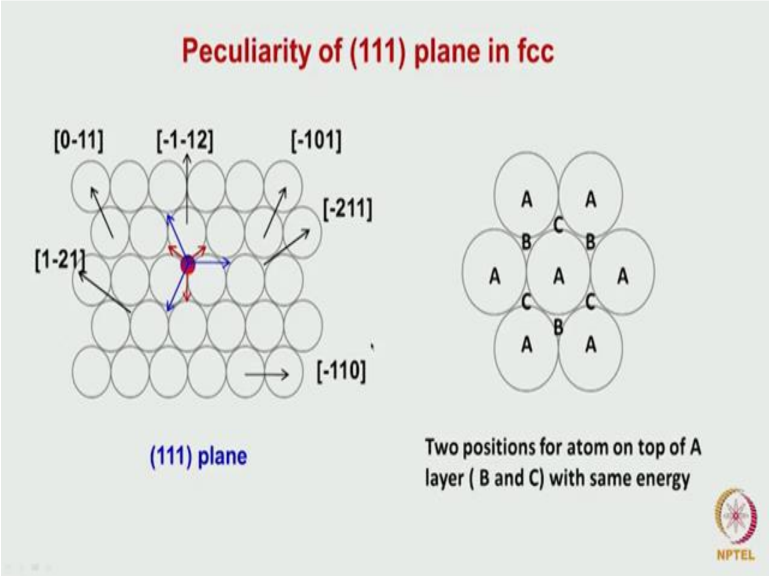

If you consider another 111, plane a distinct another 1 1 2 type of a direction will come for the partials; that means, that the burgers vector of the partial like in the case of a perfect dislocation, does not lie in thus lie only in one particular slip plane because of the dislocation can never cross slip.

So what is the consequence of it if the dislocation cannot have cross slip is that when the dislocation cannot cross slip; that means that the dislocation has to lie in the same slip plane. Even if the dislocation has split into partials we are not able to observe them. Since they cannot cross slip the tendency will be for the dislocation to lie in the same slip plane; that means, planar arrangement of dislocations will be seen, that is what it happens in the case of high stacking fault energy material not high intermediate stacking fault energy material.

In the case of high stacking fault energy material, the cross slip of perfect dislocations will be seen. Intermediate stacking fault energy material we do not see the splitting of the partials, but the tendency for the dislocations to lie in a planar arrangement is being seen. When the stacking fault energy is small the separation between the partials is so large that it is visible very clearly is this clear.

Then another thing also which one should consider it is that, if an atom has to move from this B position to this B position, it has to go in a path which is over because this is a hard sphere model, it is a ball over which from here to over a curvature of a ball.

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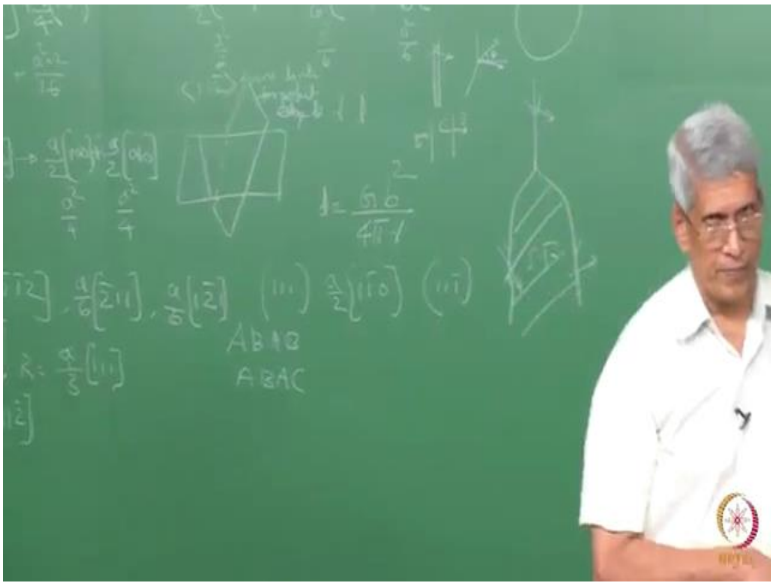

Like if this is the surface from this position to this position. It has to pass over a curvature like this correct. Like this it has to like that comes the other case, here what happens it is moving from here to an another position which is almost the height which it has to overcome is very small and it can come; that means, that the tendency to split into partials this also is an indication that the barrier height is going to be high for going from B to B position, but in FCC if it goes from B to C, because the C has got the same energy.

But the barrier height is small. So it can go easily. So energetically that is what also we talk about it. So whichever way we look at it that finally, this reaction is always possible correct. And in this reaction, we consider it is that if an atom has to be moved from here to here the way it has to be moved first this B atom has to be moved to this position. That is what the first dislocation should do. So the movement of a first dislocation will move all atom from B position to C position, then the second dislocation which comes behind. That is if the first dislocation moves the all atoms which are there in this B position here to C position when the second dislocation which comes trailing behind it that will move atoms from C position to B position right. That is how if you consider between these 2 dislocations on either side we will have a atoms in the B position in between atom is going to be there in the C position.

Suppose we consider the reverse reaction that is can it go from here to this position and to this position; that means, that we have to move from here to A position which is going to be on top of this which is a barrier that is from this one it has to come on to this one height. Generally, we will say that it is not possible, but this sort of reactions also does take place, which will talk about later. This is called as an formation of an extrinsic stacking fault.

Let us confine our attention only to an intrinsic stacking fault repressor. What will happen to the bottom layer, bottom layer the atoms are there in C position correct. That is this is A B C we have considered. Below A layer atom will be in that C position. So atom in the C position can move from here to here, and from here to here. So that reaction is possible that is what essentially we are showing it.

Now what we can make out is that this reaction which we write here we have to mention from which layer the slip is taking place, above layer or below layer. That decides what is the type of which is the one which is the leading dislocation which is going to be the trailing dislocations you can see here right. Here this is the layer this dislocation which was initially which was following. Has now is the one which is creating the stacking fault. And the other one is which is what were the fault which is created when the second dislocation comes it is just eliminating that fault.

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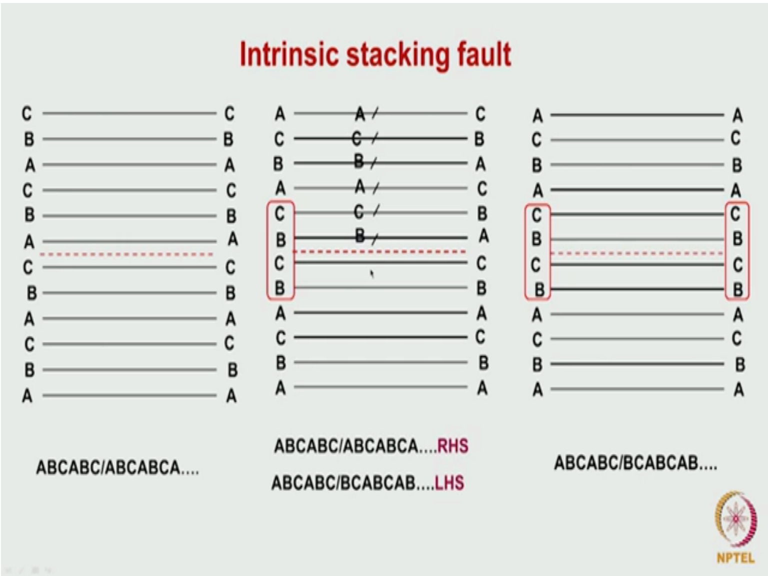

Right the same stacking sequence at because I had shown it in different ways how one can consider the same stacking fault formation. Like this is A B C A B C type of a stacking sequence A layer B layer different layers are being shown. Here with respect to this plane the plane above the C layer with the A layer it is being moved to B layer.

By a movement of a dislocation that dislocation could be we have considered 2 types can be there either 1 by 3 111 type the frank dislocation. Or a by 6 111 type it does not matter what it is it will move the atoms to this position this A position to B the B position is changed to C. Because by a movement of a dislocation it will move all the atom players above that slip plane by the same burgers vector. So this is what the stacking sequence now become right.

When that stacking sequence is completely gone across the surface of the sample, that is full volume of it, this is how it will appear both the sides we will have a fault which is going to be there correct. Here the same dislocation reaction which we considered. Because the in this case which we considered it is, we are not talk about which is the type of a dislocation reaction which is responsible for fault to be created, but what is the type of stacking sequence, how it is being changed that is what we have talked about.

Now, let us look at this case, where a movement of a perfect dislocation. Here half 1 0 1 bar 0 1 this is the perfect dislocation. This dislocation has split into a partial 1 by 6, 1 bar 1 bar 2 plus 1 by 6. This reaction is energetically possible. Here what I had shown it is that burgers vector of this partials are being shown. Suppose we assume that, this dislocation moves from here to this position. Then if a dislocation moves from here to this position, what should happen for the dislocation to reach that position this atom should be moved from here to this position.

Correct? All this atom should be moved from this A position to A B position has to be shifted. When that is shifted this would have moved correct? And then here if you see it what is it which is going to happen, when this dislocation moves from here to this position, the second ring because this is the dislocation which is moving in this direction this dislocation which comes is trying to move in this same direction because both the dislocation from the application of the force are trying to move in the same direction. Then what essential it will happen? This will be when this dislocation reaches here it is equivalent to this will be replaced from here to this position, A position. This will be replaced to A position, then when they come to A position this dislocation like might have shifted and come here correct. So you can see that this entire layer is now getting shifted from this to and another position like this. That is how the dislocation moves, but the separation between this dislocation is being governed by the what is the energy which is required to form the surface, when the fault is created and this energy we call it as the stacking fault energy of the material. Is it clear?

So here we have considered an intrinsic stacking fault. Then, what is the separation between the dislocation? That is force balance equation we can write it. And from that we can find out what will be the separation. Here this we have considered it for a perfect screw dislocation edge dislocation. There will be a 1 by mu will come into this picture when we have a screw and an edge dislocation. And then this is a sort of that is if it is a mixed dislocation which is splitting it to 2 partials. Then this is how it is going to be the formula for the dislocations have which split into partials.

The dislocations which has split into partials also could be a pure screw or a pure edge or a mixed dislocation right, like for perfect dislocation we consider it to be a pure screw or a pure edge or a mixed dislocation. The same is true for partial dislocations also. So the terms are described here B one and B 2 are the magnitude of the partials. Theta 1 theta 2 angle between the partials and their line direction, for both the partials and mu is the shear modulus, d is the separation between the partials gamma i is the intrinsic stacking fault energy, and mu is the Poisson ratio.

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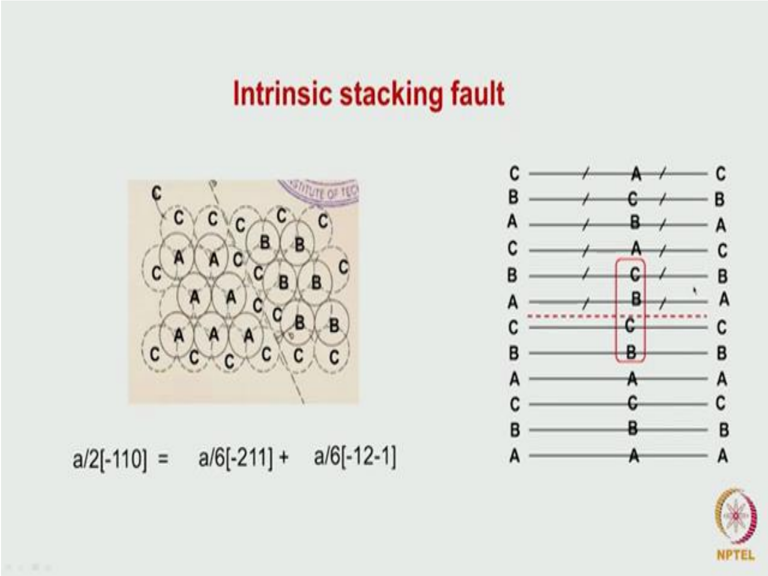

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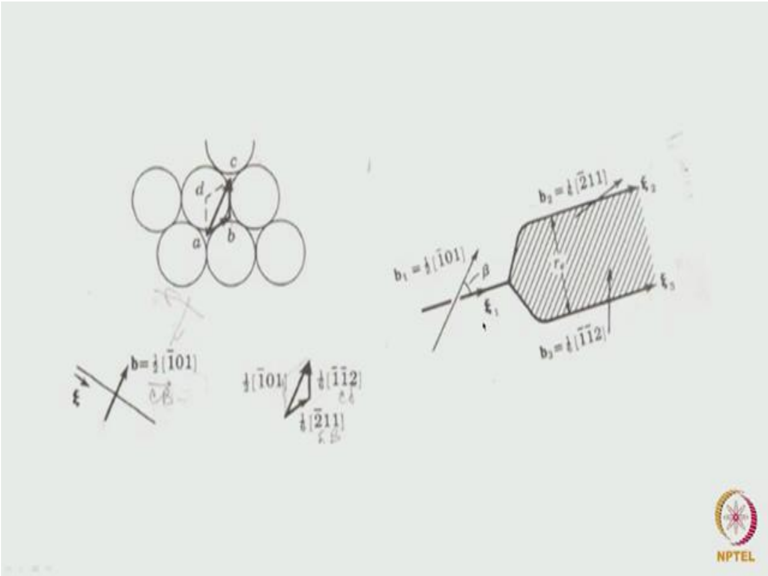

This is schematically in most of the books if you look at it how this partial separation will be shown. This is how essentially a perfect translation a dislocation split is into 2 partials. And this will be shown like a one dislocation line.

Perfect dislocation line I can take it is we split it into 2 partials. And the shaded area is their stacking fault. And suppose we have a this is the burgers vector of this dislocation, if it split is into partial, it will have one burgers vector which may be in this direction, there may be an another burgers vector which maybe in this direction, the net product will give this burgers vector of the perfect dislocation, that I may not have drawn it correctly in the sense that perfectly, but I hope you understand what I mean.

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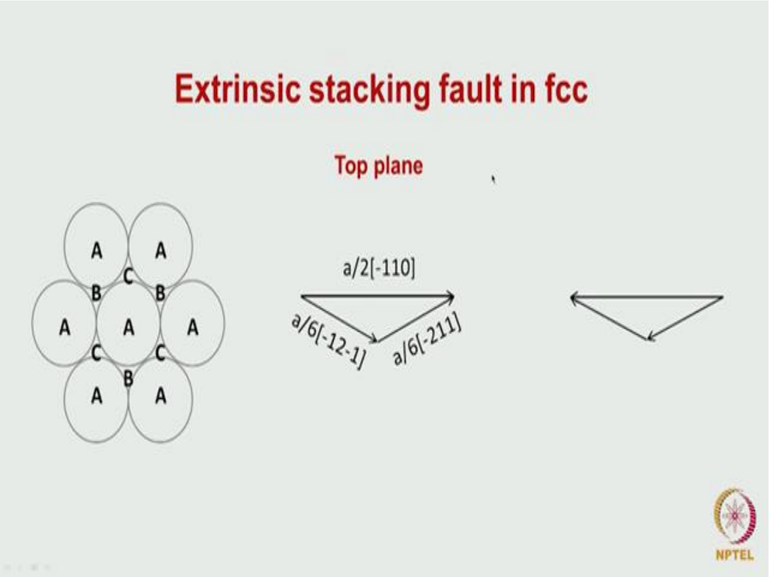

So far what we have considered is essentially a reaction which is intrinsic stacking fault. There is an another type of a stacking fault which is there, which we call it as the extrinsic stacking fault. Because the type of reaction which we considered was if A B atom is being shifted from here to this position, and then to this position which is energetically a favorable one. This type of reactions will occur under equilibrium conditions.

Suppose we have deforming a material we are putting a external energy. Then what it can happen is that we can try to since extra energy is being put into deforming the sample, it can move an atom from here to here or from here to here or to here to here. All these 3 are trying to move the atom to a high energy position correct. Or one more aspect also which one should understand is that once the plane has been decided, and we talk with respect to a dislocation movement to create a stacking fault, the movement from here to here easily generates a stacking fault a movement from here to here is not equivalent because it takes to A position which is not a C position, goes takes it to A position which is an A position this is because this is not a perfect translation vector. A perfect translation vector will shift an atom from one position to an identical position by the movement of the dislocation. Whereas, a partial translation vector in one way moves it to A position which is not equivalent, but correspond to another one, but the opposite direction both of them require different type of energies correct.

So here also we can write a reaction of the type. It can move from here to here. And then from here to this position if you move it or from here to here and from here to here it is essentially equivalent to moving it, but requires a very high energy correct.

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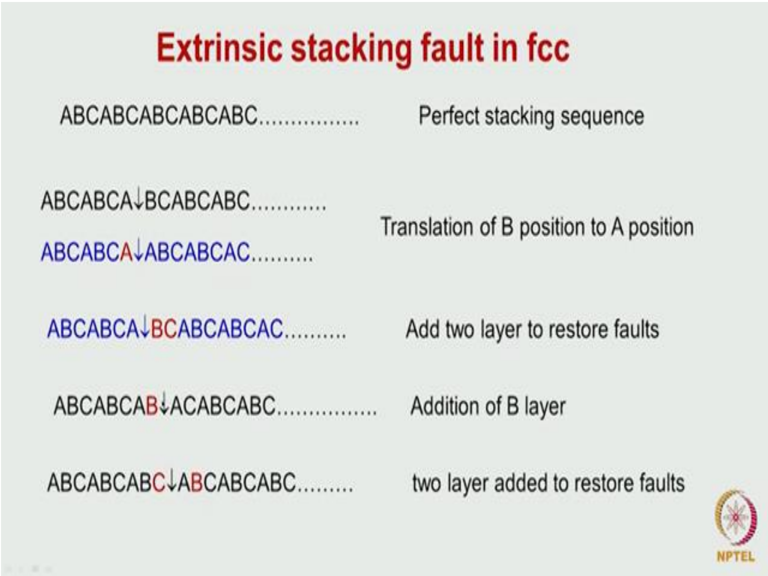

Let us look at what is the type of a stacking sequence which will be required. Like the way we consider for intrinsic stacking sequence this is a perfect stacking sequence where no fault is introduced. Suppose I move it what we have done it is we had moved B by a movement of a partial to from B position to an A position. So on a atom and another is sitting on a atom; that means, this is also a type of a simple cubic lattice which it has generated by moving it from one position to an or a simple hexagonal lattice it will generate, because it moves from all atoms from A to an another A position correct. But suppose I wanted to restore the order in this.

What I have to do? I have to add 2 more layers then only the order can be restored correct. That means that the burgers vector; that means, that movement of partials on 2 layers have to be generated to restore order. That we can consider it here that will come back a little bit later. Another is that in this perfect ordered lattice, if assume that between B and C, I introduce an another layer A layer. If I introduce a A layer what happens now. It has become A B C A B C A B A C A B A C this type of a stacking sequence comes. This is the type of stacking sequence which is generated correct by adding one layer. To know whether this is equivalent to this, to restore order in this type of a stacking sequence, here again I have to add 2 layers, but these 2 layers are added at 2 different positions. Here one C layer and adjacent one there another B layer which is added. So essentially either in this case or in this case both the cases addition of 2 layers is required to restore order.

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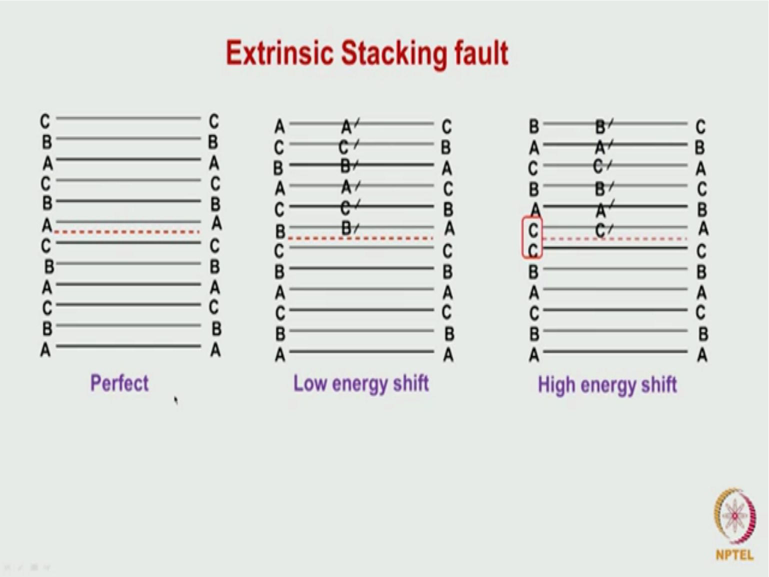

So the fault vector turns out to be different here. So the same stacking sequence which we talked about with respect to a stacking sequence. We are now looking at it in a different way, that is the stacking of the different layers are being shown, with respect to this particular position layer. Suppose we move an A atom from here to this position B position. Then we create A B B C. This type of a stacking sequence comes this is what it generates an intrinsic stacking fault correct. And if I consider here, the stacking sequence here, what I have done it is instead of moving it from A to B the next case which we considered it is moving from a to C we have done it; that means, that this atom C positions are coming on top of each other. So this is a high energy shift correct.

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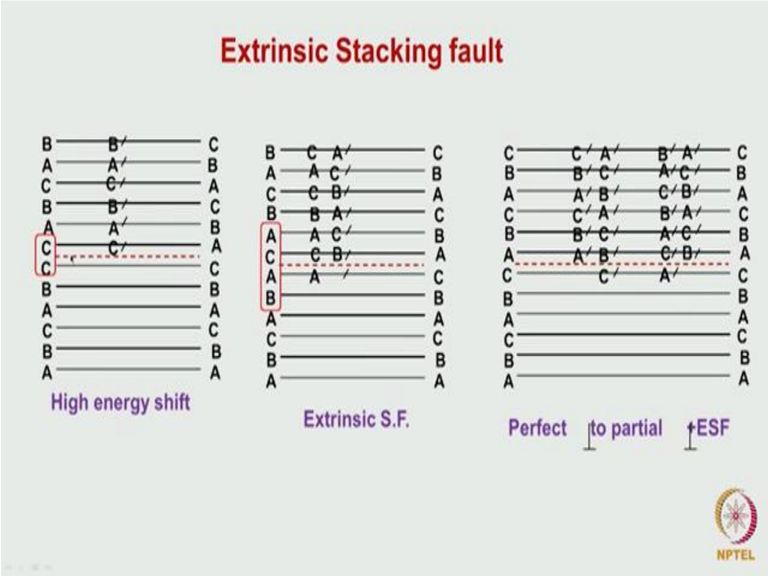

Let us look at this high energy shift is being introduced. By suppose this this dislocation create a intrinsic stacking fault, what we have done it is we have used an another dislocation a by 6 112 bar is the dislocation which has which is in the opposite direction which has created this atom coming one on top of the other, correct. So after introducing this shift here, suppose in the layer which is just below we again introduce another stacking fault. Because we have seen that and different layers by moving atoms from one position to another position, we can create a stacking fault we create an intrinsic stacking fault.

By the movement of this atom from C to A position when we do it, all the atoms above this also will be moved from this B position to a C position. This which has been moved from C it will now move to A position. This is how they will move correct. This movement finally, leads to a stacking sequence A B C A B A C A B like that. So in this if we consider the stacking sequence become A C A B type of a stacking sequence. Earlier the stacking sequence which we consider in intrinsic case is a A B A B type of a stacking sequence. Here the stacking sequence has become A B A C type of a stacking sequence.

So but what we have done? We have generated one stacking fault, A layer above the slip plane another is layer below the slip plane another intrinsic type of a stacking fault which has been created by doing. So we have generated that change the stacking sequence to A

B A C type of a because A B A C type of a stacking sequence also in HCP type of a structure, but what one should consider it is that; that means, that 2 vectors which we have introduced.

One vector which has moved from B to C A not the vector which has moved from C to A, right. In that below layer, these 2 burgers vectors if you take it with B to C and C to a, and the net sum of a will be equivalent to a movement which gives from a. To C type of a stacking movement you understand that. So essentially what we have done it is that, we have made shuffling of atoms or movement of atoms on 2 layers have been implemented by 2 partials.

And the net effect of that with respect to this layer if we consider it is moving the atom from A layer to a C layer. This is how exactly it happens. Because the way we can consider, it is in this if we add if you wanted to remove the stacking sequence we have to add A B layer right and another A layer has to be added. Here also if you have to do it similar thing which has to considerate that is, 2 layers have to be adder at a A layer and A B layer has to be added correct. So if you look at it both of them are identical, but this high energy fault could be introduced by making movements on 2 layers, that is if you do movement of partials on 2 layers that always requires higher energy then making a movement in a single layer. So this requires a high energy.

And because of that generally the intrinsic stacking faults have got a stacking fault energy which is normally double that of an extrinsic stacking fault has got an energy which is double that of the intrinsic stacking fault energy roughly one and a half times to 2 times that is what essentially it will be.

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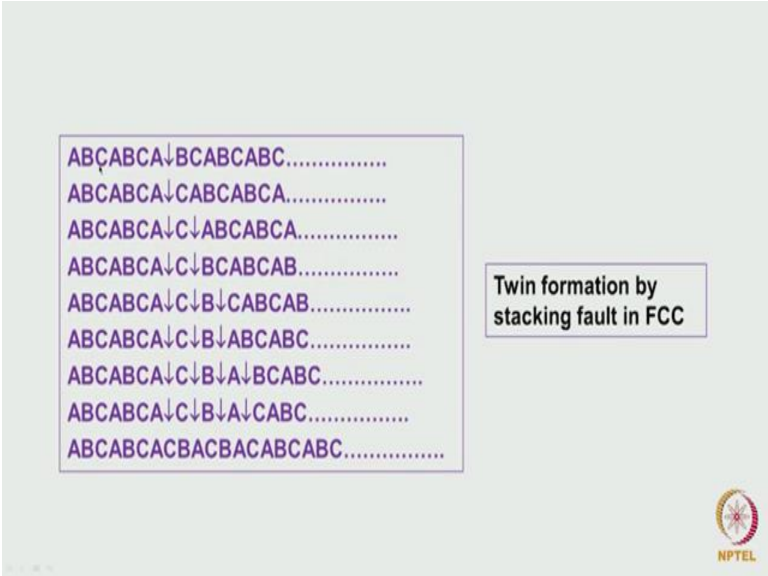

We will talk about this faults in detail in the next class. Before that one more case which we have to consider, it is that if we introduce an intrinsic stacking faults successively on every layer. Here A B layer is changed to a C layer, that is how this a C this then this A layer is now changed to an another layer. So it goes into A B layer. Then this layer is again changed to another layer successively, we are introducing stacking faults in each of this layer. Then we will see that A B C A B C type of a stacking sequence here it changes to A B C, then C B a right. So the stacking sequence reverses, when the stacking sequence is reversed which is a mirror reflection of each other, then we say it is a twin which has formed. So by introducing intrinsic stacking fault by the same type of a partial burgers vector on every plane, we can generate a nuclei of a twin is it clear.

So considering what we have done. So far in this class we have considered different types of stacking sequences. We have considered in other way on a on 111 plane. And we should understand that that priority is that there are 2 positions are there on every layer which are energetically identical, that is why we are able to generate these faults in a similar type of a situation happens in the case of a close packed plane. That is basal plane in the case of HCP material also. We generate stacking faults layer not in all materials, we will be generating stacking faults.

So far we have considered the various ways in which the intrinsic and the extrinsic type of stacking fault could be generated. One of the problem which one has to understand here is that the type of reaction which I have written here in this expression if you look at it. I can put this as the first terms and this as the second term. It does not make much of a sense, but when you look with respect to the atomic arrangement that makes a lot of sense to decide which direction which way the reaction will proceed, correct.

So every time one cannot draw a picture of the atomic plane and which direction atom will move, it becomes very difficult. So for this purpose to work on this only a notation which has been used to represent the movement of different dislocations is followed is called as a Thompson tetrahedral. That make the life simpler and it immediately tells that which will be the leading partial which will be the trailing partial these things we can understand.

We will talk about this in the later class. We will stop here now.