Nature and Properties of Materials
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Lecture 3
Advanced and Exotic Materials

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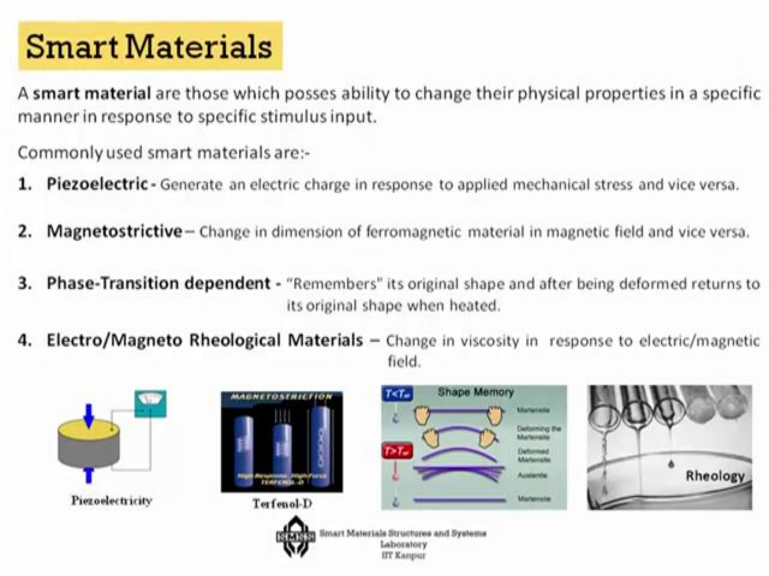

Now we will talk about some of the advanced materials okay. So we have seen the basic materials and the advanced category, we keep those materials which are just coming up their use, so mostly from the laboratory, they are just getting rolled out and they are used in certain very high-performance applications. One of them is the smart material as you can see here that there are various groups of smart materials.

I will talk about them later on like piezoelectric, magnetostrictive, phase transition dependent or Electro/Magneto Rheological Materials. Now in all these materials, the reason why they are called smart materials is that they do something more than a simple you know coupling with the stress and the strain in the sense that every material if you apply force it deforms.

But not many materials will actually deform with the application of let us say electric field or say magnetic field or say you know light itself temperature or say, not many materials will change their viscosity with respect to the change of electric field or magnetic field. These are the group of materials which have very good use in terms of making sensors in terms of making artificial muscles, etcetera. And they are covered as smart materials, so that the one group of materials that has just you know that are just coming up. The other groups of material which are becoming very popular are actually biomaterials. Now they are the materials which are actually getting linked or coupled with the living system itself, okay.

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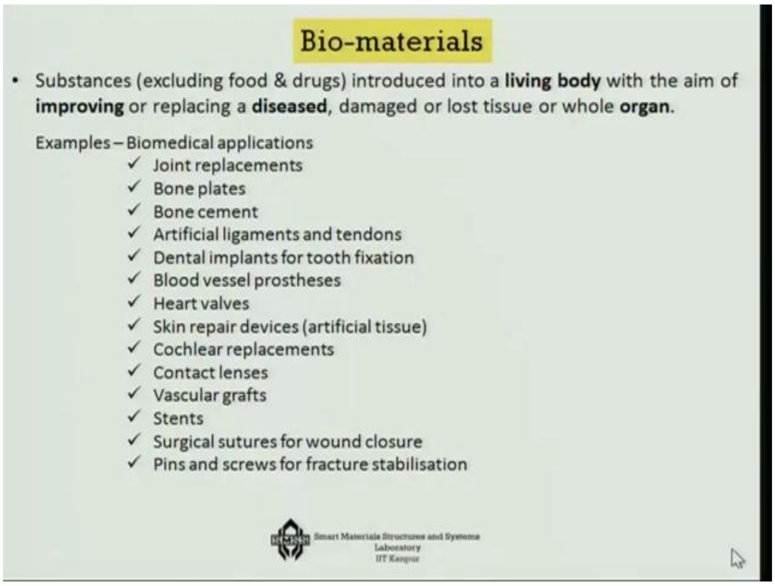

For example, you think of the artificial joints, you think of the bone replacement, you think of artificial tendons, you think of dental implants or something which changes the blood vessels, heart valves, skin repairing, cochlear implant, contact lens, what not our entire human body.

In fact, if you go through some of the science fictions you would see that a person is depicted is of 300 years of age and the person is telling you know there is hardly anything now in my body which is having kind of genetic origin, which is something which I got from my biological parents, everything got gradually replaced by actually engineering materials. Now that is the way towards which we are advancing.

We would see that all the joints today are getting replaced by engineering materials. Our eyes are getting replaced by these you know the synthetic eyes like the specs and similarly the various parts of the body. So that is the biomaterials and that are actually becoming very-very important into this context.

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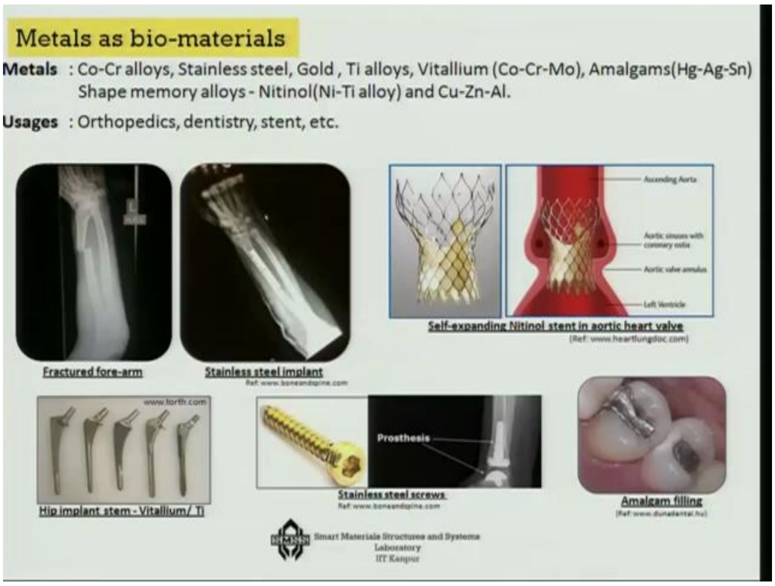

Now, biomaterials could be materials, could be nonmetals that means ceramics and other things or polymers. So for metals, you have chromium alloys, stainless steel, that essentially important thing here is that the material should not react with the living tissues okay. So some of the very important applications are for example, the stent which saves you know a lot of life today, right. So what is this stent technology?

Here we are talking about a material which at a particular temperature, you know blood is warmer, so at a particular temperature it actually expands and then through that expansion it actually there is some place where there is constriction in the blood vessel, it tries to actually clear up that constriction, so that is one type of also smart material, but it is a biological material.

Then of course there is this you know implants in terms of dental implants. You have the prosthesis in terms of a fracture of bones where it is used for the hip implants, so metals are used very much, some of the metals are very well accepted inside the body and they are used in terms of prosthetic systems that is one of the important biological materials.

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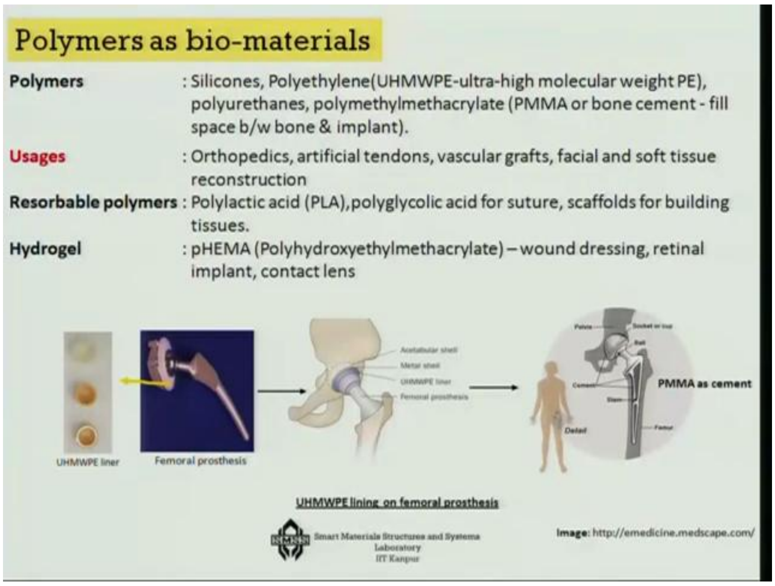

The other groups of the polymers which are also used in orthopedic applications but more in terms of say artificial tendons or say you know artificial skins, tendons or grafts, facial and soft tissue reconstruction. There are these (())(5:21) for example which are coming up in the migraine, then scaffolds for building the tissues or wound dressing for example okay or retinal implant or contact lens, this is where the polymers are mostly used.

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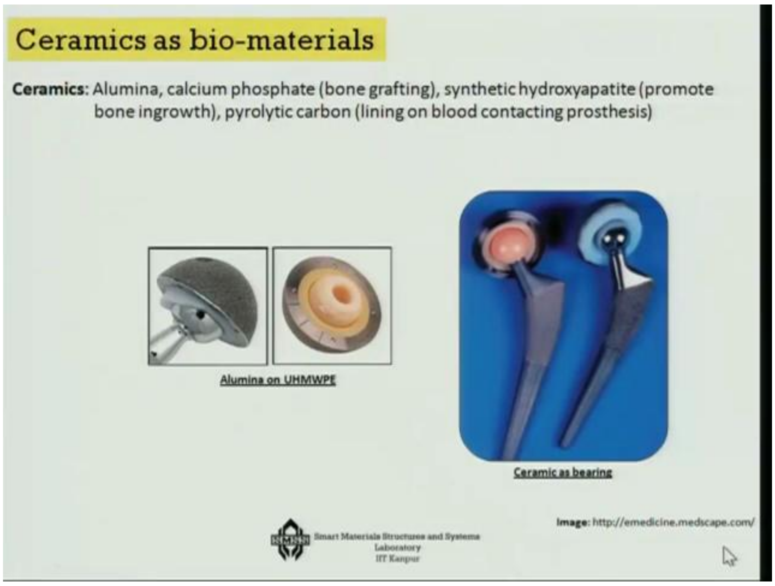

Then there comes the ceramics, so ceramic you would see again in prosthetic in terms of mostly as a joint because I told you that one of the most important property of the ceramics is that its coefficient of friction is quite low, it is almost like a can work like a frictionless material almost and that is very good in the joint. So they are used in joints in various types of joints, in knee joints, in shoulders, etc, so that is one of the good things and also where you need a high compressive strength for example, for dental you know prosthesis, ceramics are used in a in a very large manner.

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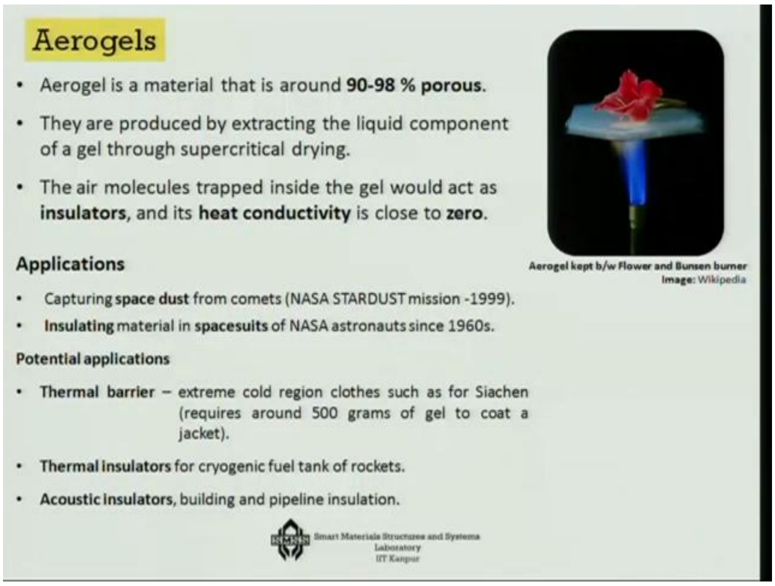

Then there comes a very interesting type of a material, so that is so far I talked about the biomaterials and the smart materials. This one that I am talking about is called Aerogel. Aerogel is a material which is like 90 to 98% porous; it is very highly porous. And they are produced by extracting the liquid component of a gel through a supercritical drying process which extracts all the moisture out.

And once you do that, then the air molecules that get trapped in the gel would act as insulators and its heat conductivity will be almost close to 0. They are nowadays getting used in terms of thermal barrier, thermal insulators and acoustic insulations, etcetera. That is about the aerogels.

(Aerogel demonstration)

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I told you that aerogels are highly porous, it is so porous and lightweight that see for example this salt like material that you can see here which is an aerogels, just disturb it a little bit and you will see that almost it looks like a liquid okay why it is basically highly porous, we have to give it some time so that it will actually settle down. So that is the level of porosity in the system. Now this porosity has a very wonderful application.

Because of this high porosity, they can actually interrupt air inside them and hence they become an excellent thermal insulator for example, you know this is like the same material we have developed heat foam, okay out of it. And you see there is a heater here and it is very hot that you will not be able to keep your hand, it is full-fledged condition.

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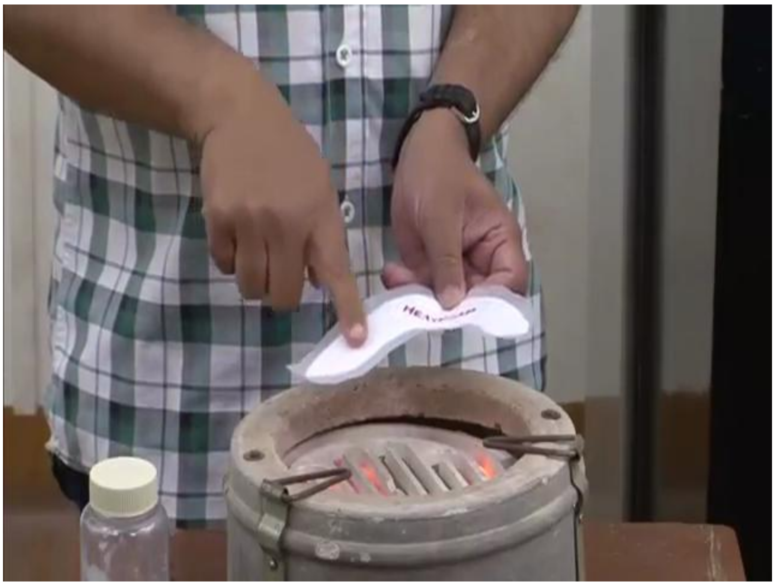

But if you keep the material, the area where you will keep this material, you can actually very easily keep your hand there okay, so it can work very well in terms of heat insulation. So that is the beauty of one of this advance material which is the Aerogels. Then there is another group of materials which are known as superconductors.

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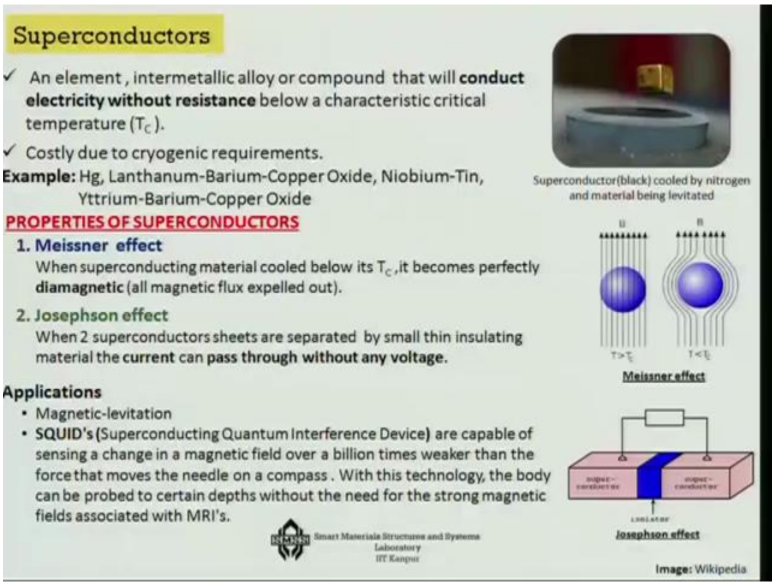

These are much better than the metals why because they conduct electricity without any resistance. And if there is no resistance, means there is hardly any loss of electricity, but they are costly because of the cryogenic requirements. So they have 2 very important effects, one is the Meissner effect which can be used in terms of magnetic levitation.

And another is the Josephson effect, which can be used in terms of for example fuel cells, etcetera, where you can have without any you know voltage generation and voltage you know EMF, you can actually pass electricity if you keep superconducting elements in between if you keep an insulating film, that is the Josephson effect. So superconductors are the dream for tomorrow's technology.

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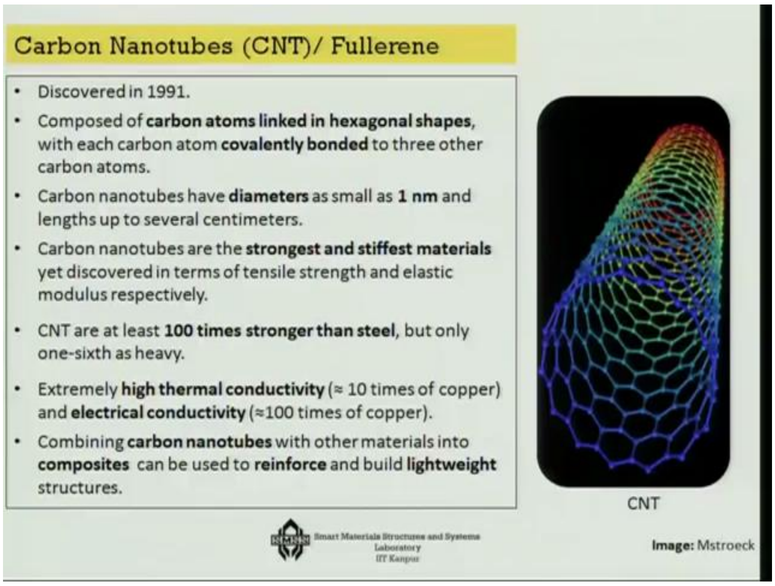

And then one of the most fascinating things is the Carbon Nanotubes, is developed in 1991 but in various forms in fact as CNT first may be in terms of (())(10:01) structure there is a Nobel Prize and then there is the Garfield people got Nobel Prize, so this is something that has actually, that has a promise to revolutionize everything.

I will talk about the power of the Carbon Nanotubes also at a later stage when will talk about a very specific development in terms of a space structure. Now these carbon Nanotubes are actually, they are essentially carbon atoms which are linked in hexagonal shapes. And as you know the Carbon bond, equivalent bond is one of the strongest bond, is the strongest bond available in nature and this strongest bond is actually used completely by the Carbon manner.

And hence it is the strongest and the stiffest material available in the nature, something like which is hundred times stronger than steel. It also has very high degree of thermal conductivity and electrical conductivity. So together with all the very good properties, CNTs are going to be one of the most important materials for breeding tomorrow’s technology.

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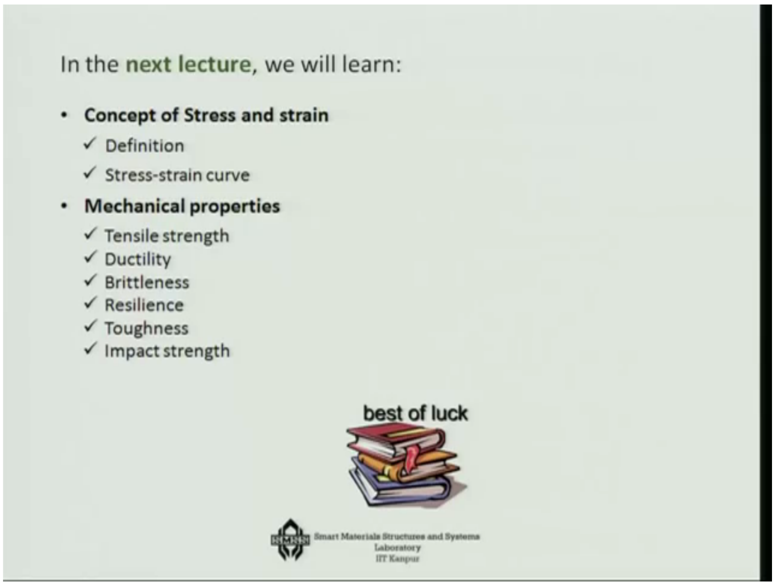

Now this is where you know I am bringing the whole discussion to an end. In the next lecture we will talk about the basic concept of stress and strain and the group of mechanical properties like the tensile strength, ductility, brittleness, resilience, toughness, impacts strength a basic understanding of it, this is where we will bring an end. Thank you.