Nanotechnology in Agriculture
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Lecture-12
Detailed Physical Techniques-II

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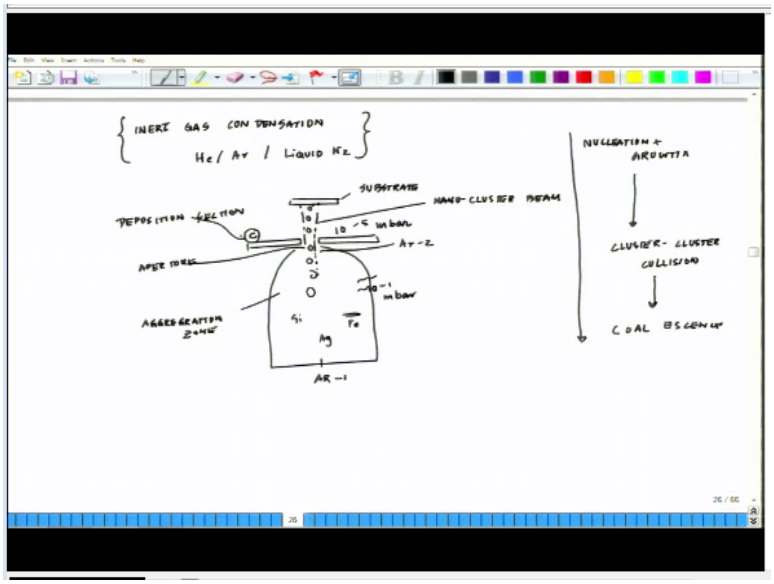

Now moving on to this line what we are having next is, so we talked about the inert gas condensation, now from here we move onto physical vapour deposition. Physical vapour deposition is again is a collective set of processes commonly used for so.

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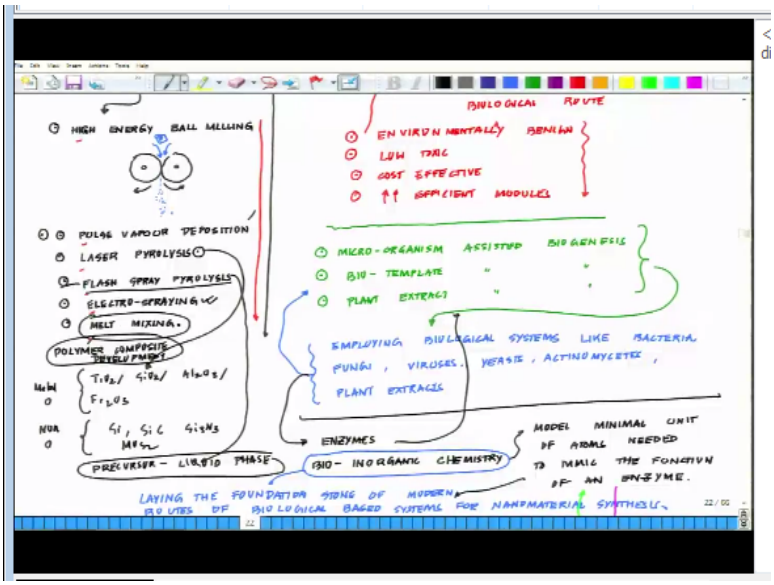

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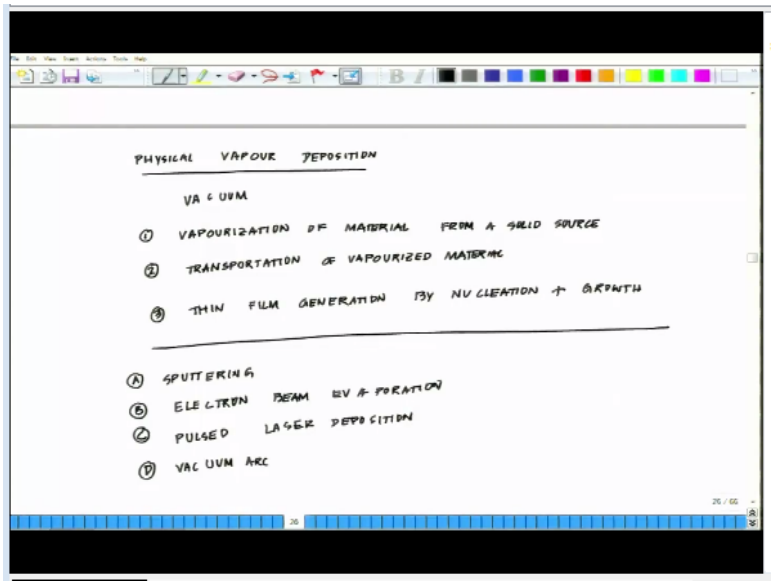

Physical vapour deposition, so physical vapour deposition is a collective set of processes commonly used for producing nano material and to deposit thin layer of material typically in the range of few nanometer to several micron meter. So you see here that whole deposition on the substrate is what is happening, so basically what you are doing if I had to understand this whole technique. So you are creating a vapour phase and, so you are the material.

You are creating a vapour phase and you are depositing the vapour on top of a substrate. So, again in order to take something into the vapour phase requires a significant amount of energy and then you place it on the substrate. So, you are forming layer or thin films on the substrate

and these are some of the techniques which are pretty extensively used in the electronic industry and all other manufacturing industries okay.

So, coming to the physical vapour deposition, so what you are doing is which is also called PVD is an environmental friendly vacuum deposition technique consisting of 3 fundamental step. So, you realize that you need conditions of vacuum in such situation. And this is the first thing is vapourization of the material from a solid source this is step1, step 2 is transportation of vaporize material.

This is step 2 and the third step is nucleation and growth to generate thin films. So the whole area of thin films, thin film generation by nucleation and growth. So the whole area of thin film generation is dependent on this kind of physical vapour deposition. The most commonly use PVD methods are sputtering followed by it could be electron beam evaporation and you might wonder why I am highlighting this technique.

Because if you do appreciate the biological roots of synthesis that realize how much complex these processes are, how much energy intensive and instrument intensive these processor. Pulse laser deposition and then will be needing vacuum or so this is what I was talking to you, pulse vapour depositions. So these are some of the ways by which physical vapour deposition works okay sputtering is a vacuum based PVD process which is often used to deposit films of nano material.

And a sputtering works on the principle of momentum transfer in which the atoms from the target which is made up of the material to be deposited at ejected by the ion bombardment. The deposition of material by sputtering can be achieved using DC pulse or direct current pulse, pulse DC or radio frequency as I told you that you can use all these kind of energies.

And the plasma of the natural glass commonly argon is generated between 2 electrode by the collision of electron to the gaseous molecules. Ions present in the plasma are the accelerated towards the target by applying potential between the 2 electrodes. And these ions with

appropriate energy thus hit the target leading to the ejection of the material from the target. So, it is something like if you follow this picture okay.

And ejected material are the transported and deposited onto the substrate, say basically making them travel through this nano slit are the aperture and getting them deposited okay. And there are 2 advantages they led to higher deposition rate and prevent target over hitting and damage, so this is what essentially the sputtering is all about similarly you have electron beam evaporation EBE technique okay EBE are electron beam evaporation is a vacuum based again all these are vacuum based PVD process pulse vapour deposition process or physical vapour deposition process which is used to fabricate the thin films of nano materials.

And EBE system consist of vacuum unit electron beam source and target material again you see you have a vacuum unit out here as I showed you aggregation zone which is vacuum unit than you have electrons source. And then you have a deposition ground, so the weight works is very simple electron beam hits the target and hit the target material. The target material atoms evaporates when temperature which is above its boiling point.

And evaporated material then transported condensed on the substrate and the advantage is again high deposition rate and can be used to deposit material ranging from conducting to insulating and unlike thermal evaporation electron beam evaporation can be used to deposit material of high boiling point. So you realizing that all these techniques if I talk about all the physical forces I told you in the very beginning.

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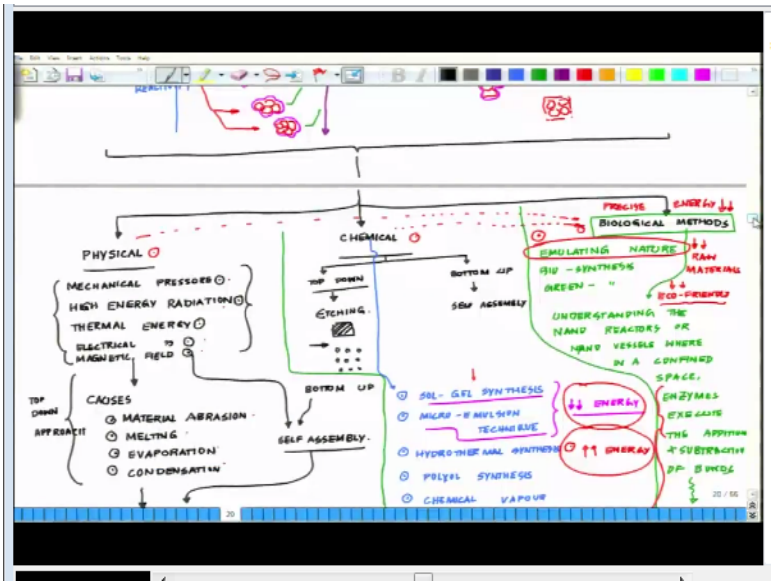

It could be mechanical, it could be high energy radiation, it could be thermal, it could be electrical, it could be magnetic.

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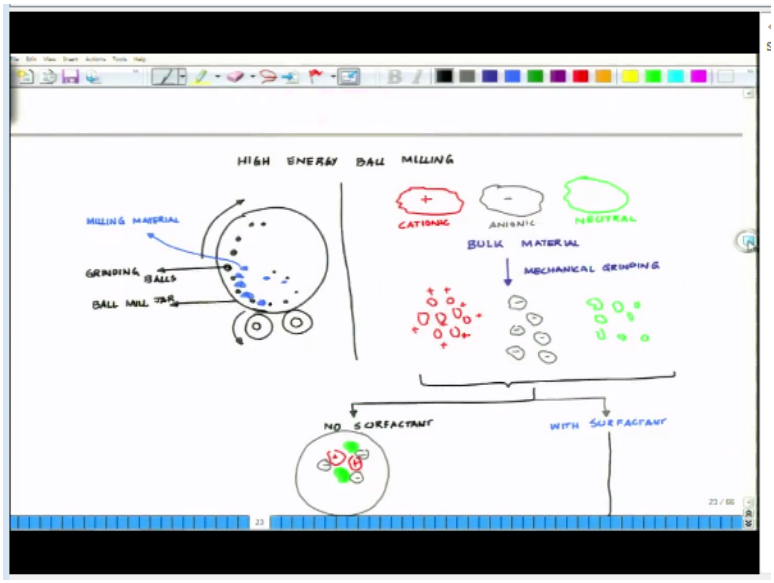

So using all these forces, so in other word, if you logically brakes down the whole thing what is happening is you have this bulk material and you are using all these different physical forces on this bulk material.

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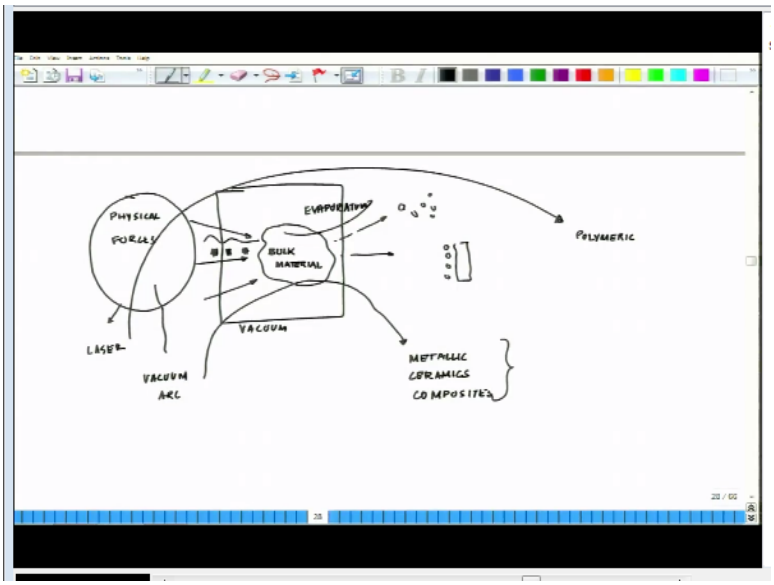

Here is your bulk material these are the physical forces and you are applying the physical forces and most of the situation in vacuum situation and you making thin films by depositing them. And all sorts of different kind of things what you are achieving by using these techniques, so then we talk about the laser ablation or pulse laser deposition. Laser ablation methods utilizes high power laser beam.

So, again here the physical forces is now laser okay and laser ablation method utilizing the high power laser beam that evaporates the particle from a solid particles. So, from the solid material, so from here the evaporation is happening because of the laser beam it is a high energy laser. So, in normal laser ablation process the laser can either be continuous laser or pulse laser. You could have a continuous source of laser or you can pulse it depending on what kind of evaporation pattern you want.

So laser ablation offers flexible approach in the production of micro and nanostructure of polymeric materials. So if you have to work with the polymers what will the talking about while talking about the applications. So, there will be lot of such applications of laser and laser assisted or laser ablation technique or pulse laser deposition techniques okay. Then we talk about the vacuum arc or vacuum based PVD process in which the arc is used to vaporize the materials.

So, you are using as a physical force you are using a vacuum arc which is again a very high energy process and using the vacuum arc. You are ablating the material in which the arc is used to vaporize the material from for the synthesis of metallic ceramic and composite nano materials and films okay. So vacuum arc uses for metallic, ceramics, composites, whereas laser is used for polymeric and many other of course one of the areas is polymeric materials okay.

Then you have laser pyrolysis, the laser pyrolysis technique is again vapour base synthesis process. This method can be used to synthesis wide vacuum nano material like titanium oxide, silicon oxide, aluminium oxide, iron oxide like you know tio2, sio2. So you have following up where I told you, so this is what we have talking about laser pyrolysis and laser pyrolysis could be used for synthesis of Tio2, sio2, Al2 O3, F2o3.

And there are series of other oxides and non-oxides like, so these are all the metal oxides and among the non-oxides you are having silicon, silicon carbide, silicon nitride, molybdenum sulphide. There is series of things which you could produce using laser pyrolysis in this process the resultant condensable product or generate from the laser induce chemical reaction at the interface of the laser beam.

And the molecular flow up gaseous vapour phase reactants okay. So, again the logic is the same you are using different kind of high energy processes to generate these kind of nano materials similarly you are having flame spray pyrolysis which is flame or flashes by pyrolysis which is the latest of all the flame arrows old technologies. It is one step combustion process where the precursor is in the liquid form.

So, realized for this kind of things you have to have the precursor in the liquid phase that is very essential your precursor is in the liquid phase. It is a one step combustion process where the precursor is in the liquid form with significantly higher combustion enthalpy that is more than 50% of the total energy of combustion usually it is an organic solvent. The important technological element of this process include self sustaining flame usage of liquid feeds and less volatile precursor.

And it has very high scalability high temperature flame and large temperature gradient. So, these are some of the techniques some of the prerequisites for flame spray pyrolysis oaky. The same line your next things come is the electro spraying techniques which is this technique. Electro spraying is the techniques similar to electro spinning. But it differs in the type of material to be produce, so electro spraying is basically done is for synthesis of nano material where as electro spinning is being done for developing different kind of fibers.

So, lot of fibers nano fiber rest materials especially the polymer fibers are being used or which are being used are produced by electro spinning technique. But electro spraying on the country is that which is logically pretty much similar it uses it is used for nano material mostly nano particle synthesis okay. So coming back to the electro spraying techniques what we are talking about, so your electro spraying is basically the electro spraying method is based on electro mechanical device in which mixture of solution.

So, its semi-liquid phase containing the selected polymer and the solvent is taken up by a syringe and high voltages applied to the capillarity that results in the production of charge droplets okay. The solvent is evaporated on it is a way to the counter electrode. And particle or fiber are then collected at the n product, the electro spraying technique provides goes flexibility and control of the surface parameters.

And electro spraying is one pretty neat process to produce nano particles, so then last of this lot is melt mixing. So, melt mixing is essentially a method involve mechanical mixing of a polymer with modified nano colors by extrusion or needing and less commonly by injection molding techniques okay. This is one of the oldest method to design polymer composites with nano particles, so, this is used for mostly the polymer composite development.

And one of the oldest techniques available okay, this is one of the oldest methods to design polymer composites with nano particle as a pellet which he design material characteristics. This is most commonly used mechanical process because it is friendly and it is also well suited for current industrial practices. So over all this is what we needed to understand about the physical

methods of synthesis of nano material which find applications for high energy synthesis using physical forces as I have already mentioned.

So, here you have the bulk material which here is the bulk material which is exposed to this kind of different kind of forces which are enlisted here. And the process what happen is this mechanical material abrasion melting evaporation condensation and this leads to the nano structure formation. So, keep this key in mind, so most of these techniques if you realize these are top down approach big material you are bringing down smaller sizes okay.

So, next what we will do I will close in here next we will talk about the chemical and the biological mode of synthesis, thank you.