Introduction to Materials Science and Engineering
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Lecture – 129
Grain growth

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The final stage of annealing is the grain growth. We the first stage is recovery, second recrystallization and it is followed by grain growth.

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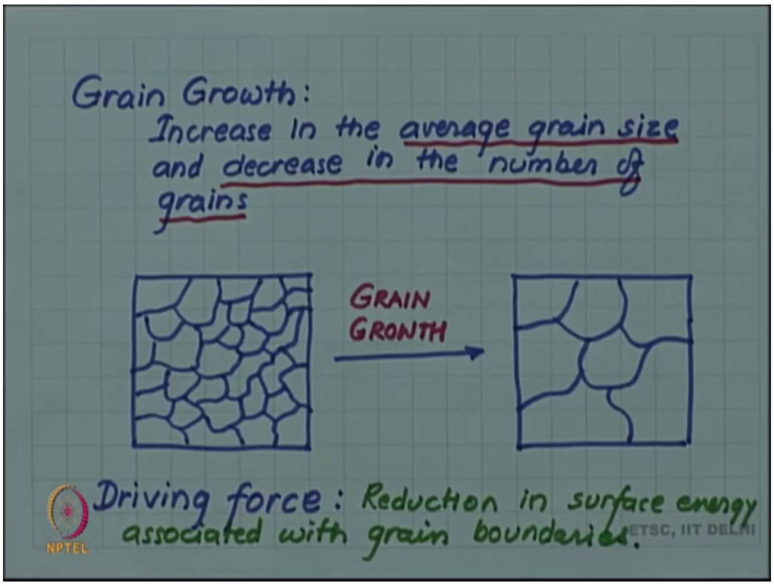

So, grain growth as the name suggest is increase in the average grain size and this obviously, since the total volume of the material is constant will lead to decrease in the number of grains. So, you can see here a fixed volume of material with a fine grain microstructure when is undergoing annealing and after recrystallization.

So, the grains will increase and this step is called the grain growth grain size is increasing, but since the total volume of the material is constant the number of grain because same volume is now divided into smaller number of grains to have larger grain size. So, it is obvious that the driving force for such a process is the reduction in the grain boundary surface energy. So, the driving force is a reduction in surface energy associated with grain boundaries let us try to do a simple calculation related to this. So, let us say that the initial grain size.

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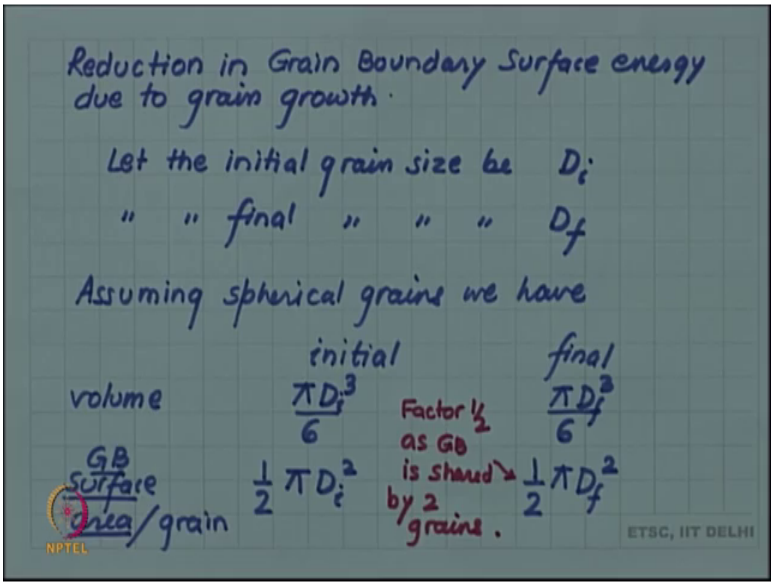

So, we are trying to calculate reduction in grain boundary surface energy due to grain growth. So, let the initial grain size be let the initial grain size be D initial D i; and let the final grain size after grain growth be D f.

Now, assuming spherical grains for simplicity of calculation; so, assuming a spiracle grains, we have let us say volume grain boundary surface area initial final. So, the volume will be pi D i cube by 6 will be pi D f cube by 6 and the surface area will be pi D i square pi D f square, but remember that we are talking of grain boundary surface area and this will be area of one grain, but each grain boundary is being shared by two grains. So, grain boundary surface area per grain will be half of this.

So, the factor half is coming factor half as grain boundary is shared by two grains. So, now, we can calculate the surface area per unit volume grain boundary surface area per unit volume.

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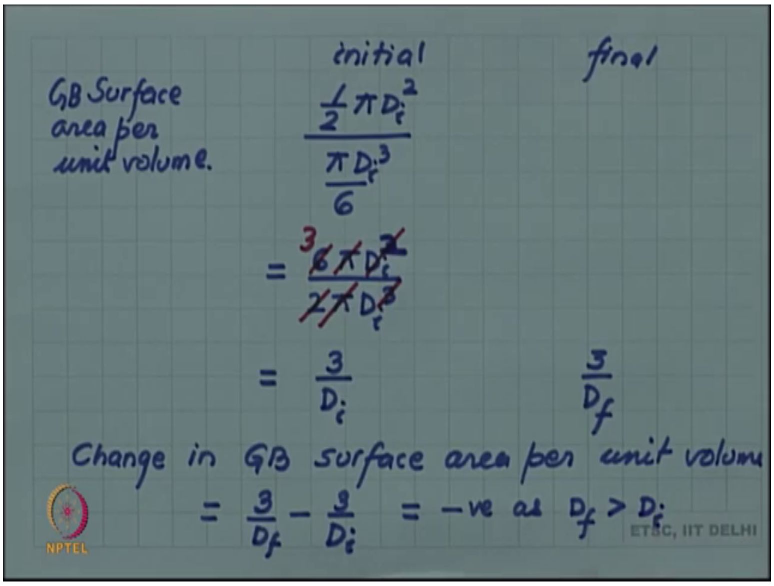

So, we have the grain boundary area is half pi D i square and the volume is pi D i cube by 6. So, this will give you 6 pi D i cube, but 2 pi where 6 pi D i square and 2 pi D i cube cancel pi D square will cancel and you will have 3 here. So, you will get a nice simple formula of 3 by D i similarly, in the final case, you will have 3 by D f. So, the change in grain boundary surface area per unit volume will be 3 by D f minus 3 by D i and you can see that this is negative as D f is more than D i.

So, there is a reduction there is a reduction in surface area associated with this reduction, there is a reduction in grain boundary energy per unit volume.

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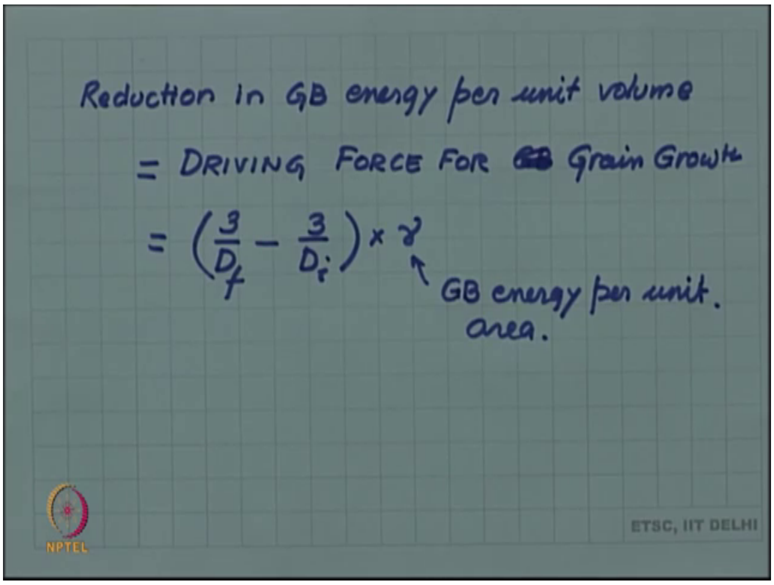

And this is what is the driving force for grain growth 3 by D f 3 by D i times gamma where gamma is grain boundary energy per unit area. So, this is what in the way, we can approximately calculated of course, recall that our assumption was of a spherical grains and spherical grains, of course, we will touch each other only at a point. So, this assumption itself is not correct, but an order of magnitude estimate can be found using average grain diameters using a calculation like this.