Solid State Physics
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Lecture – 03
Structure of Solid

So, electro static force or potential energy between 2 atoms that we have seen in last class, that basically holds the atoms in solids.

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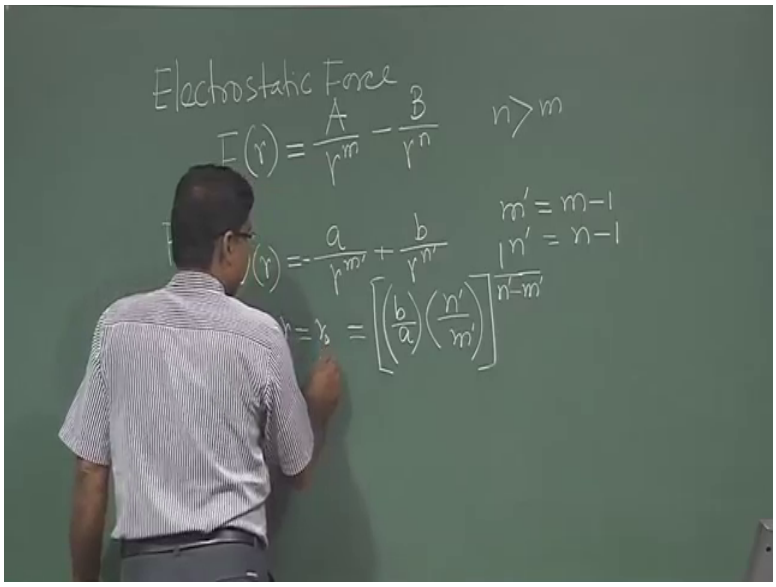

So, that electrostatic force F as a function r, the distance between 2 atoms that we have written in last class. So, A by r to the power m minus B by r to the power n, where n is greater than m and corresponding potential energy U as a function of r, a by r to the power m dash this minus here plus b by r to the power n dash; in last class that dash was missing. So, basically m dash equal to m minus1 and n dash equal to n minus 1.

So, this now this small a b m dash n dash is another constant, that characteristic constant of atoms. So, this the potential energy it will be minimum for a particular value of r equal to r 0, that we have seen in last class and that has come out the b by a n dash by m dash. So, dash was missing in last class. So, one has to put dash to the power 1 by n dash minus m dash n dash.

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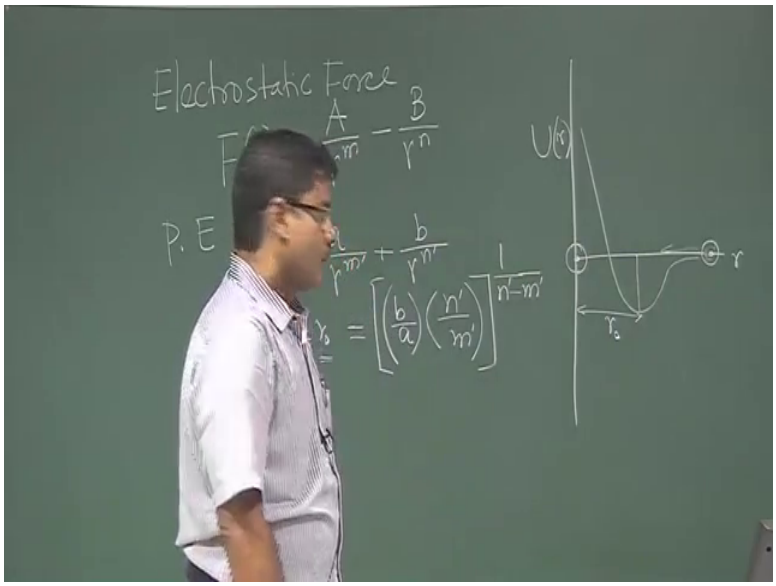

So, this is the equilibrium distance between atoms in a solid and that equilibrium distance depends on the on the atoms a b m dash n dash, these are the constant characteristic constants for atom and we have plotted earlier. I think I have to, so y axis is potential energy and x axis is basically r. So, if we think that one atom is here and another atom moving towards this atom.

So, basically r is changing and because of change of r the potential energy will change. So, this change we have seen this axis x like this. So, for a particular value of r so this r 0 but potential energy is minimum, when atoms are in a solid the inter atomic distance will be r 0; so that the energy of the system will be minimum so that nature prefers. So, always natures try to minimise the energy of a system.

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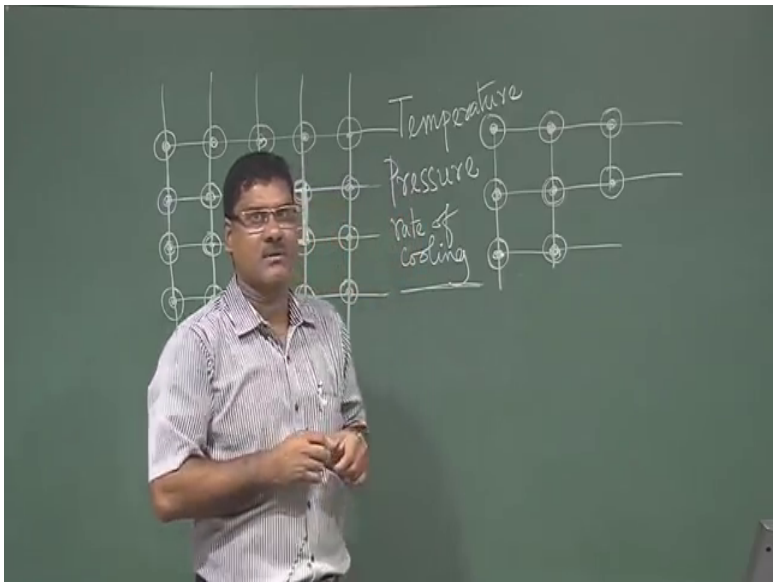

So, thus the atoms in a crystal or solid, they will arrange keeping some distance. So, next atom will come here. So, this way atom will be placed in solid or solid forms adding the atom itself in the solid this way. So, this other side also say will sit like this. So, similar way one can so arrangement of atoms will continue like this. So, atoms will arrange in solid keeping their inter atomic distance equivalent distance r 0.

Now, these are is 2 dimensional pictures. So, in other way also other side also other direction. So, atom will follow the same way; so one can get the 3 dimensional arrangements of atoms in solid. So, if you see this picture, so here one can identify a pattern unit say like this and this same structure can be produced just repetition of this unit. So, that is why it is we tell; it is call it as pattern unit. So, atoms are arranged orderly in solids and then it will have a pattern unit, then the repetition of the pattern units will give the same structure of the solid.

So, if I pick up if I know the pattern unit of a crystal structure and now if I repeat this pattern unit, so then we can get the same structure of that crystal. So, pattern unit say now I know the pattern unit of this crystal structure, is this so now just repeat this1 in all direction right. So, then you will get the same structure as just we have put the atoms following the equilibrium distance minimum energy. So, whatever the structure we got, the same structure; we will get if we repeat the unit pattern in space.

So, this way this atoms are arranged in a solid because this order structure is preferable by nature because of minimum potential energy, but it is not the always case sometimes this it violates because of the external environmental condition, like temperature pressure; say rate of cooling rate of cooling or heating during formation of the crystal. So, so these external parameters external in environment affects the crystal structure.

So, thus atoms assembled and form a solid. So, mainly 2 types of solid structure wise, 2 types of solids are found one is crystalline structure of solid.

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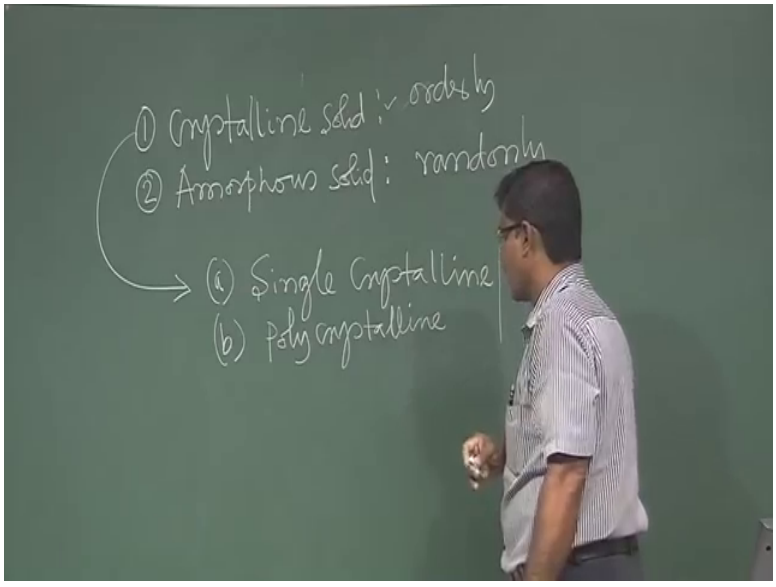

One is crystalline structure or crystalline solid; another is amorphous solid. So, in nature whatever this solids we found most of them are under this group crystalline solid, but there are some materials which are amorphous say this for example, this glass is a amorphous solid. So, what is amorphous and what is crystalline solid let us define. So, crystalline solid is basically, atoms are arranged orderly in the solid. So, that then it is crystalline solid, when atoms are not arranged orderly; they are arranged randomly in the solid then it will be called the amorphous solid.

So, basically here atoms are arranged randomly in solid. So, this crystalline solid, again it is 2 type, one is single crystalline solid and another is polycrystalline solid. So, both are crystalline; that means atoms are arranged orderly in the solid. So, difference between these 2 are basically it is single crystalline; it is a long range ordering of the

atoms in the solid and this is polycrystalline this is basically short range, ordering of the atoms in the solid.

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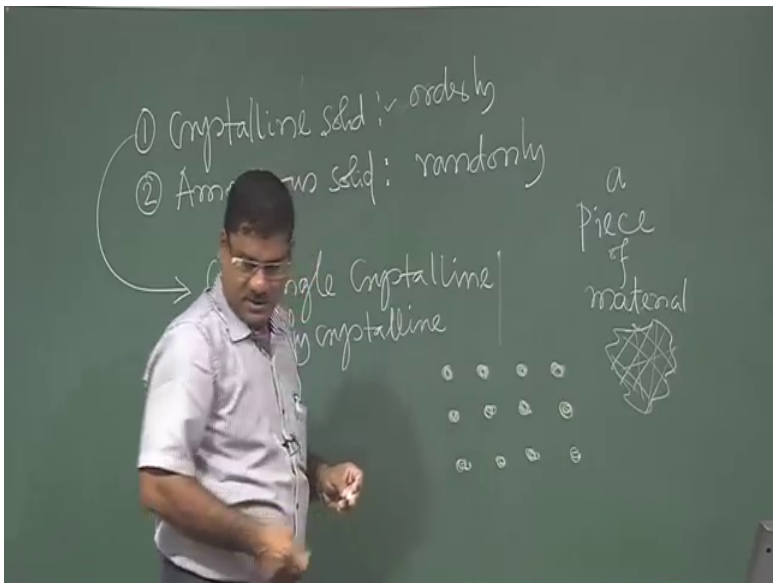

So, what is that? so when throughout if you take a piece of material, now in this piece of material if atoms are arranged in same manner, atoms are arranged orderly in same manner throughout the material; then it is called single crystalline solid. But during the arrangement of the atoms in the solid, if sometimes interruptions are there it is if arrangements are interrupted. So, then it will not be single crystalline it is called polycrystalline.

So, basically if I just atoms arranging like this throughout the material. So, it is single crystalline, but what happens during this arrangement if after some distance if it is interrupted means it is not continuing in same way.

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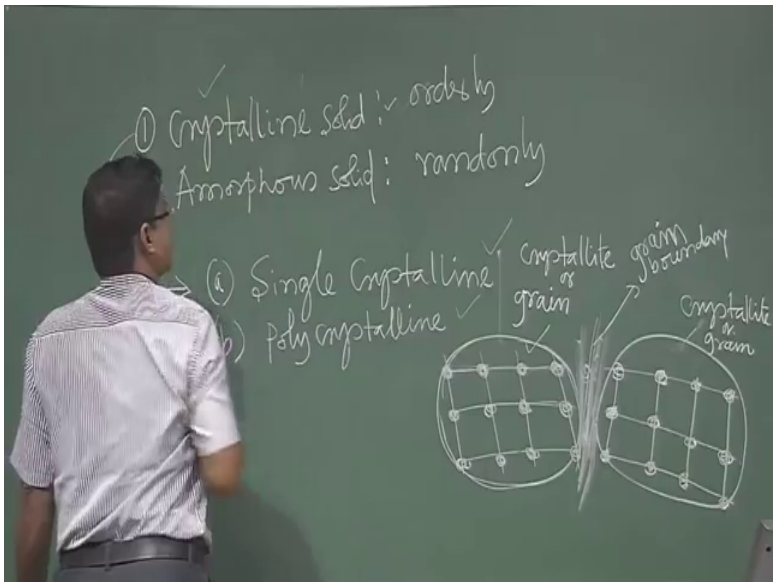

So then it just here that interruption is there because of interruption. So, this now it is again ordered arrangement is ordered, but what is the difference you can see here say. So, this same arrangement is there, but there is a interruption at some places. So, is not continuing in same way so then this and their atomic arrangement are same but just we can this is as if here the just orientation is changed slightly.

So, in this region same way it is arranged in this region also same it is arranged, but just change of orientation at this at this boundary. So, this region they are they are called basically grain or crystallite; this also crystallite or grain and between these 2 grains there is a boundary so these called grain boundary. So, basically this in polycrystalline solid will find many grains are arranged with grain boundaries and the same solid can be seen in crystalline when this interruption is not there.

So, there will not be any grain boundary. So, this grains; this other grain they will have the same orientation. So, as if they are continuing the arrangement in same way. So, single crystalline it is a say the arrangement of the atoms in a longer region and poly crystalline it is basically arrangement of the atoms orderly in a small region. So, that is why it is a; I told that this single crystal this long region order and the ploy crystalline is basically short range order of the atoms. So, we will concentrate our discussion on this crystalline solid and basically the single crystalline solid.

So, if we take a piece of material and want to know the structure of that material, that is our interest we want to learn the structure of the of that material, means how atoms are arranged in that material that we want to find out we want to learn.

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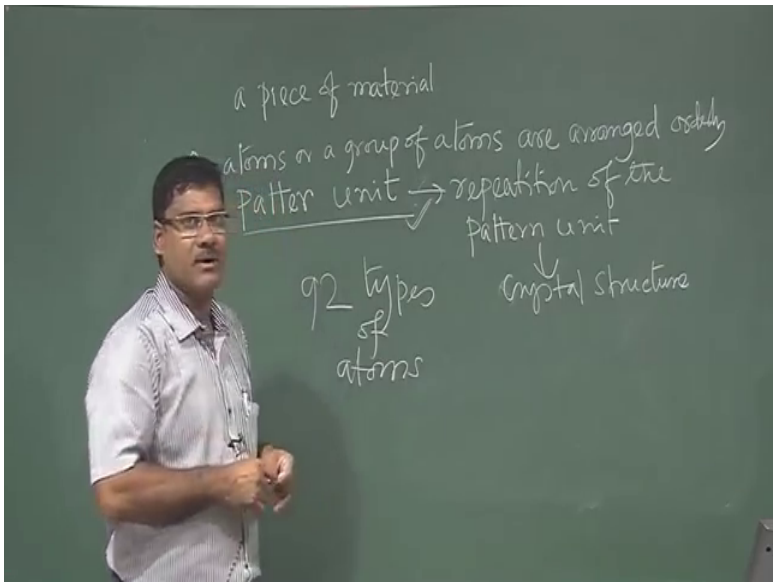

So, a piece of material crystalline material single crystalline material; means what we know that atoms or a group of atoms are arranged orderly in this piece of material. So, that is known that we defined as a single crystalline solid. So Secondly what we want to find out that, we already we have discussed that in this material one can find out the pattern unit, see it is single crystalline atoms are arranged orderly so it will have a pattern unit.

So, as I told or we have seen that if we know the pattern unit of a crystal, then basically we know everything about the structure of that crystal because pattern unit in contains all information's about the crystal and repetition of the pattern unit is basically forms the crystal structure, forms the crystal structure right. So, to study the crystal structure of a material basically we will study the pattern unit of that material.

So, this pattern unit of that material that we have to find out; now question is how many materials exists in the universe, answer is thousands and thousands materials exists in this world, in this classroom itself we can see many solid materials chair, table, window, computer, plug board, dusters everything are solid material. if you go just outside of this classroom you will see car train bus road building glass window etc and in dining table

also we use salt right. So, these all are solids and many many solids exist around us. So, now question is this pattern unit of each solid, will be different or it will be same for all materials.

So, if it different, it cannot be same for all materials that is obvious, now whether for each material this pattern unit are different or there are some limit in number of this pattern unit. So, answer is similar to the number of atoms as we discussed earlier that only 92 types of atoms forms all matters thousands and thousands, millions and millions matters exists in world, but all are made of 92 types of atoms. Similarly the crystal structure of materials they have few numbers of pattern unit and using this basic pattern unit one can get all sorts of solid materials, just changing the atoms or group of atoms which will give different names of materials. So, in next class we will we learn about the pattern units; how many pattern units are required to describe the structure of all materials.

Thank you very much.