Surface Engineering of Nanomaterials
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Lecture - 17
Functional Coatings

Hello, in this particular chapter, we are going to discuss about the different types of functional coatings, what we are adopting for the betterment of the surface engineering. So, before going to start, we have to know that what are the different types of functional coatings or maybe what is the definition of these functional coatings by which we are changing the material properties. The term functional coatings, describes system other than the classical properties of a coating maybe decorations or protections.

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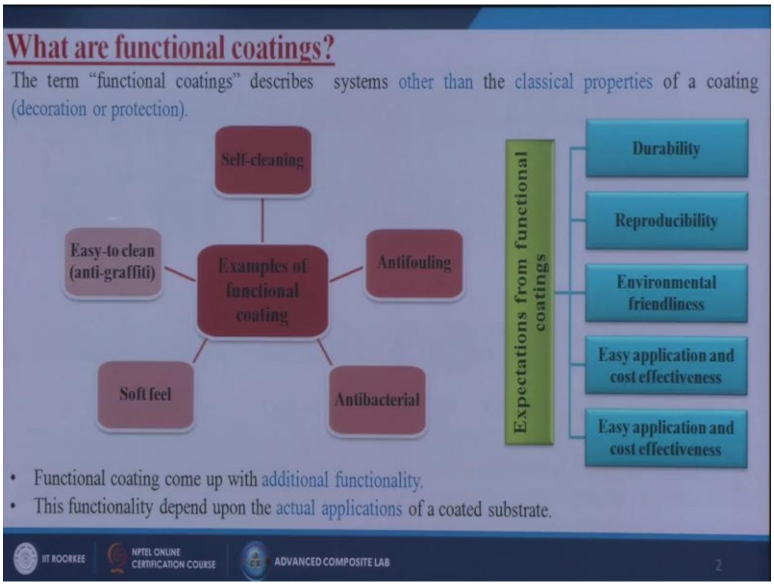

Sometimes we are doing some kind of coatings for the ornamental purpose. So simple, we are changing the outside aesthetic properties of that particular material so that it can maybe looks good, maybe it can glitters and sometimes, we are putting some kind of coatings for the safety purposes so that it cannot direct; not directly interact with the environment or maybe that water moisture, water molecules or maybe the moisture inside the environment or maybe some kind of acidic or maybe the basic conditions. But here just to widely spread here, we are doing some kind of coatings which is more than this kind of coatings or maybe the techniques.

First one is that there are several types of functional coatings are available by which we can change the material properties like easy to clean anti graffiti properties, self cleaning anti fouling properties, antibacterial applications, soft feel, but these all types of coatings will come into our future slides or maybe in our future lecture. So, here what is the expectation from these kinds of functional coatings? Actually what we want? Why we are doing this kind of coatings? So, first is called the durability then is the reproducibility, environmental friendliness, easy applications and cost effectiveness; easy application and cost effectiveness. So these all are the 5 properties, rather we can say these all are the main 5 properties for which we are doing this kind of functional coatings, but if we go for; if we see that these kind of functional coatings having numerous advantages or maybe the applications.

Functional coatings come up with additional functionality, these functionality depend upon the actual applications of a coated substrate. So, these all are the applications by which we can do these kinds of functional coatings.

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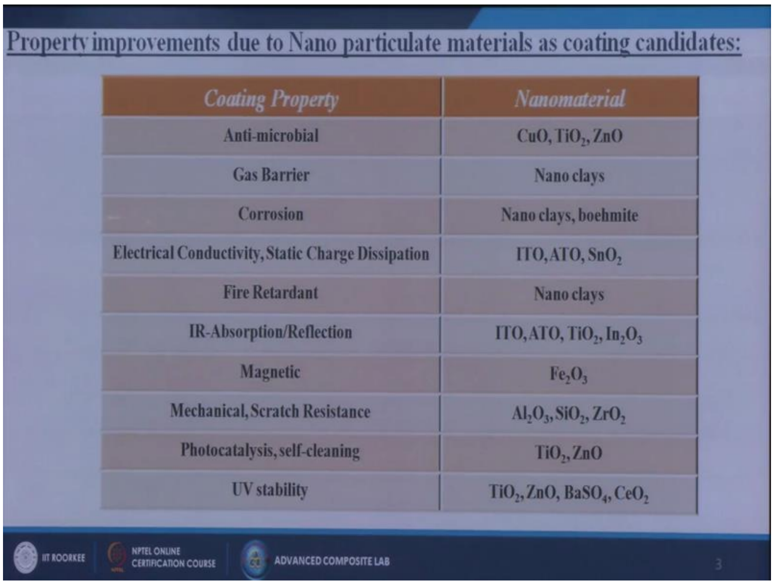
Property improvements due to Nano particulate materials as coating candidates:

Coating Property	Nanomaterial
Anti-microbial	CuO, TiO_2, ZnO
Gas Barrier	Nano clays
Corrosion	Nano clays, boehmite
Electrical Conductivity, Static Charge Dissipation	ITO, ATO, SnO_2
Fire Retardant	Nano clays
IR-Absorption/Reflection	ITO, ATO, TiO_2, In_2O_3
Magnetic	Fe_2O_3
Mechanical, Scratch Resistance	Al_2O_3, SiO_2, ZrO_2
Photocatalysis, self-cleaning	TiO_2, ZnO
UV stability	TiO_2, ZnO, $BaSO_4$, CeO_2

Here, we are trying to show you the different properties and for getting this kind of properties, what type of material we can take or maybe what kind of nanomaterials we can take for doing this kind of functional coatings. So, if we want to increase the antimicrobial properties of our materials, we can take the copper oxide, titanium dioxide, zinc oxide materials or maybe the nanomaterials. If we want to increase the gas barrier properties, we can use several types of nano clays, nano clays is nothing but the clays into the nano form, then we are increase; if we are trying to increase the corrosion properties, we can use different kind of nano clays or maybe the boehmite electrical conductivity and static charge dissipations, we can use the indium tin oxides, then antimony doped tin oxide or may be that tin oxide.

Then fire retardant materials we can use, some kind of nano clays, nano particles, IR-absorption, reflections we can use ITO, ATO, TIO 2, indium oxide, magnetic properties we can use the Fe 2 O 3, mechanical, scratch resistance we can use Al 2 O 3, SIO 2, zirconium oxide, photocatalysis, self-cleaning properties, TiO 2, zinc oxide, UV stability we can use TiO 2, zinc oxide, Ba barium sulfate or maybe that CeO 2. There are several types of materials. From this particular chart, we can see that if we use this kind of materials so this kind of properties maybe changed for that particular substrate or maybe that material.

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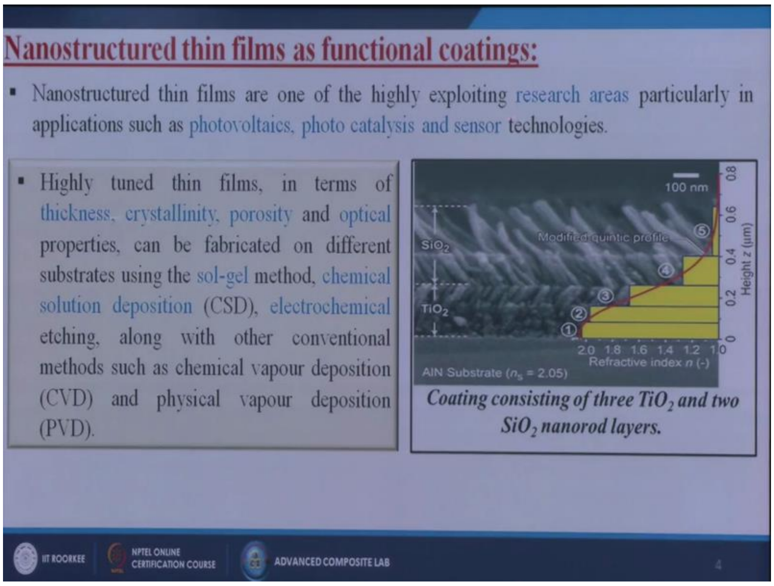

Now, we are going to discuss one by one, first one is called the nanostructure thin films as functional coatings. So, nanostructure thin films are one of the highly exploiting research areas, particularly in applications such as photovoltaics, photo catalysis and the sensor technologies. So, these all are the applications, where we can use this kind of materials like photovoltaics, properties 5 photo catalysis, some sensor applications for some devices, we can change this kind of or maybe we can get this kind of properties.

So, highly tuned thin films in terms of thickness, crystallinity, porosity and optical properties can be fabricated on different substrates using the sol-gel method, chemical solution deposition method, electrochemical etching along with other conventional methods such as CVD; chemical vapor deposition process, physical vapor deposition process. So, these all are the process will come into detail in our later slides.

Here this one is the example. So, here we are taking a substrate of AIN on which we are giving a layer by layer technique of different materials, coatings of different materials like titanium dioxide, then silicon dioxide like these and from here you can see that what is the size of that particular layer into micrometer? So, coating consisting of three differ TiO 2 and two SiO 2 nanorod layers. So, it is a 1, 2 and 3, these 3 combined of TiO2, but having different layer, then we are using the silicon dioxide having 2 different layers.

Next is we are taking about the photoactive self cleaning fibers, this is also a one kind of technology by which we can change the material properties.

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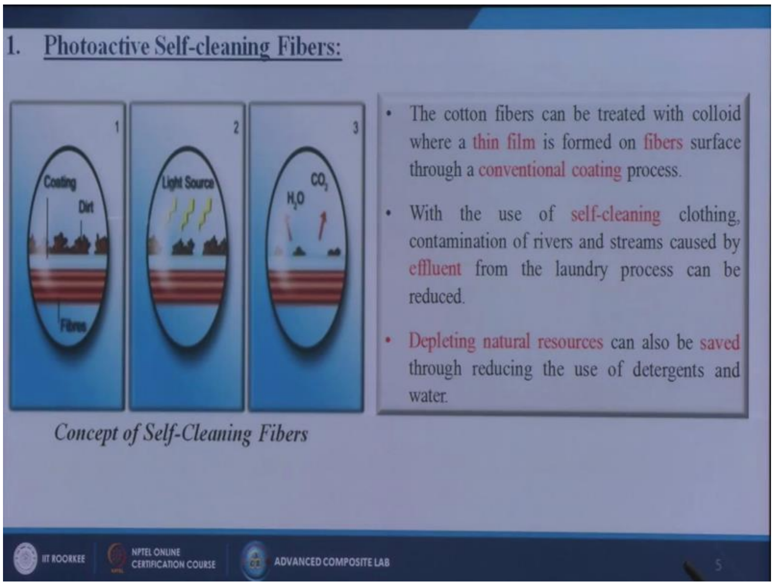

How we are doing it? The cotton fibers can be treated with colloid where a thin film is formed on fiber surface through a conventional coating process with the use of self cleaning clothing contamination of rivers and streams caused by effluent from the laundry process can be reduced depleting natural sources can also be saved through reducing the use of detergent and water.

Simple, we are using some kind of materials on to the top of the fibers so that the dirt particle or maybe the dust particle will not deposited onto our shirts or maybe onto our cloths so that we no need to clean that cloths for a longer time. So, here simply when this dirt particle is coming, light sources is coming then when the light is coming, they are reacting with the coating materials onto the cloth and then automatically they are destroying so that it is a self cleaning fibers, generally we are adopting for our cloths.

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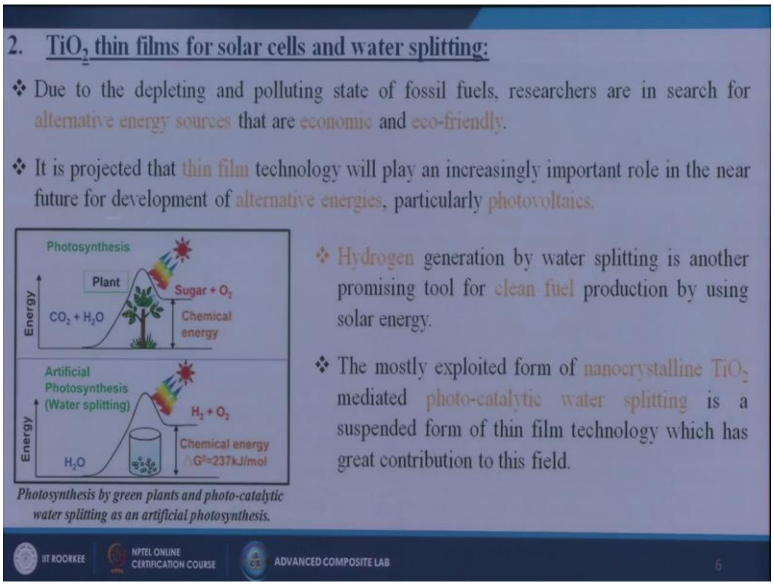

Next is that TiO 2 thin film for solar cells and water splitting, so, due to the depleting and polluting state of fossil fuels, researchers are in search for alternative energy source that are economic and eco friendly. It is projected that thin film technology will play and increasing important role in the near future for development of alternative energies particularly the photovoltaics applications.

Here generally we are using the TiO 2, generally we know that TiO 2 can be obtained into different form. So, one particular form of the TiO 2, we can use for the photovoltaic operation or maybe the solar cells because it is one kind of renewable energy. So, by which that we can generate the electricity from directly from the sun light without getting any kind of external sources or maybe that external energy sources.

Next hydrogen generation by water splitting is another promising tool for clean film production by using the solar energy. So, we are nowadays high and research is going on for the hydrogen storage and the hydrogen production. So, these hydrogen is generally we are using for the water splitting so that we can get the energy and that energy, we can use for our electrical purposes.

The mostly exploited form of nanocrystalline titanium dioxide mediated photo catalytic water splitting is a suspended form of thin film technology which has great distribution to this field. So, this is another advantage of using this kind of functional coatings by which we can change the material properties and we can use this kind of materials for different aspects.

Next we are using the titanium dioxide thin film for the water treatment. So, generally in this particular case, the anatase form of the T titanium dioxide we are using. So, we are using this titanium dioxide, we are putting into some dirty water. In which we are using certain kind of UV source or maybe the UV light by which these titanium dioxide is activated and in that titanium dioxide when it is getting the ans, then directly through this excited electrons, the oxygen of these titanium dioxide is getting activated then they are trapping the impurity inside the water.

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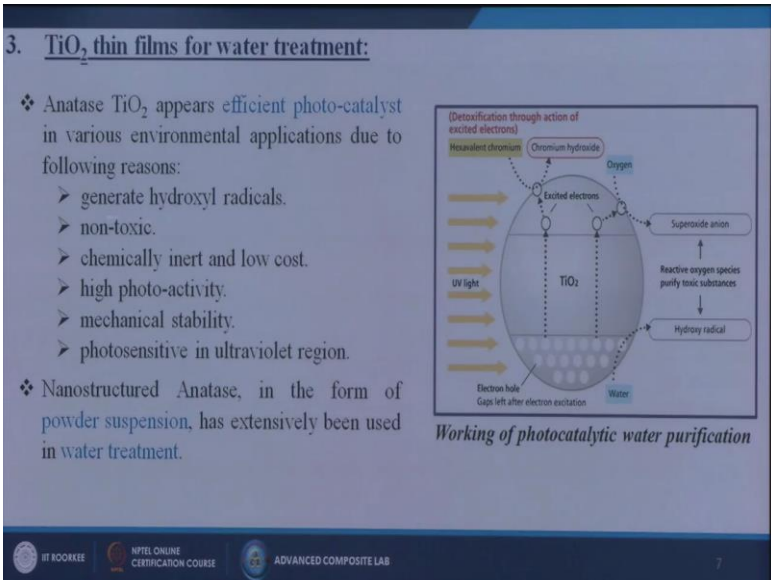

Then after that simply we are cleaning those water or maybe we are filtering those waters so that the dirt particles or maybe the dust particles will come out from the water and we can get the pure water in the form of a drinking water or maybe some other treatment. So, Anatase TiO 2 appears efficient photo catalyst in various environmental applications due to following reasons, generate hydroxyl radicals, non toxic, chemical inert and low cost, high photo-activity, mechanical stability, photosensitive in ultraviolet region. Nanostructured anatase in the form of powder suspension, has extremely used in the water treatment. As I already described that we are using this kind of titanium dioxide powder inside the water to trap the impurities from the water itself.

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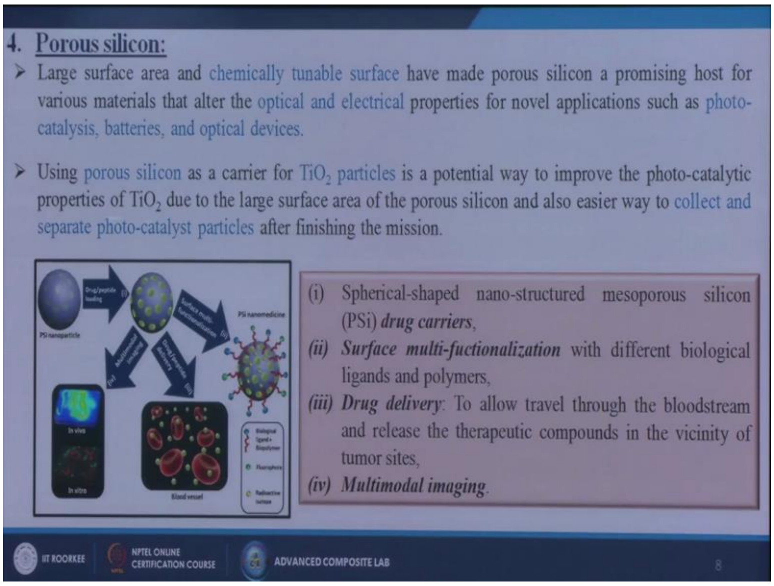

Next we are applying this kind of porous silicons for different applications. So, here the applications are like this large surface area and chemically tunable surface have made porous silicon promising host for various materials that alter the optical and electrical properties for novel applications such as photo-catalysis batteries and optical devices. So, just for the electronic devices or maybe some kind of optical properties, who we are using this kind of materials. Using porous silicon as a carrier for TiO 2, nano particles is a potential way to improve the photo catalytic properties of TiO 2 due to the large surface area of the porous silicon and also easier way to collect and separate photo catalyst particles after finishing the missions.

Here we are using several types of materials like spherical shape nanostructure mesoporous silicon for the drug carriers surface multi functionalization with different biological ligands and polymers drug delivery to allow travel through the bloodstream and release the therapeutic compounds in the vicinity of the tumor sites and the multimodal imaging.

So, from that particular thing we can understand that we are using this kind of materials for the biomedical applications like targeted drug delivery something that I am having some tumor in my hand or maybe in somewhere else. When we are putting this kind of materials; that materials directly go to the affected zone and it will heal those tumors or maybe some kind of unwanted things inside our body, it will not affect we any good sides in our body itself. So, here we are showing that different types of modifications by which we can do. So, like some kind of PSi nanoparticles for the drug peptide loading, then we are doing the surface multi functionalizations drug peptide delivery. So, for the black vessels so directly it will go to the effected side and it is reacting then some multimodal imaging, it is in vivo conditions, it is into the in vitro condition or maybe the in vitro conditions. There are several types of applications for this kind of nano functional coatings.

Next we are discussing about the nano composite coatings for controlling UV, IR and other radiations.

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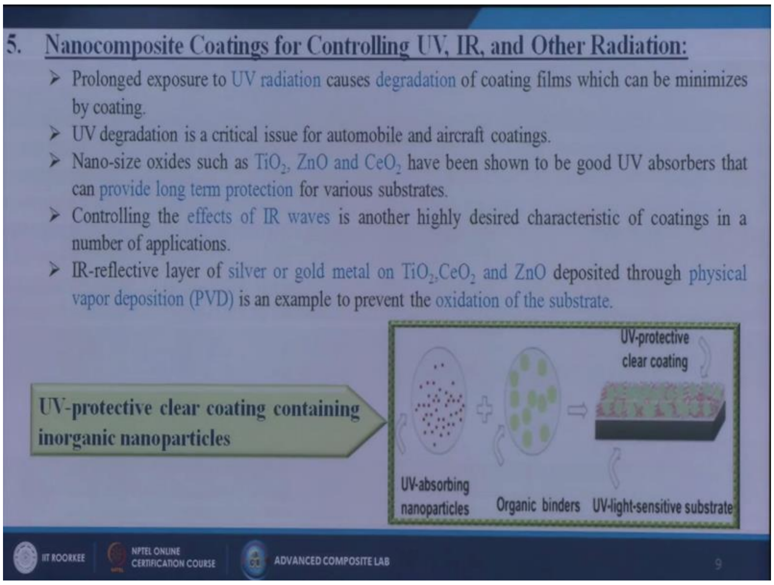

Just we are protecting our materials from this kind of ultraviolet ray or maybe that infra red or maybe some other radiations process. So, prolonged exposure to UV radiations causes degradation of coating films which can be minimizes by coating.

UV degradation is a critical issue for automobile and aircraft coatings nano size oxides such as titanium dioxide, zinc oxide and the CeO oxide have been shown to be good UV absorbers that can provide long term protection for various substances controlling the effects of IR waves is another highly desired characteristic of coatings in a number of applications, IR reflective layer of silver or gold metal on titanium dioxide CeO 2 and zinc oxide deposited through physical vapor deposition is an example to prevent the oxidation of the substrate.

These all are the different applications different materials by which we can adopt and we can change the material properties. So, here is an example where UV protective clear coating containing inorganic nanoparticles. So, UV absorbing nanoparticles then we are using some kind of organic binders then through that binders we are putting that coating on to the substrate itself so that it is making some UV light sensitive substrates which can attract the UV light.

Next we are using some kind of conductive coatings. So, from the name itself, we can understand that just to change the whole materials by changing the outer surface of that material, we are making that material from nonconductive to conductive one.

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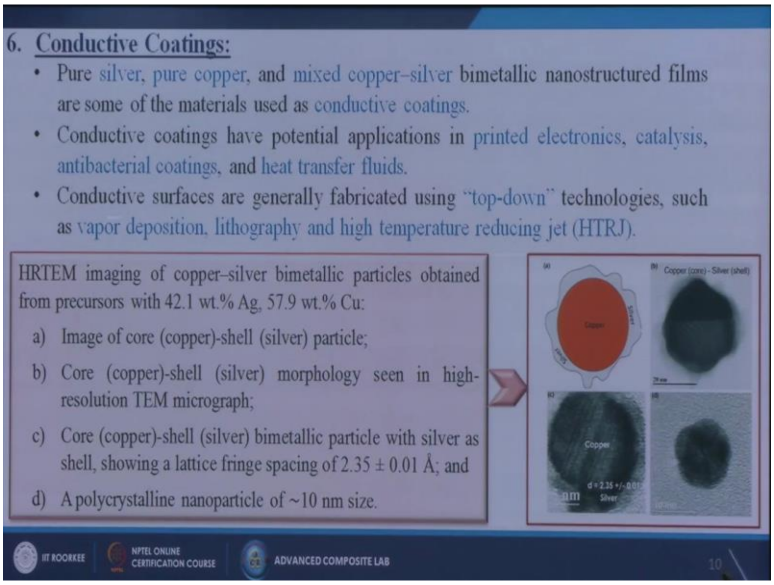

Pure silver, pure copper and mixed copper silver bimetallic nanostructure films are some of the materials used as conductive coatings.

Conductive coatings have potential applications in partial potential have potential applications in printed electronics catalysis antibacterial coating and heat transfer fluids conductive surface are generally fabricated using top down technologies such as vapor depositions lithography and high temperature reducing jet, in that particular case, actually we need the fillers which is having highly conductive, but without changing the total material properties just giving a coating on to that surface, we can change the material properties from the nonconductive to conductive one, here we are giving some kind of examples like we are having that copper materials on top of that we are giving a coating of the silver one. So, here the copper is the core and silver as a cell material, it is the high resolution transmission electroscopy microscope figure.

In that HRTEM imaging of copper silver bimetallic particles obtained from precursors with 42.1 percent of silver and rest is the 57.9 watt percent of copper, first one is that image of core copper shells silver particle, it is a schematic illustrations, b is nothing but the core copper and shell is the (Refer Time: 15:20) morphology seen in highly resolution TEM micrograph, c is nothing but the copper and bimetallic particle with silver as shell showing that lattice fringe spacing of 2.35 plus minus 0.01 angstrom and last one is that a polycrystalline nanoparticle of the 10 nanometer size by which just we are proving that silver is having a very good affinity and a good coating thickness onto the copper particles.

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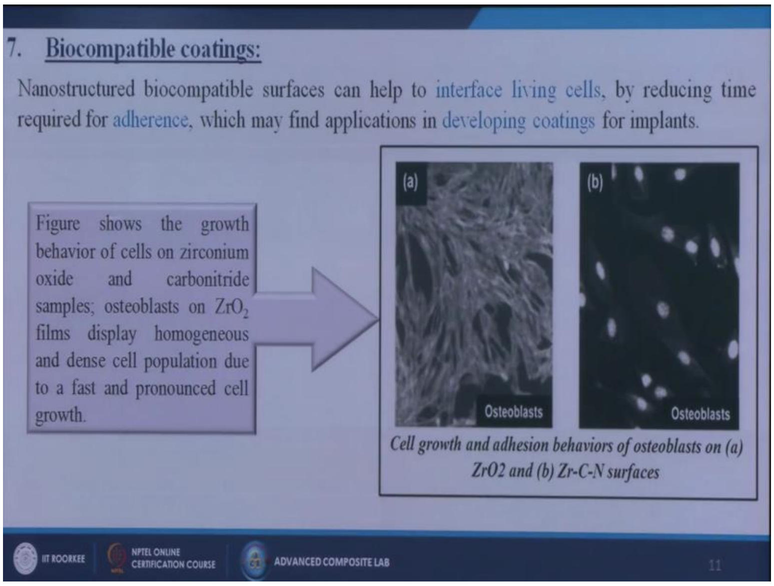

Then next one, we are talking about the biocompatible coatings. So, here the nanostructured biocompatible surface can help to interface living cells by reducing time required for adherence which may find application in developing coatings for the implants. So, generally this type of materials, we are using for the biomedical implants other maybe some kind of knee replacement, maybe some kind of elbow replacements. So, where we are using some kind of inter metallic materials or maybe some kind of metallic materials and by coating this kind of materials which can be easily used or maybe can be easily inserted into our body and our body can readily accept this kind of implants.

Here is the figure, shows the growth behavior of cell on zirconium oxide and carbonitride samples, osteoblasts or zirconium oxide films display homogeneous and dense cell population due to a fast and pronounced cell growth. So, here we are using some kind of zirconium oxide best materials or maybe that zirconium copper nitride base surfaces where we from these particular same image, we have shown that cell has been grown on to these kind of substrate or maybe these kind of materials; that means, that our body is accepting this kind of materials as an implant. So, in future if we want to make any kind of implants we can use these kinds of materials.

Then we are coming to the summary of these particular lecture is that we have summarized that what are the functional coatings, in this particular topics, we have discussed that what is the definition of functional coatings what are the advantages and different types of functional coatings.

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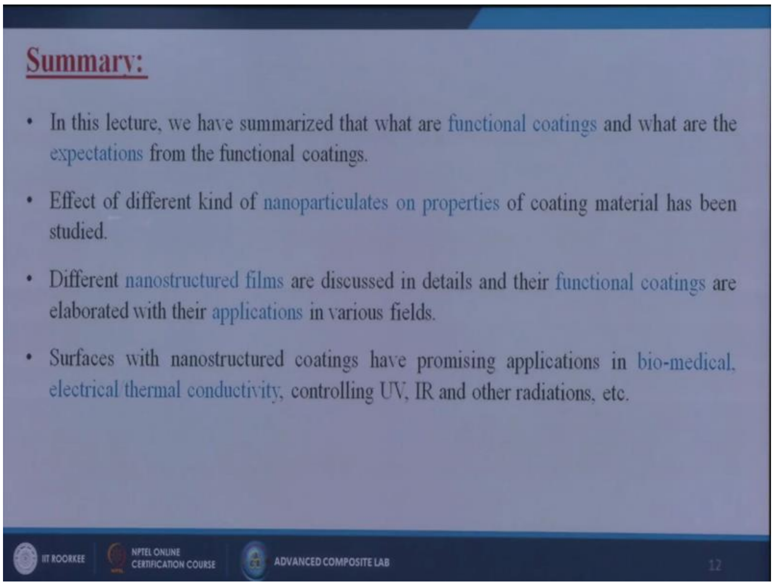

Why we are using this kind of functional coatings effect of different kind of nanoparticulates on properties of coating materials has been studied, in this particular lecture, different nanostructured films are discussed in details and their functional coatings are elaborated with their application in various fields surface with nanostructured coatings have promising applications in biomedical we have described in detail, electrical thermal conductivity that it can enhance the electrical and thermal properties of those kind of materials controlling of the UV IR and other radiation we can increase or decrease the acceptance of UV light or maybe that reflection of that UV light from the substrate itself. Though we have discussed several applications, but these all are the applications are very few there are N numbers of applications by which we can for which we can do this kind of functional coatings.

Thank you.