Surface Engineering of Nanomaterials
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Lecture - 20
Applications of Nano-Coatings

Hello, today we are going to discuss about the different Applications of the Nano-Coating. If you remember in our last lecture we have discussed about the various types of advanced coating practices which we are going to do for the modifications of the surface of our substrate so that we can get some better properties. So, in this particular lecture actually we are going to use those kinds of materials for different applications. So, before going to start let us give a glimpse of that nano-coatings that what we are doing and what we are going to be get. So, first is that nano-coatings are one of the most important topics within the range of the nanotechnology.

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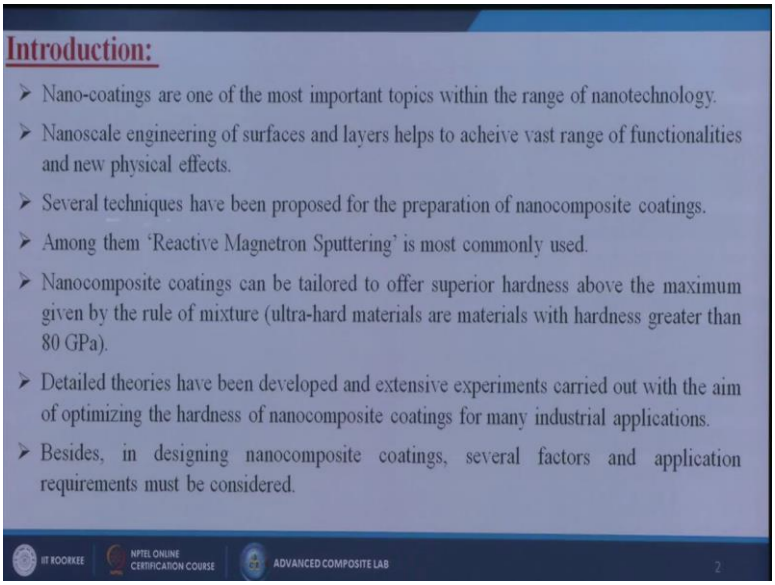

This sentence we are talking several times, so actually the main motto of this particular lecture is that whatever the nano modifications or may be the nano composites modifications we have done, how we are going to use those materials for our normal life or may be day-to-day life or for the industrial purpose or maybe some other applications like biomedical or maybe some kind of industrial applications.

So here the nanoscale engineering of surface and layers helps to achieve fast range of functionalities and new physical effects as I told in my last lecture that when we are going to modify those nano-composites of course, there is certain reason behind that. Suppose I am having some materials which is showing some conducting nature, but in you have to use that materials for some other purpose where I need that material into the non conductive mode, so what I am doing, I am trying to put certain kind of coatings, some kind of non conducting materials so that our substrate or maybe the materials can change from conductive to non conductive one.

Same thing we are using for those materials for the biomedical implants, suppose I am making any kind of metal composites for any joint replacement, but if I directly put that material into our body; maybe our body will not accept those materials. So, for that purpose I have to attach some kind of materials which can be compatible with our blood stream or may be blood vessels and our cells can grow on it so that we can get the exact purpose of that particular implant.

So, here the nanoengineering of surface; that means, when we are doing the coatings of these nanomaterials, it is having a vast applications that same material can be used for several applications at a time. Several techniques have been proposed for the preparation of nanocomposite coatings, so these different types of advanced nanocomposite coatings already we have discussed in our last several lectures that how we are going to do like PVD, CVD, ion spattering, ion depositions, ion implantation like this and not only that how we are going to modify by the solideal technique and some electro deposition techniques, so there are so many n number of applications, n number of synthesis process we have already discussed by which we are trying to modify our materials. Among them reactive magnetron sputtering is most commonly used, so this is also one kind of latest technology by which we are changing our surface of that particular materials so that we can get some advanced properties.

Nanocomposite coating can be tailored to offer superior hardness above the maximum given by the rule of mixture; ultra hard materials or materials with hardness greater than 80 Giga Pascal. So, in that particular case what we are trying to say that not only that we are only changing its appearances, we are changing its outside lucrativeness, but still we are trying to change its physical properties like we are changing its mechanical properties in terms of strength weld strength elongation at break, not only that sometimes we are

changing its hardness, sometimes we are changing its optical properties, sometimes we are changing its electrical properties, sometimes we are changing its some kind of morphology kind of thing.

So, there are n numbers of properties we can change by doing this kind of nano-composites coating. Detailed theories have been developed and extensive experiments carried out with the aim of optimizing the hardness of nanocomposite coating for many industrial applications. So, actually we are trying to modify this kind of nano-composites for our machine tool purposes where we are using this kind of nano-composites for cutting tool changing or maybe the preparation of the cutting tool, sometimes we are using these kind of materials for the indentation method, sometimes we are using this method for the scratching purpose. So, there are n number of applications are available in the point of a mechanical engineering side and also besides in designing nanocomposite coatings several factors and applications requirement must be considered.

So, when you improving these properties simultaneously we have to keep in mind that when we are increasing some properties, some properties may decrease also. Suppose I want to increase the corrosion properties of that particular material maybe wear resistance property can be decreased at that certain time. So, what we have to keep in mind that what is the main motto of our coating techniques, why you are doing this coating, which property I need at most. So, depending upon that property may be this property is not required to me, so that time we can decrease those properties or maybe we can eliminate those properties.

So, here first we are going to discuss that what are the coating properties actually we are getting.

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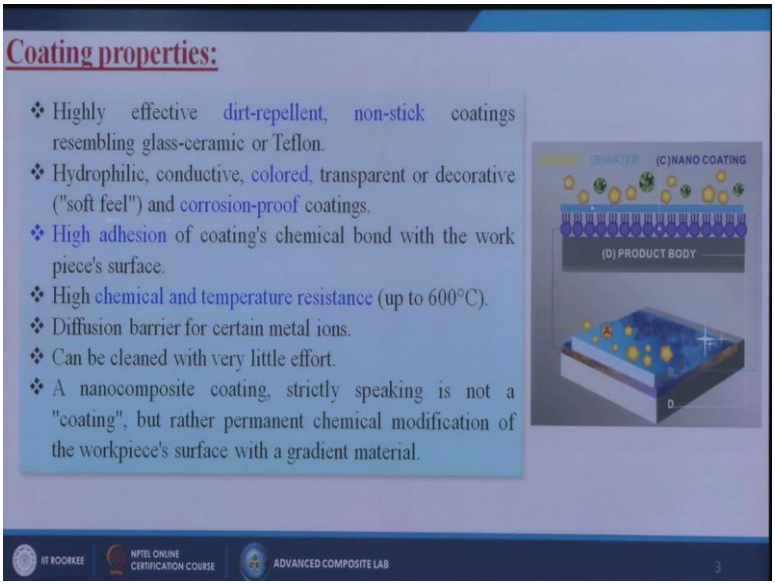

So highly effective that replacement or maybe the nonstick coatings determining glass ceramic or Teflon, nowadays we are using several chemical utensils. So, in that particular utensils what do you want we when we are keeping that instances you know a lab may be some dust or may be the dot can come, they can stick with the glass or maybe that ceramic bowls maybe the micropipettes, pipette or any kind of chemical in utensils.

So, what our main motto is that we are trying to introduce some kind of material when we are putting onto the glass substrate so that the dust or that particle will not be stick with those chemical instruments and also we no need to cling it several times, also it will reduce the cost of that total experiment procedure, not only that it will reduce the usage time because we no need to clean several times, also it will reduce the cost.

Next is that hydrophilic conductive colored transparent or decorative and corrosion proof coatings. So, sometimes we are making our nano-composites from hydrophobic to hydrophilic just a coating of some materials which is hydrophilic in nature. Sometimes we are making as I told already sometimes we are using some kind of conducting materials coatings onto the non conductive material so that; that material can be used as a conductive material, sometimes we are doing the colored for ornamental purposes we are doing some decorations or maybe some kind of aesthetic view, some kind of interior designs or maybe some kind of interior products which we are using in our day-to-day life.

In that particular case we can do some kind of coatings so that it can be lucrative and not only that, it can be corrosion proof because nowadays the biggest problem is that corrosion, suppose I am keeping some materials in the environment for a longer time, what will happen; it will try to absorb the water molecules or maybe the moisture or maybe some kind of toxic gas from the environment itself and the reaction will be going on, due to that either maybe its paint will go off or maybe rusting can be done. So, we have to put certain kind of material on our substrate so that it will be corrosion proof material.

Next high adhesions of coatings chemical bond with the work piece's surface, not only that when we are putting the coating our main motto is that the self life of that coating should be increased, but when we are doing some kind of coatings onto our base materials we have to check whether that coating materials is compatible with our base materials or not, if it is not compatible what will happen after certain times just simply it will come out.

So there should be attachment in between the coating materials and the base material so that it can stick properly. Next high chemical and temperature resistance that is also another motto, suppose today I am preparing some materials which I am using in India. So, India generally the temperature goes around 40 to 42 degree centigrade or maybe 45 degree centigrade in the summer, if we keep that material into the desert maybe temperature goes around 60 degree centigrade. Suppose same material, if I want to use in USA, so in the winter time temperature goes around minus 10 degree, 15 degree, 20 degree centigrade like that.

So I have to prepare a material which can work in USA; in the minus temperature if I keep that material into the maybe south pole the temperature goes around minus 100 degree centigrade. So, my material ranging should be from minus 100 degree centigrade to the maybe the higher side maybe 200 degree or 300 degree centigrade. Sometimes I can use that material for the oven purpose or maybe the furnace purpose which temperature goes around 800 degree, 900 degree centigrade.

So my coating material should have that capability that it can withstand the temperature ranging from minus 100 degree centigrade to 800 degree centigrade. Next is the diffusion barrier for certain metal ions, next can be cleaned with very little effort that is also

another issue. Suppose I am using certain kind of coating materials and maybe some dot or dust has come but if it will stick rigidly with the coating material then it is very difficult to release or maybe that clean those dark material. So, our coating materials should be like that that it will not absorb the dust or maybe the moisture from the environment itself.

Then in nano composite coating strictly speaking is not a coating, but rather permanent chemical modification of the work piece surface with a gradient material yes of course, the thing is that our main motto is to save our substrate material from the environment or from any kind of attack. So, the thing is that not only we are doing the coating rather we are changing its chemical structure, so that; that material can be used several times for several applications in near future.

Next we are going to discuss about the some conventional coating technologies for automotive and the aerospace industry. Nowadays, if you remember when in the earlier days when we are preparing some car and all these things that is made by some kind of aluminum, nowadays the flight actually also previously it was made by some kind of aluminum composites, but nowadays the flight or maybe the car that is made by some kind of polymers like abs polymers flight is making by the (Refer Time: 10:58) polymer which is more harder than the steel. So, though when you are using this kind of polymers though its processing is little bit difficult, but still they are very light in weight and also the cost is cheaper and not only that they are giving maybe two point five times or maybe three times better than the steel; in terms of mechanical strength.

So, when we are talking nowadays, so we are trying to make these kinds of polymers or maybe the coatings onto the surface so that we can use these materials for the automotive parts or maybe the aerospace parts. If you remember that when we are keeping these cars or maybe the automobiles or maybe the aerospace like a flight or maybe some kind of missiles, we are keeping it into the normal environment, so that it is getting the sunlight when it is going to the top; its temperature goes around minus 50 degree to 60 degree centigrade, again certainly it comes to the room temperature. So, the applications wise the temperature range is bigger, so we have to keep these coatings in such a manner so that it can act into the room temperature, into the minus temperature and also into the higher plus temperature.

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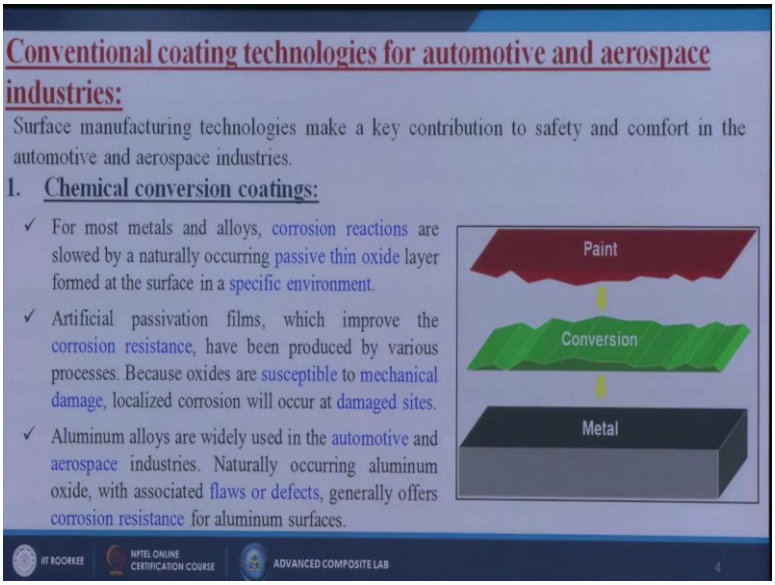

So, how we are doing, first we are doing by the chemical conversions coating. So, what is the chemical conversions coating, so simple by doing these kind of things we are going to do the chemical conversion coating. So, first we are putting some paint on our metals or maybe that our substrate, so that paint when we are putting they are trying to change its properties and then they are sticking with these metals so that after conversion this paint will remain unaltered for a longer time.

So, for most metal and alloys corrosion reactions are slowly by a naturally occurring passive thin oxide layer formed at the surface in a specific environment because these corrosion reactions are the most irritating properties for us. Suppose I am keeping a material for a longer time, so it will slowly absorb the moisture on may be that some kind of acid or maybe some kind of base from the environment itself and they will react each other. When there will be a reaction, they will make certain kind of oxide flames or maybe the sulfide flames or maybe the nitrate flames on to it.

So, what will happen? We lose our materials as well as we lose our weight of that particular material. So the main motto of this study is that we are trying to put certain kind of coating materials which will just make a barrier in between the environment and in between our substrate. Next artificial passivation films which improve the corrosion resistance have been produced by various process because oxides are susceptible to mechanical damage localized corrosion will occur at damage site. So simple that we are

making certain kind of material which will give us a corrosion resistant property so that environmental will not directly come into the contact with the substrate itself.

Next aluminium alloys are widely used in the automotive and aerospace industries, already I have discussed naturally occurring aluminium oxide with the associated flaws of defects generally offers corrosion resistance for aluminium surface. So sometimes what we are doing, we are adding certain kind of materials like some kind of rare earth materials like niobium, chromium or maybe some kind of anti-corrosive materials with the aluminium, then we are preparing the aluminum alloy; then we are doing that material coating onto the aluminium.

So, that what will happen because if I keep only aluminium, so it will just absorb the oxygen and it will form the alumina oxide; so it will make an oxide layer on to it. So, just to stop that one we are adding some kind of nanofillers into the aluminium itself so that it can act as a self healing. So, if there is some virgin aluminium will come then automatically they will do the reaction and they will make the protective coating onto it.

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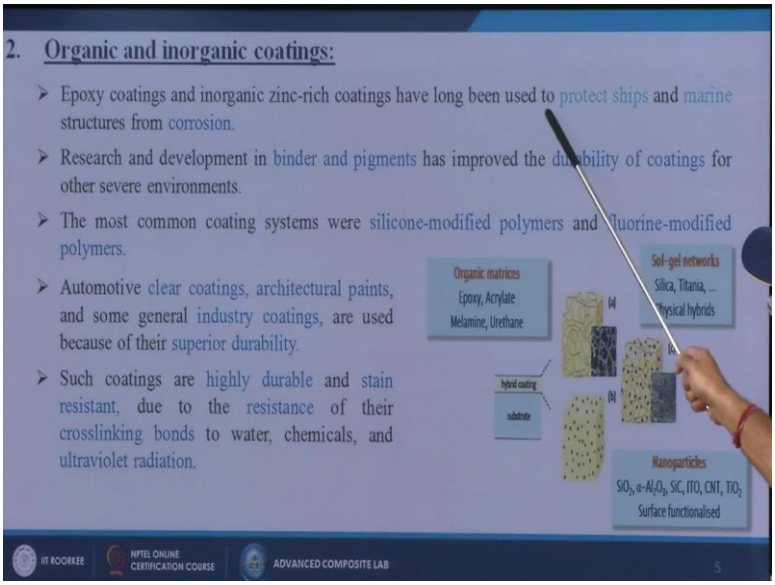

Next is that organic and inorganic coatings, so like epoxy coatings and inorganic zinc rich coatings have been used to protect ships and marine structures from the corrosion. Yes, if you remember i had talked about the antifouling, so what is that; when we are making any kind of submarines or maybe we are making any kind of ships, when it is

going inside the water; in the water there are several creatures or maybe the animals are present. So, they are exerting certain kind of their waste product which is reacting with that body of that submarines or maybe the ships, so what is happening some kind of algae formations is taking place, some kind of bacteria is taking place or maybe some kind of rusting is taking place; just to stop all these things we are putting certain kind of epoxy coatings or maybe some kind of zinc rich coatings because they are acting as a anti corrosion element onto it, so by which that the material will remain same inside the water also.

Next research and development in binder and pigments has improved the durability of coatings for other severe environments. Sometimes we are putting certain kind of binders because we have seen that several times that coating material may not stick with the substrate properly, so that time we are using certain kind of binder or maybe pigments or dye, what is that actually they are acting as an additives. So, what they will do; they will make a bonding in between your coating materials and in between your substrate so that they can stick together. The most common coating systems where silicon modified polymers and fluorine modified polymers.

So nowadays people are trying to use the products by the polymer because that is having less weight that is cheaper than metals and that is the easy process. So, what we are doing we are trying to add some kind of silicon element inside this polymer or maybe that some kind of fluorine inside this polymer so that any kind of oxidations may be corrosions or may be anti-wear properties can be achieved. Aautomatic clear coatings architectural paints and some general industry coatings are used because of their superior durability. When you are talking about the automatic layer coatings generally we are putting it into the glass itself.

So, previously what happened when you are using our car and when we are going into some rainy seasons, the water is coming; the water droplet is sticking with our window shield or maybe that front window or maybe that front glass. So, now-a-days we are trying to put certain kind of coating onto the glass itself so that water bubble will come, but it will not stick with the glass itself simply it will go; that means, we are putting certain kind of hydrophobic materials onto our glass so that water particle will not stop on to it. Not only that when you are using this kind of architectural prints; previously what happened we are trying to put certain kind of paints, but during the summer; the

intense heat the panes is having some crack or maybe some rainy seasons that water particles go through inside and it can damage our structure; concrete structure, but nowadays we are trying to put certain kind of paint if there is certain kind of cracks, so automatically they will come over, they will make the new reactions and automatically they will stop this kind of cracks over there.

Next is that such coatings are highly durable because the life of that particular materials is increasing day to day and stain resistance; so there will not be any stress; so that the strain will be almost 0; due to the resistance of their cross linking bonds to water chemicals and ultraviolet radiations. So, as I told already if there is any breakage in between the polymer chains what they will do, just simple they will absorb that may be the sunlight or may be the water or may be some other molecules and the chemical reaction will be taking place in between the coating materials and once again they will join together so that they will make the continuous coating on to the substrate itself.

So, here it is an example like for organic matrices generally we are using certain kind of epoxy materials acrylic melamine or maybe the urethane. Urethane is nothing, but a one kind of polymer or maybe that rubber generally you are using. When we are talking about the sole gel networks, we are using the silica, titania and some kind of physical hybrid material. So, here the thing is that this is all the examples of that substrate and on to that we are doing the hybrid coating. Sometimes what happen, if we see only a single material onto that if we put some only one single material onto our substrate maybe that material is not sufficient for the coating purposes.

So, what we are doing we are try to add three to four different types of nanomaterials or maybe that different types of materials to make the coating material. So, that is why we are sometimes it is called is at say hybrid coating then when we are talking about the nanoparticles sometimes we are using the silicon dioxide then alpha phase alumina silicon carbide, ITO, CNT, carbon nanotubes titanium dioxide surface functionalized. So, not only that in these days we are not satisfying for a single material we are trying to do the modification of these nanofiller and several by several route several approaches we are trying these nanofillers and we are trying to develop a new materials which will be more durable having good wear resistant corrosion resistant and which can remain same for a longer time

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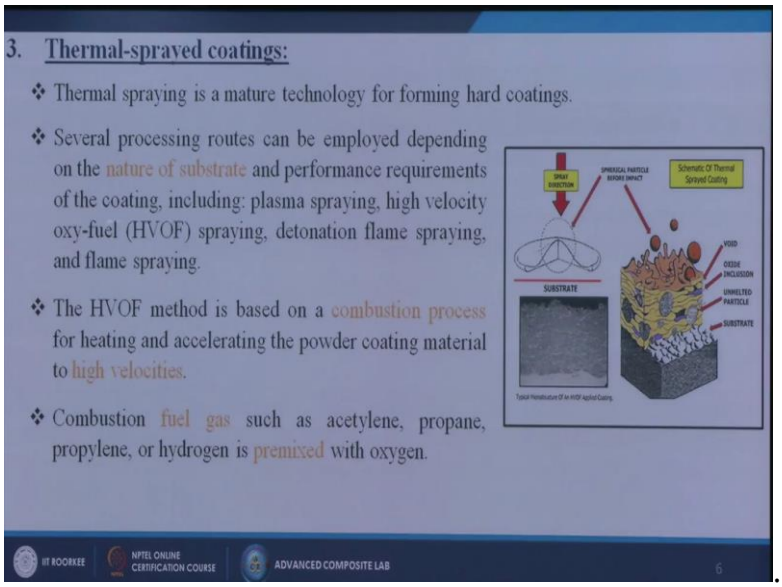

Next we are going to discuss about the thermal spade coating, so in the thermal spring is a mature technology for forming the hard coating. So, in the last class also you have discussed about the thermal spring. so several processing routes can be employed depending on the nature of substrate and performance requires of the coating including plasma spring high velocity oxyfuel HVOF spring detonation flame spring and the flame spring if you remember in my last lecture I have discussed about all these kind of techniques here nothing, but whatever the nanoparticles we are using simple we are heating those nanoparticles then I am having some carrier gas which is taking that nanoparticles from the gun; to the substrated cell then that heated nanoparticles is simply stick onto the surface itself and then gun can rotate throughout the material or maybe that gun may be in the static positions and your material can rotate into the different angle and different actions, so that you can get a uniform coating all over around.

So, the HVOF method is best on a combustion process for heating and accelerating of the powder coating material to high velocity. So, we are giving a high velocity to these nanoparticles, so that its kinetic energy directly giving a thrust onto your surface or may be the substrate, so that due to that that kind of due to its high kinetic energy that nanoparticle can stick onto the surface itself. Then combustion of fuel gas such as acetylene propane, propylene and hydrogen is premixed with the oxygen so that the heat generation of that particular thing will be more because sometimes we are using certain kind of nanoparticles whose melting temperature is too high. So, that time we are try we

need to ignite those nanoparticles then for that particular purpose maybe we have to put certain kind of combustible liquids which can heated up at that particular temperature and then that nanoparticles can be melted.

So, here this is the things actually what we are going to do, so here we are having that substrate then simply we are putting the Spain onto that substrate itself, this is the a p s m image where you can see that we are having that substrate in white in color and then little bit grayish color, it is showing the how much coating thickness we have done by this spray thermal sprays for processing. Here also the same thing, this is our substrate then here I already I told that if the temperature of that nanoparticle will not go up to its melting point, maybe some kind of unmelted particles will be included into that, then we are some kind of if there is some portion cracks; the oxide formation will be taking place and then we can see some kind of pores or tracks. So, what we are trying to do we are trying to make that melting of the nanoparticles in a certain temperature, so there should not be any unmelted particles or maybe there should not be any cracks or maybe the oxide formations will be there, so these all are the added advantage for these type of coatings.

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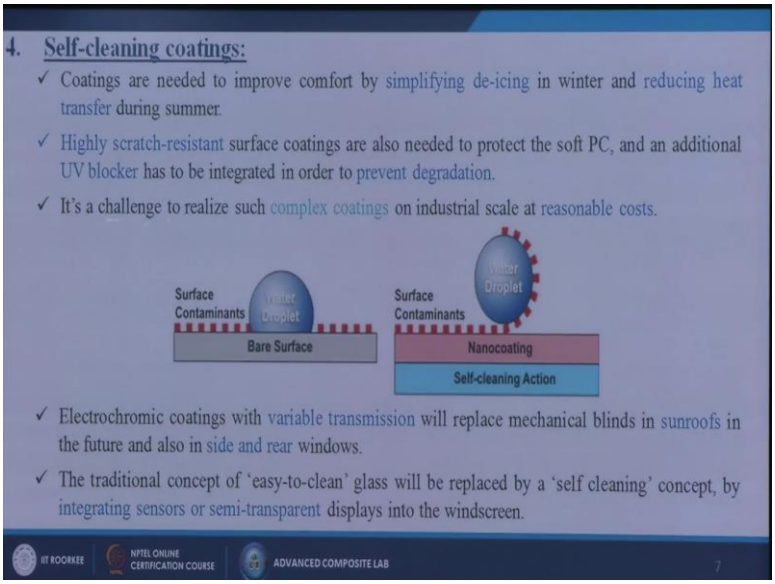

Next we are trying to do the self cleaning coatings, so as I told already we are trying to put certain kind of materials on the glass or maybe our window glass or maybe somewhere where we need that water should not be stopped or maybe wet water should

not from any kind of droplet over that. So, in that particular purpose what we are trying to do here that coating are needed to improve comfort by simplifying deicing in winter and reducing heat transfer during the summer.

So, what we are trying to do because when we are using this glass, in the winter time the glass is going into the minus temperature, in the summer time the same glass is going to the plus temperature. So, there is a very much heat changing from winter to summer, so what we are trying to do we are trying to put certain coatings that that the temperature of the glass should not go into the minus temperature or maybe that the glass temperature should not go into the plus temperature.

If it will go on for a several times, the residual stress will be generated inside the glass through that maybe the glass can break. Simply I am giving you one examples, if you put certain if whatever the glass on with that cup we are using in our day to day life, if that particular glass or maybe that particular cup material is not good then what happens suddenly if you put the hot water inside it, simply it will break. So, that is the phenomena actually over the same thing is going on over here, so just to start this one we are trying to put certain kind of coatings onto that so that it can withstand that temperature also that temperature, that hot temperature or maybe the extreme cold temperature will not reach to the glass so that it will not break. Nowadays you can remember that we are trying to use certain kind of melamine materials which is having a very high heat resistance capability for this particular purpose.

So, here also another thing is that highly scratch resistant surface coatings are also needed to protect the soft pc and an additional UV blocker has to be integrated in order to prevent the degradation. Here highly scratch resistant and UV blocker also are the main important factor because when we are driving our car may be sunlight can directly come from the front, so if the front glass does not have any UV blocker that UV blog UV will directly come to our body, it will affect our eyes or maybe our health or maybe our skin.

So, we have to use certain kind of coating materials which will just stop or maybe the resists that UV from our front sight so that any kind of UV light can directly come to our body. Not only that another most important thing is that highly scratch resistance because when you are driving our car, the dust particle is mixed with the air. So, when we are

traveling in high speed that dust particle is continuously hitting on our glass surface, if our glass surface is not the scratch proof they will make certain kind of scratch.

Another very good example is that in our spectacle, so if our spectacle who does not have any coatings. So, continuously wearing these spectacles and going to the outside environment, so that simply the dust particle it is coming, it is stagnant on our glass surface and not only that it is making certain kind of scratch. So, nowadays we are using certain kind of scratch resistant materials onto the glass onto the specs so that the dust particle will not make any kind of scratch or maybe that rubbing actions onto the surface.

Also it is a challenge to realize such complex coatings on industrial scale at a reasonable cost. Yes of course, whatever the research we are going to do all the research now into in into the laboratory purposes because when you are trying to do this kind of research for a larger scale or maybe for the industrial site so that time the cost is increasing because for the industrial purpose; the equipment, the machines, the total utensils is in a bigger size. So, that what we are trying to do we have to modify these materials, but simultaneously we have to reduce the cost. So, that is the biggest challenge for the scientists that just not keep our research into the laboratory purpose, we have to expand our research to the industrial purpose also.

So, here the thing is that what I have told you that we are having some kind of bare surface then we are having the surface contaminants, so when the water droplet is coming simply it is sticking with the bare surface, but now what we are trying to do; we are trying to do some kind of surface contaminants onto that. So, we are trying to do some kind of nanocoatings, so when you are trying to put some kind of nanocoatings, it is generated certain kind of surface contaminants or maybe some kind of properties, so that what a droplet will not stick with this material directly, so after some time the water droplets will go out.

Next thing is that electrochromic coatings with a variable transmission will replace mechanical blinds in sun roofs in the future and also inside and rear windows, that is also one kind of latest technology we are trying to develop for our automotive purpose. Next the traditional concept of easy to clean glass will be replaced by a self cleaning concept by integrating sensors or semi transparent displays into the windscreen of course, we are trying to put certain kind of sensors then when the dot or maybe dust or maybe the water

particle will directly come into the contact with the glass then automatically its cleaning will be done. So, it will be good to use any kind of self cleaning properties, so that is also one kind of latest technology what we are going to use in our research.

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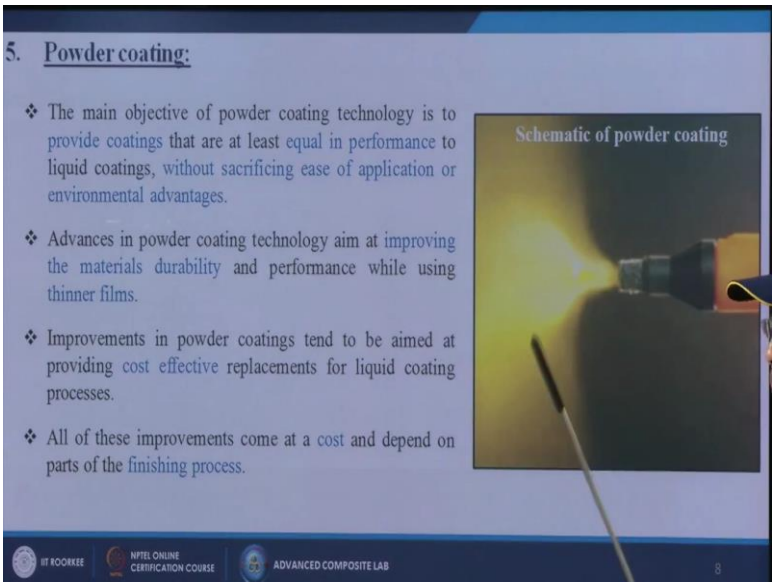

Next is that the powder coating so if you remember that powder coating is nothing, but the same kind of nanoparticles powder just we are spraying onto that our substrate. So, due to that the powder will stick, but there is certain kind of principles either that powder will be heated up or maybe that substrate will be heated up then only that powder can easily stick on to the substrate itself. So, the main objective of powder coating technologies to provide coatings that are at least equal in performance to the liquid coatings without sacrificing easy of applications or environmental advantage.

So, if we try to make certain kind of panes so either we have to add certain kind of acids or maybe some kind of toxic materials, but if you directly use this powder and directly put onto the substrate, so from the environmental point of view it is more safe and it is more clean, next advantage in powder coating technology aim at improving the material durability and performance while using the cleaner flames; so also that powder coating is increasing its life.

Next improvements in powder coatings tend to be aimed at providing cost effective repellents because the replacement of this liquid painting is biggest problem is that if we

want to do a liquid painting either I have to hire one labour then I have to use some kind of brass or maybe some kind of dawn and there are several things I have to purchase the thinner then that painting I have to do or maybe it is need some time to dry in between that something happened then again I have to do it twice. So, there are lots of problems can occur at that particular time, but it will do directly powder, so powder will simply heat onto the substrate itself so that they are it and it is easy drying so that easily it can be replaced by the liquid painting. All of these improvements come at a cost and depend on parts of finishing process also the finishing process of this case is very very easy.

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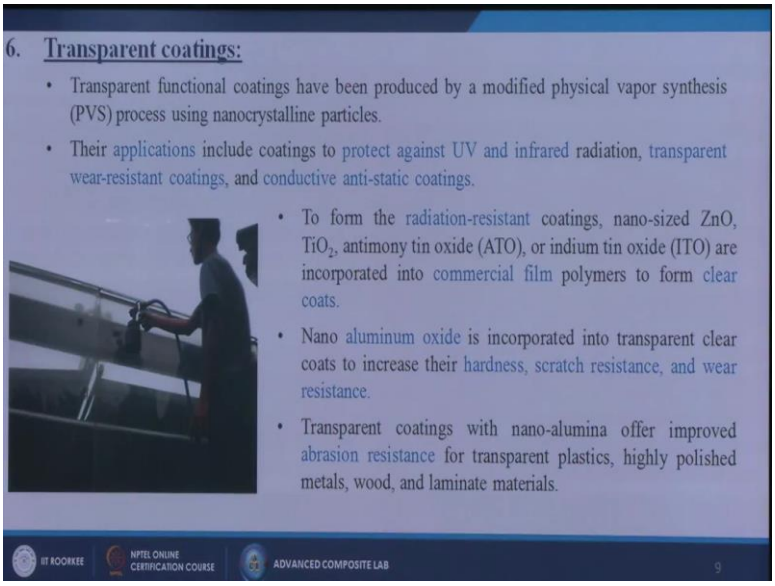

Next is that transparent coating; transparent functional coatings have been produced by a modified physical vapour synthesis process using nanocrystalline particles. So, here the main thing is that we are using some kind of transparent coatings, from this figure you can understand that here we are putting some kind of transparent coating, what are the main advantage of this coating; this will reflect the sunlight, so that sunlight will not go inside not only that this is reflect the UV so that it is acting as a UV blocker not only that it cannot absorb any water particles so that water will not stick with that glass or maybe that with that metals and there are so many advantages are there, their applications include coating to protect against UV and infrared radiations, transparent wear resistant coatings and the conductive anti static coatings.

To form the radiation resistant coatings; nanosized zinc oxide, titanium dioxide, antimony tin oxide or indium tin oxide are incorporated into commercial flame polymers to form clear coats. Nanoaluminum oxide is incorporated into transparent clear coatings to increase their hardness, crash resistance and wear resistance. So not only that they are giving you the transparency, they are trying to improve the other properties like the scratch resistant, wear resistance and any kind of hardness properties. Transparent coatings with nanoalumina offer improved abrasion resistance for transparent plastics, highly polished metals, wood and laminate materials.

Next we are trying to discuss about the thermal barrier coatings, so thermal barrier coatings generally we are using both materials which materials we are using into the higher temperature like turbine blades or maybe some kind of engine parts or maybe some kind of missiles where we are trying to use this kind of materials in a high temperature zone.

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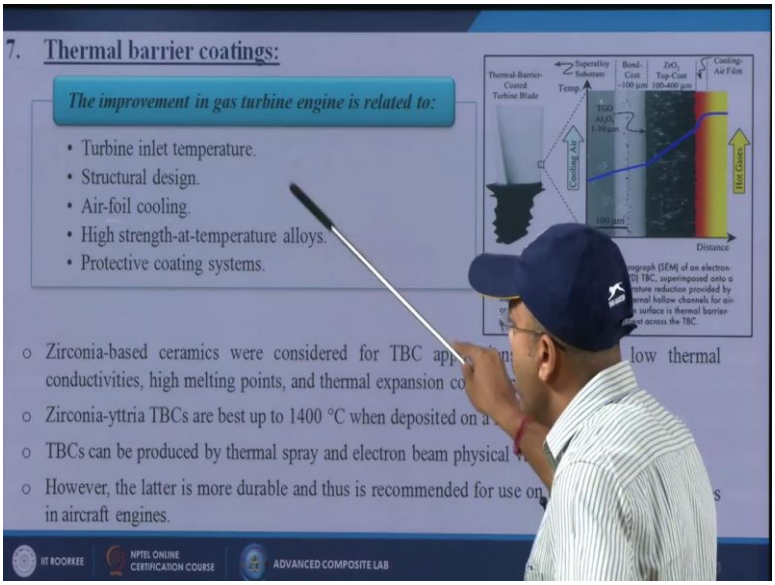

So, the improvement in gas turbine engine is related to turbine inlet temperature, structural design, airfoil cooling, high strength at a temperature alloys, protective coating systems. So, from this particular system you can understand that we are using these materials for a higher temperature; at a higher temperature then what we are trying to do we are using some kind of zirconia based ceramics were considered for the t v c

applications, thermal barrier coating applications due to their low thermal conductivities high melting points and thermal expansion coefficients.

So, another issue is that suppose I am trying to use certain kind of metals when it will get the temperature automatically the elongation will be taking place, but sometimes when it will usually using these materials into the room temperature or maybe the minus temperature it will be (Refer Time: 33:11) contracted. So, there will be expansion and contraction due to that the total machine or maybe that equipment dimension and set can be changed not only that we can get some kind of error or from that particular equipment. So, what we are trying to do we are using certain kind of gel zirconia based ceramics which will remain same which is having very low thermal coefficient and thermal conductivity is also very very low.

In that particular case it will not change its shape and size at that particular temperature zirkonia atria t b c s are best up to 1400 degree centigrade when deposited on a metallic bond quote; t b c s can be produced by thermal spray and electron beam physical vapor deposition; however, the later is more durable and does is recommended for use on turbine blades and vanes in aircraft engine. So, generally we are using these electron beam physical vapour deposition that just to make a thermal barrier coating onto the turbine blades or maybe that aerospace engine parts so that it can withstand with the high temperature.

Here this is an example, so the thing is that what we are doing we are trying to do the thermal barrier coating onto the turbine blade. So, this is the turbine blade when we are trying to take a small efficient picture on the surface of that, we can see that we are using these kinds of materials over there. So, first in that case we are having some bond course of 100 micrometer then we are using some zirconium oxide topcoat from 100 to 400 micrometer and then also we are using some kind of air film, so which will act as a cooling material so; that means, when the temperature will go up that automatically that cooling flame will absorb the temperature so that the maximum temperature will not go inside the blade, so that it will not change its shape and size. So, these are the different types of applications where we are using this type of nano-coatings.

Next is the applications; applications for the packaging applications in food and pharmaceutical industries. Yes of course, that is also a vital and most important

parameter for us because when you are using some kind of liquid products like any kind of soft drinks, any kind of milk, any kind of products which is wrapped by surround some kind of polymers or maybe the plastics, every time we are talking about the purity of that particular materials, but never we are talking about the wrapping materials or maybe about the bottles.

So, nowadays that is the biggest problem for us because we are talking about the food; food is not good or maybe food order is not good and taste is not good, but nobody is talking about that bottles that which plastic that bottle has been made, but which are polymer that we are wrapping those bread or maybe some kind of let us say like chocolates or maybe anything else.

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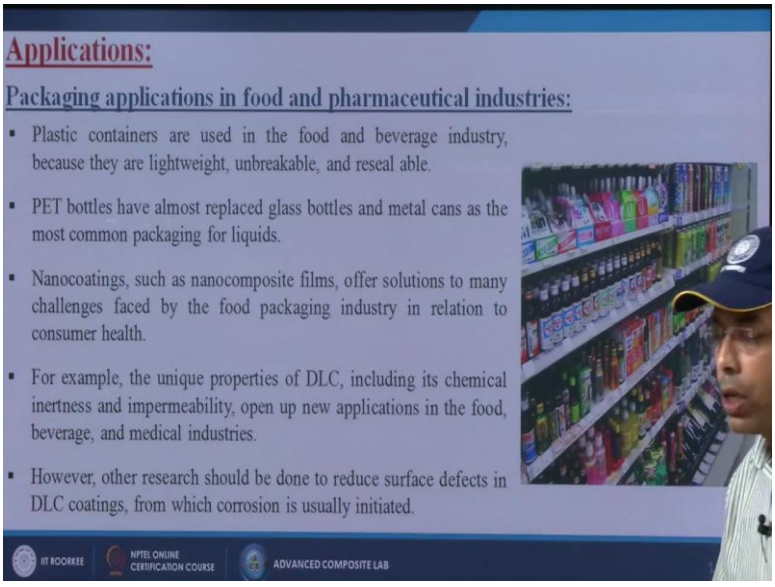

So, when you are talking about these kind of materials; that plastic should be biomedical good enough and the degradable plastic, so that; that will not make any kind of toxic gases or maybe any kind of toxic reactions that which directly will come on to the food or maybe the liquids. So, only we are talking every time about the aesthetic views of the bottles or maybe that sticker or maybe the labels, but never will talk about that by which material that bottle has been made. So, here the plastic containers are used in the food and beverage industry because they are lightweight unbreakable and re-sealable. So, previously that coca cola can was made by some kind of aluminum foil, but nowadays people are trying to replace those one and they are making this foil by some kind of

polymers away the plastics due to its less weight and also the cost of the container will be reduced.

Next PET; poly ether tetryl bottles have also almost replaced glass bottles and metals can as the most common packaging for liquids. Nowadays we are using the plastic bottles because previously we are using that glass bottles for the milk preservations, but if the glass bottle will form it will break, but nowadays the speedy bottles are flexible, if it fall it from our hand also it will not break properly. Nano-coatings such as nanocomposite claims offer solutions to many challenges faced by the food packaging industry in relation to consumer health for example, the unique properties of d l c including its chemical inertness and impermeability open up new applications in the food beverage and biomedical industries; however, other research should be done to reduce the surface defects and d l c coatings from which corrosion is usually initiated. So, there are so many initiatives have been taken just to make the bottle from the toxic free and not only that it should be less weight and it should be less cost.

Next thing we are going to discuss about the coatings for the electronics and sensor industry. So, nowadays this is also the vital parameter because if we remember these kinds of techniques are very good for our defense purposes. Suppose I am giving you one example, so when you are using that submarines that suddenly the submarines is going into the deep sea right. So, in the deep sea maybe it is some kind of toxic gases has been strapped trapped inside. So, what happened? If you remember also last two to three years ago or maybe that last year or maybe the last to last month also the same thing happened to the submarines in Indian navy that when the crew is going at that particular point some kind due to some kind of trap gas they are dying. So, what we are trying to do we are trying to make some kind of sensor materials which can detect easily that what is the trapped gas actually present over there. So, just getting the alarm they can be cautious, so that they will not reach first they will remove those trapped gases and they can easily go and by this way we can save our crew life.

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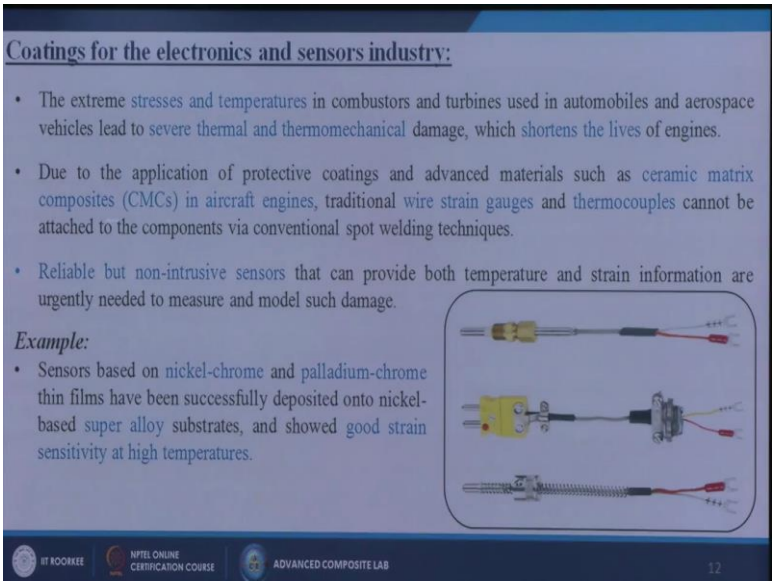

So, here also the same thing we are going to do the extreme stress and temperatures in combustors and turbines used to not only while and aerospace vehicles leads to c v r thermal and thermo mechanical damage which shortens the lives of the engines. Suppose we can detect the heat at that particular point that how much heat is originating at that particular engine points, so that we have to reduce the heat if we make some kind of sensors, but that sensor should be withstand that temperature.

So, here we have to make some kind of sensors which can detect that high heat and which can tell us that you have to reduce that in a temperature at that particular point so that we can reduce our engine temperature. Due to the application of protective coatings and advanced materials such as ceramic matrix composites in aircraft engines, traditional wear strain gauges and thermocouples cannot be attached to the components where conventional spot welding techniques. Nowadays we are trying to introduce certain kind of sensors which we can simply stick on to that such surface or may be simple we can put at the point where the temperature actually will be originating.

So, it is not about done only the thermal, it is about anywhere we can put this kind of sensors, so nowadays sensor actuators are most widely used in our day to day life. Next reliable, but non intrusive sensors that can provide both temper and strain informations are urgently needed to measure and model such damage, here we have given certain kind of examples of these sensors; sensors based on nickel chrome and palladium chrome

clean claims have been successfully deposited onto nickel based superalloys substrate showed a good strain sensitivity at high temperature. So, if at the high temperature if our engine parts or maybe body get damaged or maybe some kind of stress or strain can be generated simply this kind of sensor can measure that what is going on inside and we have to reduce the temperature. So, not only that from the temperature point of view they are going to reduce they are trying to reduce stress and strain not only that or with the temperature itself.

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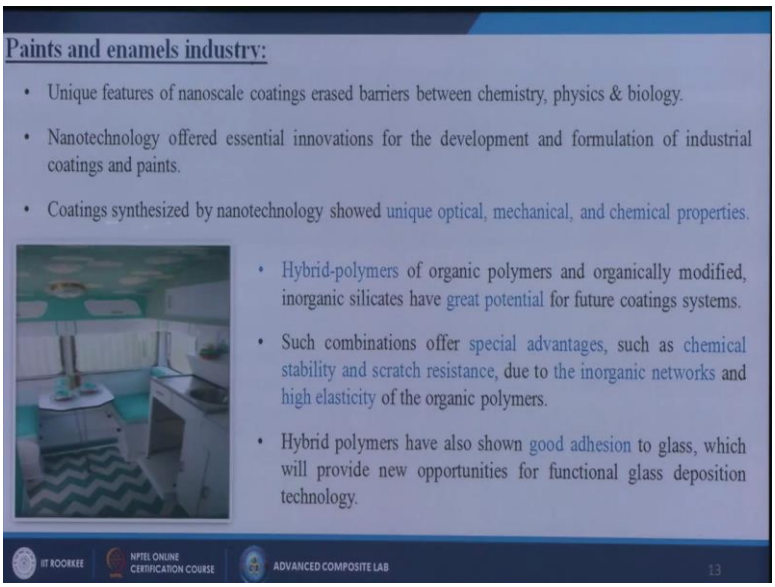

Next is that some kind of paints and enamel industry also we are trying to use this kind of nano-coatings. So, unique features of nanoscale coatings erased barriers between the chemistry physics and biology yes, previously we are talking about the chemistry we are talking about the physics, we are talking about the biology; nowadays this all subjects became a intra they have from a interaction in between that. So, we are talking about the nanotechnology, nanotechnology combines both physics, both chemistry, both biology, mechanical, methodological all fields together, so it is a one kind of intra type of department.

So, when you are talking about the nanotechnology nanotechnology when we are talking to applications it based on the physics rule, it is based on the chemical rules, it is based on the biological rule, so altogether can make this nanotechnology more better. So, coating synthesized by nanotechnology showed unique optical mechanical and chemical

properties, hybrid polymers of organic polymers and organically modified inorganic silicates have great potential for future coating systems, such combinations or for special advantages such as chemical stability and scratch resistance due to the inorganic networks and high elasticity to the organic polymers.

So, as I told already if you remember or if you watch the television you can find that when they are giving some kind of advertisement about the paint, they are talking that some kind of polymer is attached with the paint so; that means, when we are doing the paint for to the outside of our home on the house. So, what it is going it is in direct sunlight, but it will reflect that sunlight so that temperature will not go inside, it will not absorb any kind of moisture or maybe it will not allow the water droplet or maybe the drain to our wall, so that is the added advantage to that paint industry.

Hybrid polymers have also shown some good additions to glass which will provide new opportunities for functional glass deposition techniques because addition of the glass is very very poor, if anything we are putting onto the glass surface after certain time it will come out. So, nowadays people are trying to make certain kind of materials which can easily stick onto the glass substrate so that we can do the functional gloves depositions.

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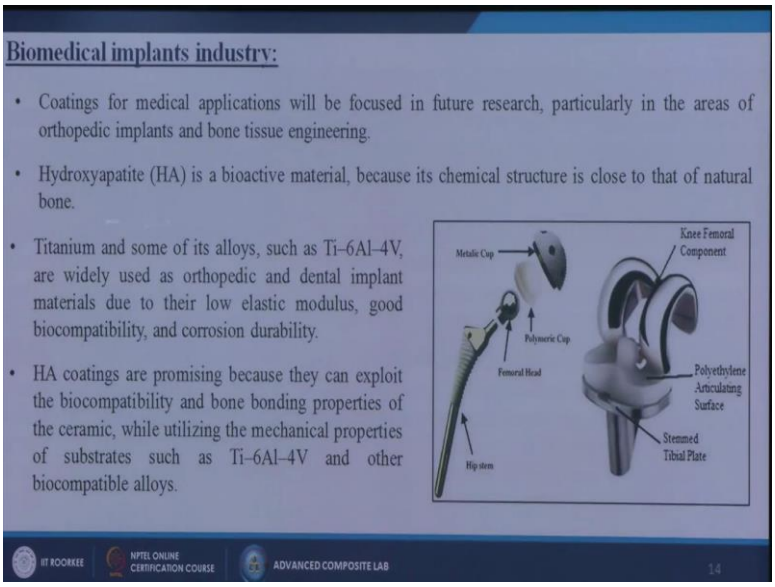

Next we are trying to use this kind of materials for the biomedical implants industry. Already I have told you that we are trying to make certain kind of materials which we

can use for some kind of joint replacement processes. Initially you are using some kind of metals, but the biggest problem in that metal is that after certain time with the reaction with the blood, the metal width is getting decreased. So, we are trying to use these kinds of metals which will be anti corrosion proof and not only that which will not react with the blood vessels and simply cells can grow unto that.

So, for these purposes we are trying to replace these replacements by these kind of hybrid composites. So, nowadays we are doing that joint replacement like hip joint, like ankle joint, like elbow joint. So, several applications we are trying to use this kind of materials, not only that we are using these materials for the stain purpose. So, when you are doing that bypass surgery, we are putting certain kind of stains, so that stains are also made by this kind of material. So, what type of material generally we are doing hydroxyapatite is the bioactive material because its chemical structure is close to that natural bone. So, simply we have developed a one kind of material whose property is almost equal as a bone.

So, when you are trying to make this kind of materials and we are incorporating those materials into the human body, simple the human body will accept those materials because that material property is equal to the bone structure. Next titanium and some of is laws such as titanium six aluminum 4 b, this is a one kind of aluminum composites are widely used as orthopedic and dental implant materials due to their low elastic modulus, good biocompatibility and corrosion durability; h a hydroxyapatite coatings are promising because they can exploit the biocompatibility and bone bonding properties of the ceramic while utilizing the mechanical properties of substrate such as titanium 6, aluminum 4 vanadium and other biocompatible alloys.

Nowadays we are using certain kind of lenses which we are putting into our eyes that is also made by some kind of polymer; that polymer is known as the p m m a; poly methyl metha crylate. So, that is also some good compatibility that is having some biocompatible because we are keeping that low for a longer time in our eyes, that is not reacting with our eyes water or maybe that eyeballs and we can use that materials for a long time, not only that they are still soft and flexible also previously we are using certain kind of glass lenses when we are putting those glass lenses in our eyes always we have to put certain kind of spectacles, otherwise what will happen may be some heat or

maybe some kind of load directly can come to our eyeballs may be that glass can break and it can damage our eyes.

So, whatever we are lenses nowadays we are using that is totally scratch free, that is totally corrosion free and that is totally flexible. So, we do not need any extra spectacle over there, so simply we can wear this kind of lens into our wear into our eyes and will be safe.

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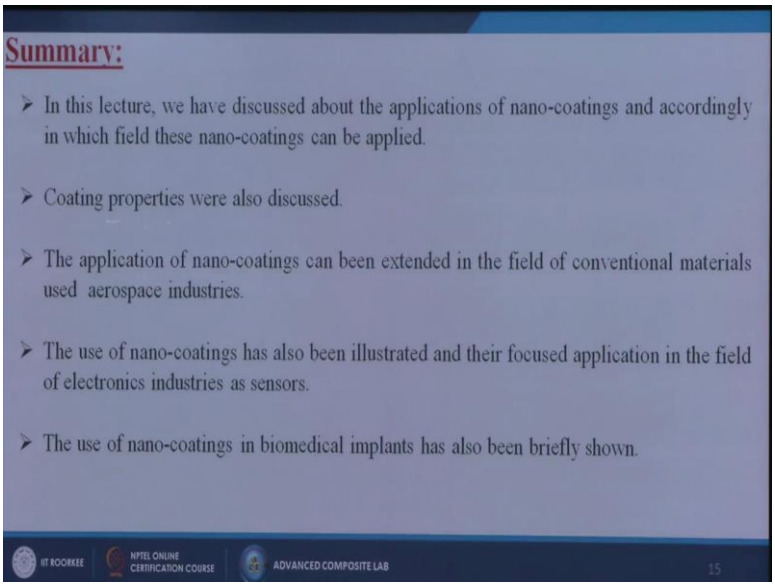

Next in summary; so here actually in this particular topic we have discussed several types of applications about that the nano-composites, but these all are very few there are in number of applications, but due to this time constraint we have discussed a very few over here. So, in this particular lecture we have discussed about the applications of nano-coatings and accordingly in which field these nano-coatings can be applied. Coatings properties were also discussed, the application of nano-coatings can be extended in the field of conventional materials used aerospace industries.

The use of nano-coatings has also been illustrated and they are focused applications in the field of electronic industries as sensors, the use of nano-coatings in biomedical implants has also been briefly shown. So, these all are the technology are very very few; there are n numbers of applications where we are using this kind of nano-composites coating.

Thank you.