Nanotechnology in Agriculture
Prof. Mainak Das
Biological Sciences and Bioengineering and Design Programme
Indian Institute of Technology-Kanpur

Lecture-15
Basic Characterisation Techniques of Nanomaterials

Continue with your basic understanding of nanotechnology, as of now we have talked about the basic geometry as well as the classification of nanomaterial based on their chemical nature. Apart from it we have talked about the 3 major synthesis route including the physical route, the chemical route and the biological route which is based on templates. And using different kind of enzymes available from biological systems, today we will be talking about the basic characterization of the nanomaterials.

So, in terms of the characterization, the characterization could be classified into 2 broad categories. One set of characterization includes the understand them the geometry of the nanoparticles other one includes understanding the surface properties of nanomaterial or surface chemical properties of nanomaterials okay. So, I will give you an overview of all the techniques and based on that you should be able to judge or you should be able be in a position to decide what kind of technique you will be needing.

And what is the purpose that is going to solve by using that particular technique or what is the question which could be answered by using that particular technique. So, coming to the slides where we started this.

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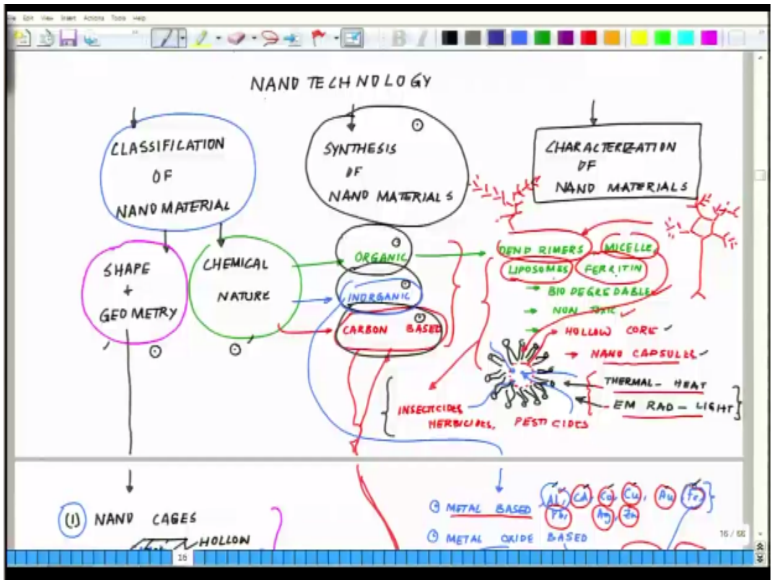

So, here when we started talking about nano technology we decided that we will talking about the classification of nanomaterials based on shape and geometry based on their chemical nature having organic, inorganic or carbon based. Then we talked about the synthesis where we talked about physical, chemical and biological basis and here this is the segment what we are going to talk now characterization of nanomaterials okay.

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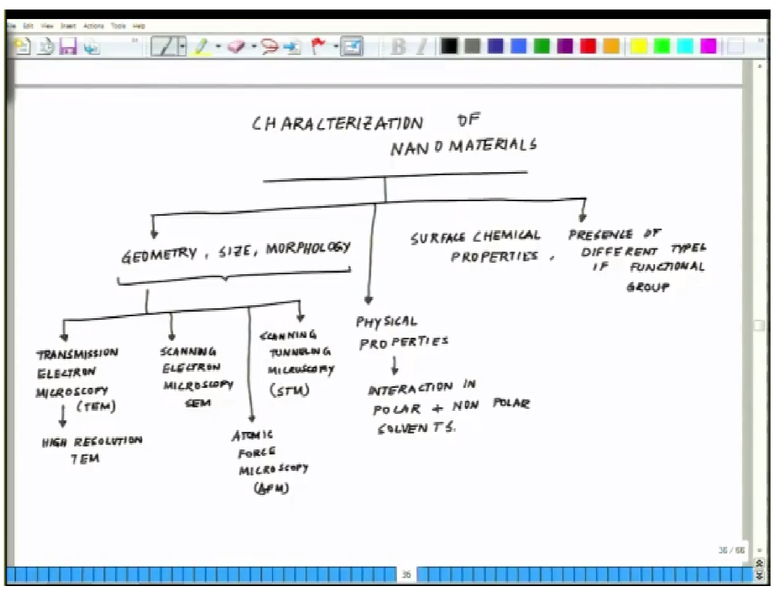

So, as I mention the characterization could be separated in 2 categories, 1 is characterizing the geometry, size and also we can call it morphology whereas the other set of characterization includes your surface chemical properties. I use the word surface chemical because when we talk about nanomaterials we talk about dimension which is maybe 1 atom or 2 atom thick.

So, it is almost the surface what you are studying, so it is not a bulk, so that is why it say the surface chemical properties and presence of different types of functional group okay. Apart from it at time we do use whenever we make thin films of nanomaterials or a layering of nanomaterial. We study their water interaction properties, so we can put another category here some of the physical properties okay, in terms of their interaction in polar and non polar solvents okay.

Now when we talk about the geometry, size or morphology we basically a stress a bond the microscopic techniques and here we are no more in a position to use optical microscopy. So, we are entirely dependent on the electron microscopy. So, the electron microscopy tools what are being used for understanding the geometry, size or morphology includes transmission electron microscopy, scanning electron microscopy.

So let us enumerate so we have transmission electron microscopy and sometime we go at a high resolution in short you can call it TEM, high resolution TEM and you have scanning electron microscopy which is SEM short. Then you have atomic force microscopy AFM and then you have scanning tunneling microscopy which is called STM. These are the 4 different microscopic techniques which are being utilized to understand the geometry, size and morphology of a different kind of nanomaterials.

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So, when you talk about transmission electron microscopy to start of it okay, so when you talk about TEM or high resolution TEM, HR sometime it is called HR TEM high resolution TEM say for example this is your material. This is the geometry of the material which is there in front of you and say these are nanoparticles okay. And this is what you are wanted to study in a high resolution TEM, so what will happen you will shoot the electron beam.

So, when you shoot the electron beam, so if get obstructed here some of the beams will move like this, some like this, like this, like this and on the back you are having a on a pleat where you are imaging it what you are going to observe is wherever the electron would not able to pass in which a shadow there out there. And wherever the electron will pass you will see a different kind of contrast which I am showing in yellow.

So based on this we should be able to figure out, so you are having the particles now I am showing in orange, so you are having the particle then you can see the dimension of the particle. And this is how the electron is getting transmitted and this is what we call as transmission electron microscopy, so you are allowing the electron to pass through those beams which are getting collided with the particle is unable to reach to the plate.

And that is where you see a contrast of on the screen okay, so this is what you get from HR TEM image and you really can go round where resolution 1 nano meter or less. And it is 1 powerful technique to study the particle size and the pattern of the arrangement. But what it does not do those do photography they may realize it would not give you the 3 dimensional feeling to come as a 2 dimensional picture on a screen.

Because in order to get a 3 dimensional feeling you needed a slightly different way of throwing the beam on your sample. So, when we talk about getting a 3 dimensional view we move onto the next technique which is called scanning electron microscopy. So, what you do here, so out here you shoot the beam and with the certain energy okay, some x amount of energy with which electron volt you are shooting the beam. Now what you do, so in here again you are having a sample same situation.

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Now will be talking about the second technique which is your sorry which is your scanning electron microscopy okay, out here what you are going to do.

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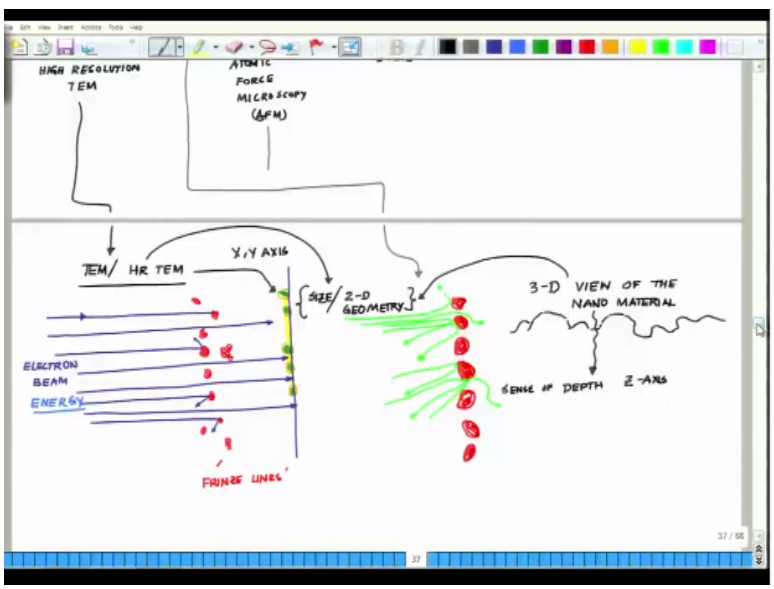

So, here is your sample, these are area of atom sitting out there and 1 more thing you forget to mention is when you do TEM or transmission electron depending on the kind of particle out here. You may be able to see the surface of the particle with the electron density pattern which we call as the frinze lines you can observe this in a pictures when if you see a transmission electron microscopy picture with there is see the frinze lines.

So, now coming back where I was on the scanning electron microscopy, so now here is your sample. Now you throw the beam in a way now here electron beam you are throwing the beam in such a way scanning through the substrate you are not throwing the beam at a very high energy, you are throwing the beam electron beam at a lower energy. And what you see you are almost the beam is scanning through the surface something like this.

Say for example I have to get a 3 dimensional topography of the substrate, so something like this. So eventually what you are going to get is a very neat 3 dimensional profiles observe in the black I am right doing the 3 dimensional view of the substrate or the nanomaterial. So, what you are going to get in a picture will be a much more 3 dimensional view of the concern nanomaterial.

In other word when we deal with scanning electron microscopy we are getting a depth sense or sense of depth or z-axis. Here we mostly get x and y axis in the TEM whereas when we talk about a SEM we get a sense of depth and the third axis. But when we do a SEM where we are shooting the electron beam at a lower energy level we lose upon some of the resolutions and that is why the particle size depredation using SEM at times can be little tricky.

So these 2 techniques on one hand when we talk about the SEM, SEM will give you a very good approximation of the size really really good approximation of the size. And 2 dimensional geometry will be perfect the way it will going to give you, whereas when we talk about the SEM we get a 3 dimensional view of the particle. So, you see the techniques compliment to each other, they help each other to build up the story of things which cannot be seen so easily cannot seen through light microscopy.

And that is where we say the different techniques compliment to each other, tell you a story which is never told before in the history of mankind.

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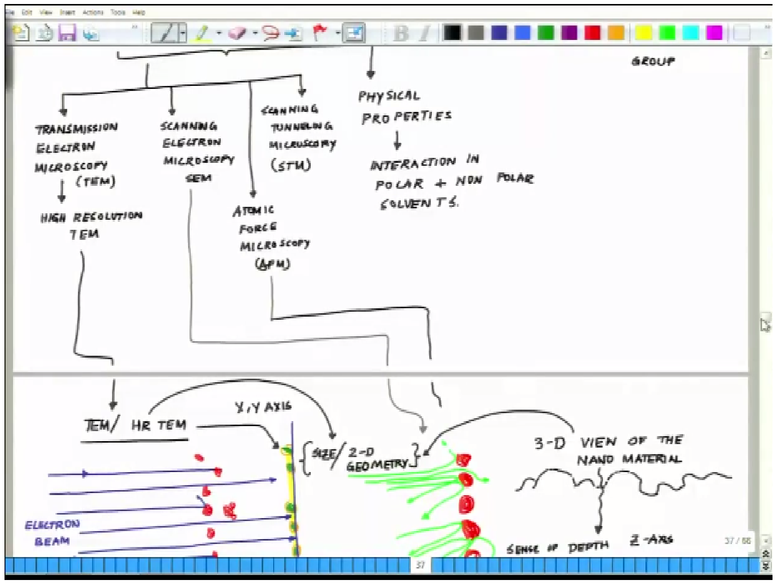

So, in the next technique in the same line is called atomic force microscopy. So, this is again a very interesting bit of innovation of mankind.

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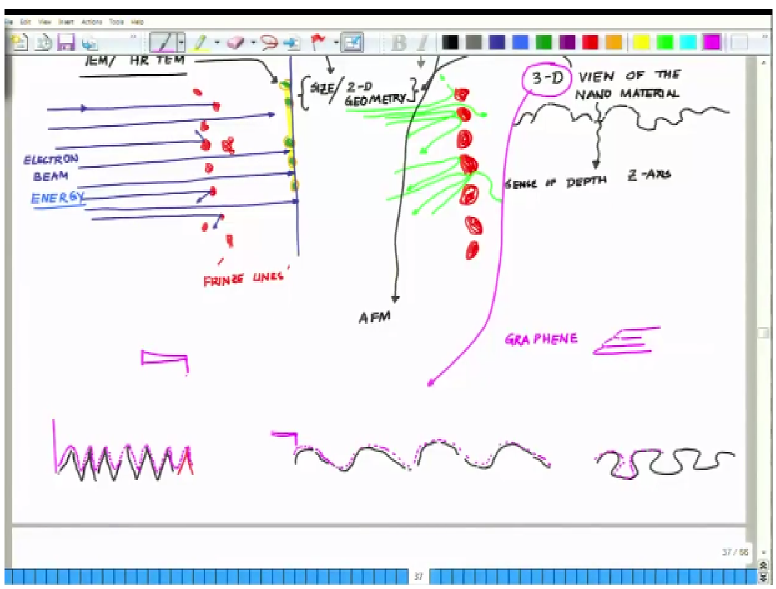

The way it works AFM, so AFM is one beautiful surface characterization technique say for example I have a surface like this drawing the surface a pattern depth surface or a surface like this. If you see the distinct feature of the 2 surfaces or surface like this what I do I take a probe like this, just imagine a probe which can really travel through it. So, this probe is travelling on the surface like this, it stopping on the surface and it is moving.

And this probe is a microcantilever it something like this and this step is travelling like this. And based on it is travel you start mapping the substrate or say for example this step is now is travelling and you can do it in multiple ways I am just giving a very simplistic view of AFM something like this. So, this could be done in 2 ways keep it fixed or you can tap it okay. So, this is the third very powerful technique where you should be able to see another aspect which partly we observe using a scanning electron microscopy is a 3 dimensional aspect.

Or say for example if you see a picture of say graphene which is essentially a 2D material but you know at times you may have multiple layer of graphene stack together. So, you should be able to see a if you see a AFM picture you see a color profile telling you how many layers of graphene is stacked. So that is the power of this technique, this technique can give you at times or the particles aggregated.

If they are aggregated then it should be able to tell you that you know this is kind of change in depth which is happening in a layer. That means these are multiple layers and it is able to kind of scam through it very neatly it is prove. So, this is s cantilever base technique you can call it on molecular cantilever base technique which complement your scanning electron microscopy, transmission electron microscopy and AFM.

So, whenever you pick up any journal paper or any work you have to do to realize that a reviewer is going to ask you that how the AFM picture looks, how the TEM picture looks, how the SEM picture looks. Based on that they build up the story that how it is going to you know shape up what kind of particle are we seeing what is the nature of the particle and how possibly the particle may be interacting okay.

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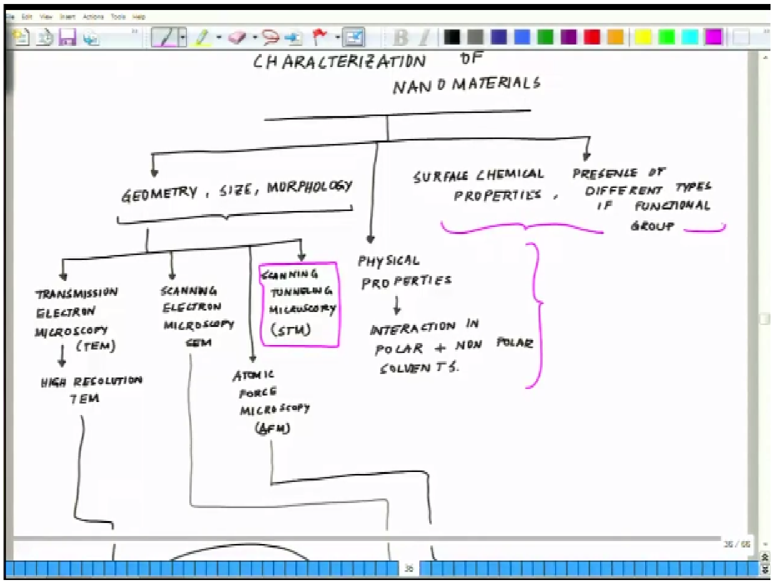

So, these are the 3 basic techniques and the fourth one in the line is scanning tunneling microscopy which a lead for guys to exploit which is in the same line of atomic force and if you look the scanning tunneling you will be able to figure out what scanning tunneling microscopy is all about. I will leave it for you guys as an assignment to see what is the scanning tunneling microscopy.

From here we will move on to the physical properties and physical properties the techniques to understand a physical properties and the surface chemical properties and presence of different functional groups, thank you.