Basics of Mechanical Engineering-1

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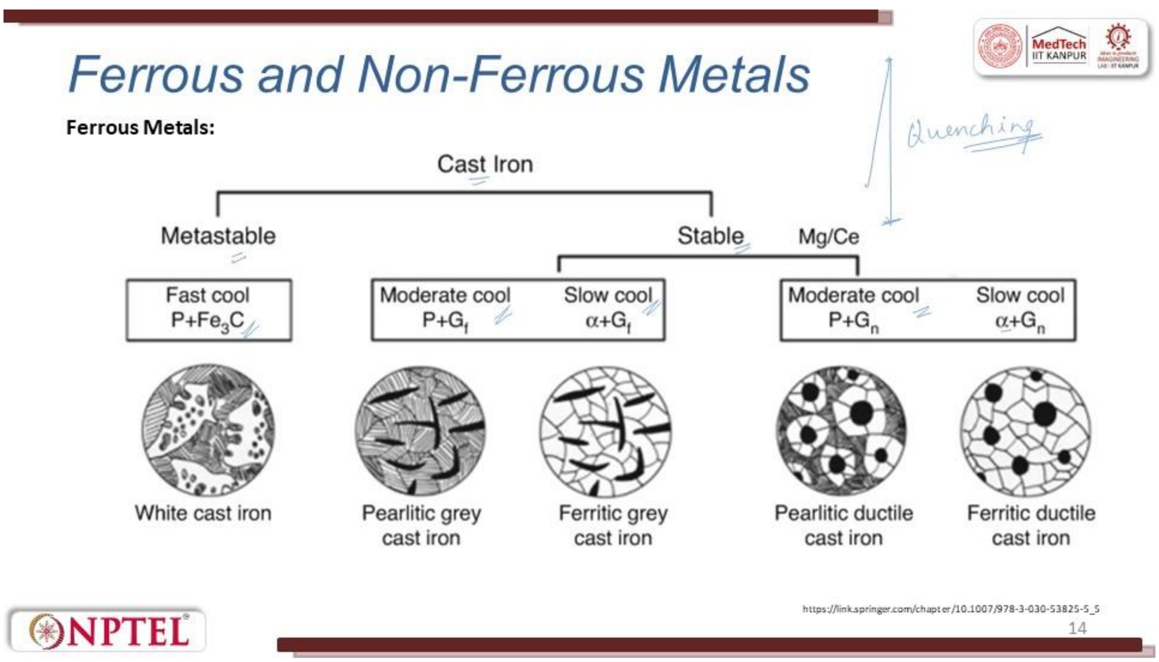
Week 05

Lecture 23

Materials, Metals and Composites (Part 2 of 2)

This lecture, we are going to talk about different materials.

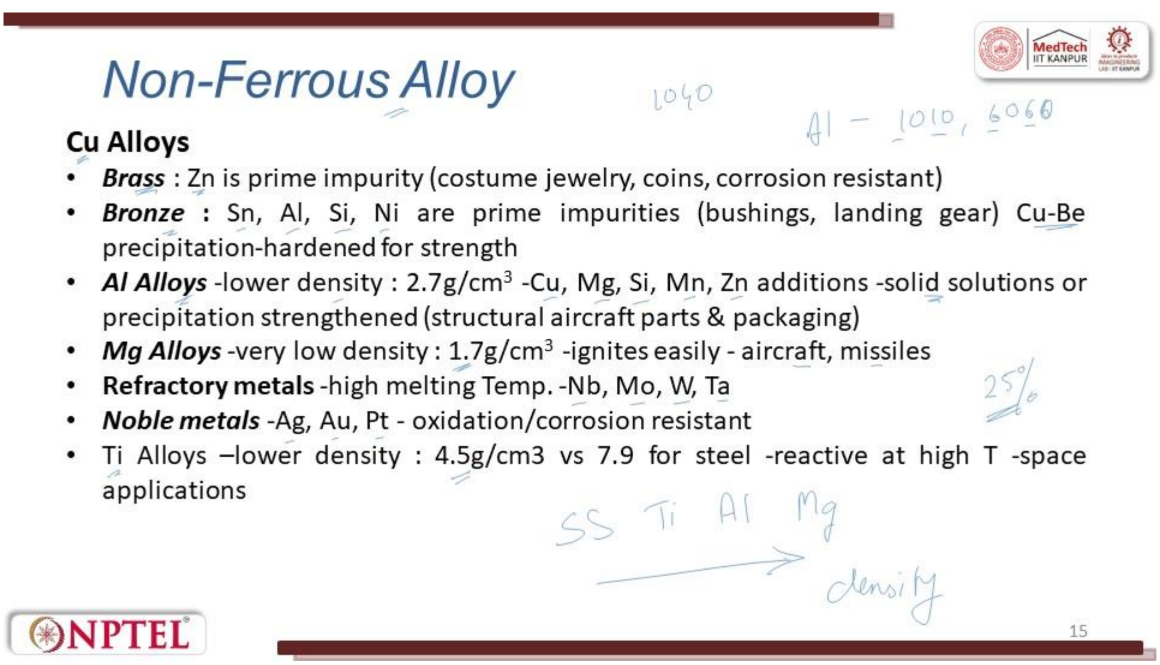


So, when we talk about Cast Iron, it is Metastable and Stable phase. So, in Metastable, fast cooling when you do, it tries to form precipitates + Fe_3C, white cast iron. Moderate cooling, what is Fast cooling? You take it to a very high temperature and then quench it.

Quenching is nothing but you try to heat the iron and then dip it in water or when you try to do a very dry heating of your kitchen utensils keeping it in a burner and then you after few seconds or few minutes, you pour water into it, you get the sizzling sound, right. So that is quenching taking it to a higher temperature and quenching it or bringing it down to the room temperature. From there instantly or slowly whatever it is. So that is when you bring it instantly, it is called as Fast cooling. When you do it slowly, it is called as Moderate cooling or Slow cooling.

So the same structure, you see a moderate cooling you get this structure and when you do slow cooling, you get this structure. When you have a Stable phase, you can do it with moderate cooling, wherein which you add in magnesium or cerium. So, you try to get Moderate cooling, pearlitic structure + GN is there and Slow cooling is alpha + GN is there. So, Pearlitic ductile cast iron, it is Ferritic ductile cast iron. So, why is all these things important?

Depending upon the alloy. The microstructure changes depending upon the microstructure, the performance of the material in service condition also changes.



Now, let us move towards Non-Ferrous Alloys. In Non-Ferrous Alloys, copper is being used for quite some time. So, copper, two most important things of alloys of copper are commonly used.

Many other things are used, but these are more common. Brass and bronze. Brass will always have zinc in its prime impurity used to produce costume jewelry, coins, corrosion resistance behavior. We always go for brass. Bronze is where in which we try to add Sn, aluminum, silicon, nickel, tin, right.

Sn is tin. Our prime impurities like we make brushings, landing gears, all these things out of brass. Copper, beryllium precipitation hardening for strength is also used. Several applications have come. Earlier landing gear we made out of brass.

Now we are making out of aluminium. Then it has gone to composites. So multiple things are there. Next important thing is aluminium alloys which has a very low density around about 2.7 g/cm^3. Here copper, magnesium, silicon, manganese, zinc are added.

So, as I told you, like steel you have 1040, aluminium also you have 1010, you have 6060, right. Depending upon the composition, these codes are given. So, what are the alloys? Copper, magnesium, silicon, manganese and zinc additions are done. So, we use solid solution or precipitation hardening method here.

If you look at magnesium alloys, which is almost half of it. Aluminium itself is light. Now, you are trying to go to magnesium which is much more lighter. So, it is around about 25 percent of the density of that of your steel, stainless steel. So, look at it.

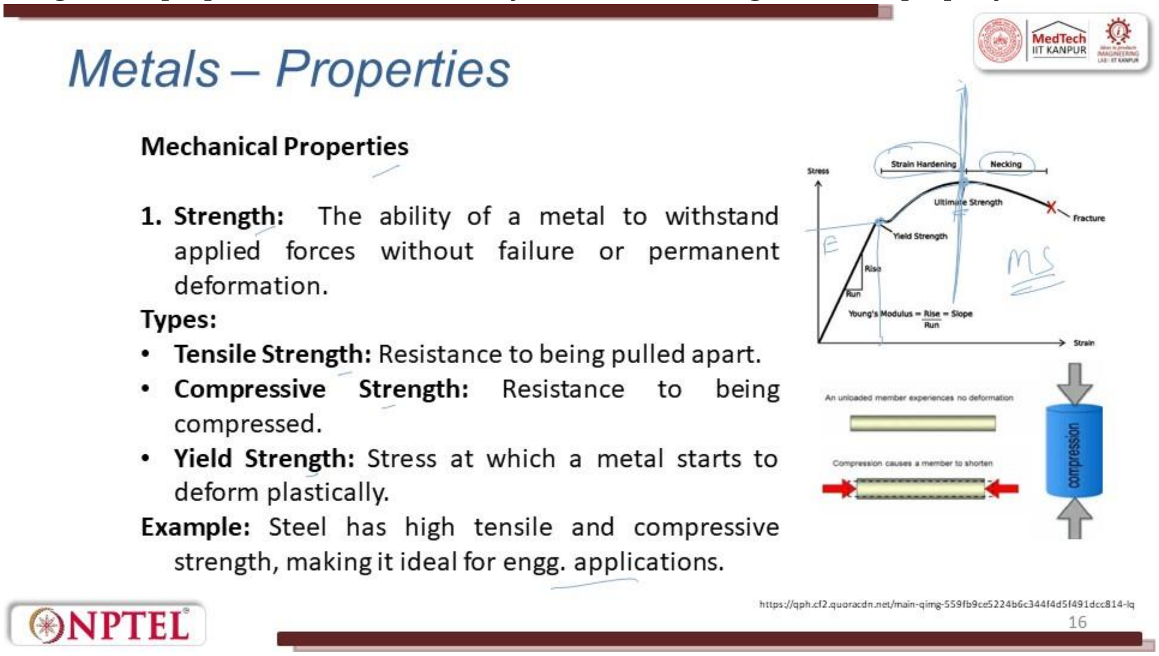
You are going to now make cars out of magnesium alloys. So, where the weight what you carry will be only 25 percent of what is there in steel. It will be very lightweight. So, once it is very lightweight, the mileage goes very high. Saying this, why is it not popularly used?

Processing is a difficulty there. So, magnesium has low density. Its value is around about 1.7 grams per centimeter cube. It easily ignites. It is used today in aircrafts and missiles.

It is very expensive. Then you have refractory materials like high melting point material, niobium, molybdenum, tungsten and tantalum. They are also getting added into copper to get the required output, then noble metals like silver, gold, platinum oxidation and corrosion resistance wherever it is required, they use it. Titanium which has a density of 4.5 grams per centimeter cube. So you will have stainless steel, then you will have titanium, then you have aluminium, then you have magnesium in terms of density.

Though aluminium is inexpensive, but aluminium also puts a restriction in several places you cannot use aluminium. For example, aluminium utensils were used till recently, but now slowly it is getting banned because they say this stresses can get into brain. So, now aluminium utensils are slowly getting removed from the market. So you can see a combination. Suppose you are trying to use a utensil and using the utensil while cooking, and if there is a filled food there, so the weight goes extremely high. When you use titanium as compared to that of magnesium, so your fatigue goes higher. So people are looking forward for magnesium.

So general properties we have already streamed. Strength is one property which we

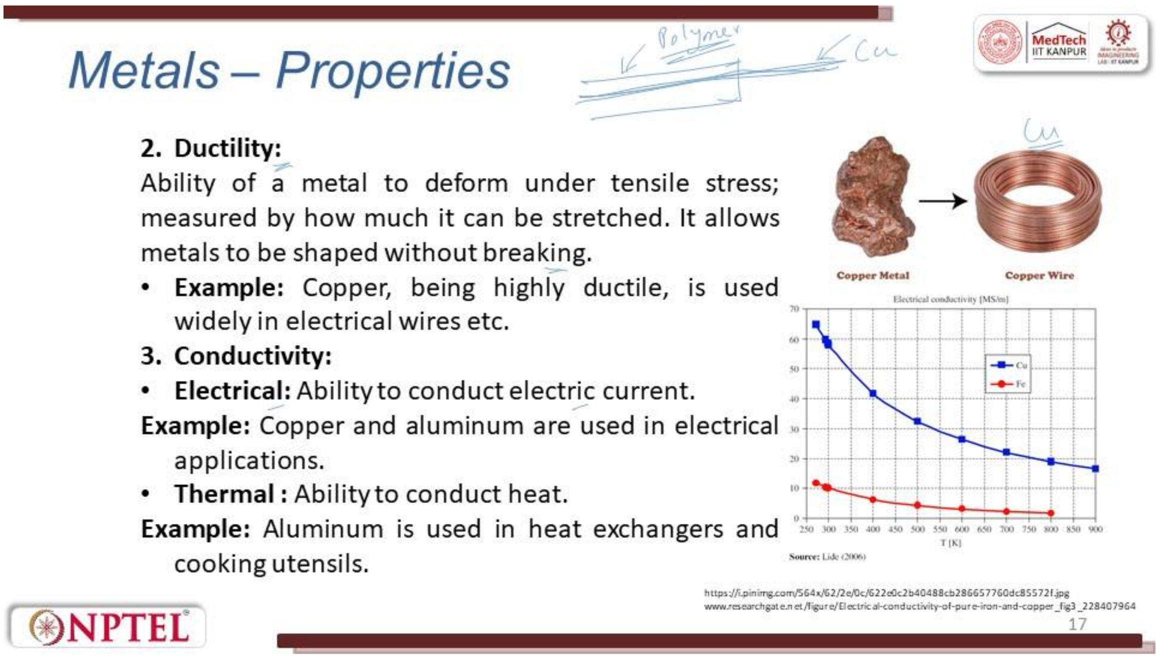


always see. So when we talk about Strength, we look at Tensile Strength, Compressive Strength and Yield Strength.

Yield strength happens here. After that the material start yielding. Before that is always elastic limits where we talk about stiffness. This is the maximum tensile strength happening. The phenomena what happens for increase in strength is called as Strain hardening.

And after the Strain hardening happens to its maximum, reaches ultimate tensile strength, there is a failure which starts. The failure when it starts, it is called as Necking. So, till this point, we always try to do metal forming operations. Metal forming operations are if you want to take a sheet and then deform a sheet to a particular application, we always try to do Strain hardening. Then we get into necking and then we try to go towards a closure.

So the steel has high tensile strength, compression strength, making it an ideal engineering material for multiple use. But this is only for mild steel curve. If it is for aluminium, it will be different. When you are doing for other specific stainless steel, it will be different. When you do for copper, it will be different. So, this is a typical curve wherein which we can see all the points very clearly.

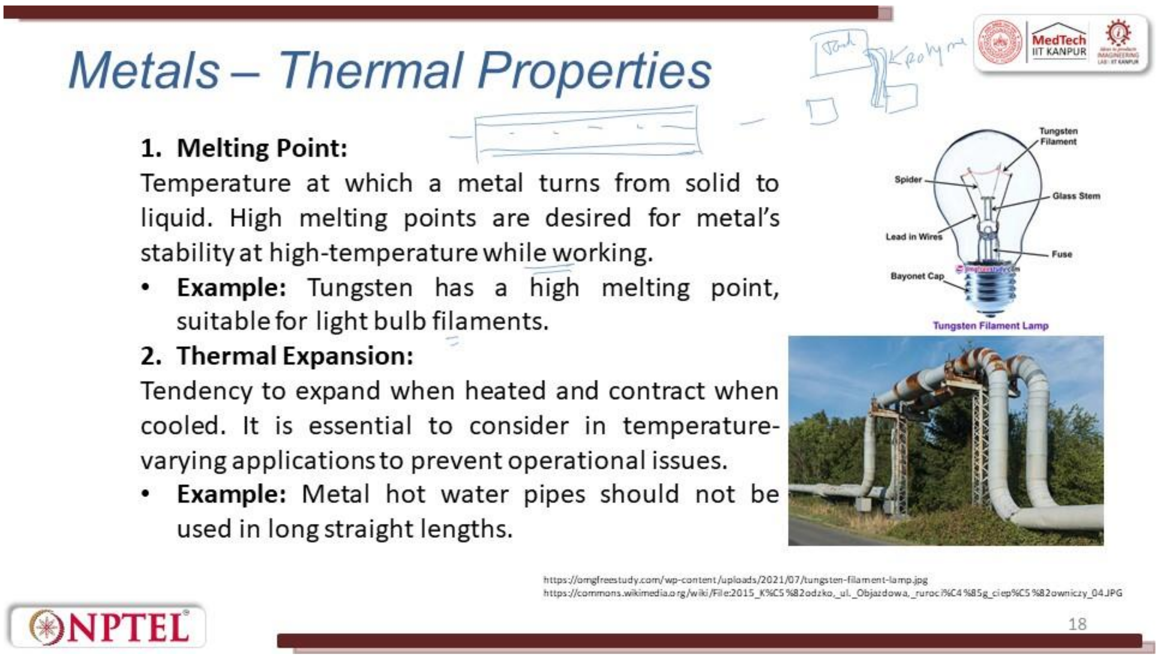


Ductility is another important parameter. Ability of a metal to deform under tensile strength measured by how much it can be stretched. It allows the metal to be shaped without breaking is called as Ductility. For example, copper tubes are ductile.

They start with a big chunk of material and then slowly they convert it and then make small tubes. Then the next one is Conductivity. Under conductivity, Electrical conductivity and Thermal conductivity. Electrical conductivity is the ability to conduct electric current or electrons to move. Copper and aluminium are used exhaustively. If you see olden days, we used to use copper wires.

Today, we are using copper wires. In olden days, we were using aluminium wires. So, these copper wires are used for conducting. What generally we do is we take copper wire, copper is here. We will always have a sealing of polymer.

This is copper wire. This is polymer. And this polymer coating is generally given because it is an insulating material for copper when the electrons are moving, thermal conductivity is the other thing where the ability to conduct heat. Aluminium is used in heat exchangers and other cooking vessels.

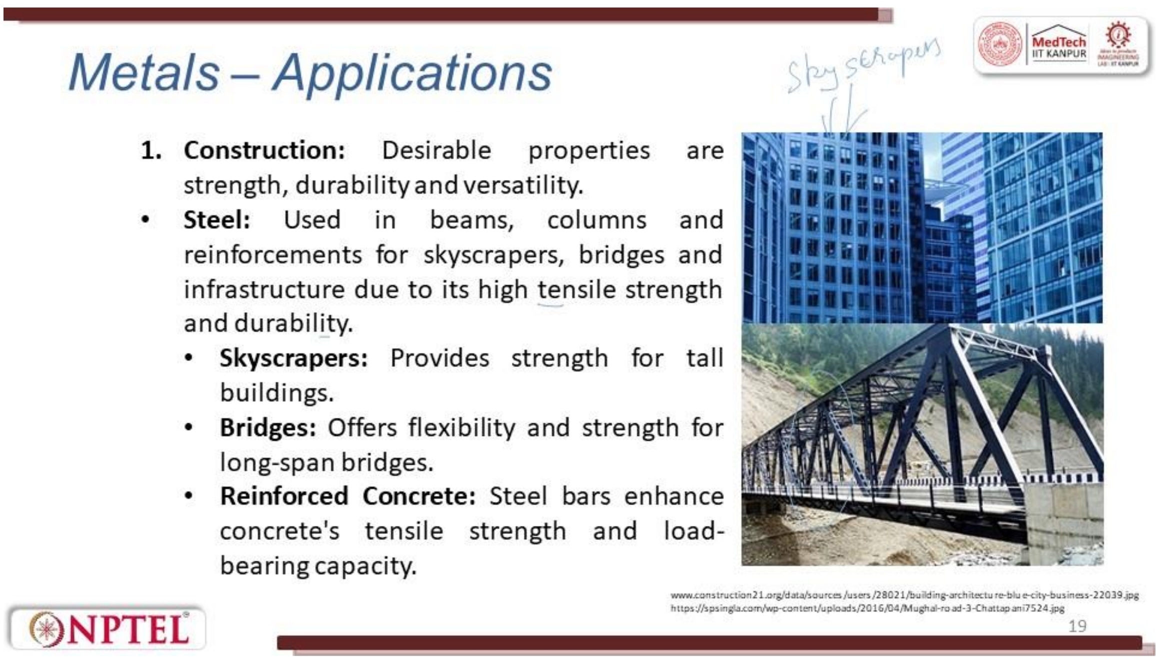


Thermal property, the melting point of metals are always higher, the temperature at which a metal turns from solid to liquid is called as a Melting point. High melting point are desirable for metals stability at high temperatures while working. So, example tungsten has a high melting point suitable for light bulb filament application. So, tungsten is always used in olden days, now it has become LED and other applications. Thermal expansion, tendency to expand when heating and contracting when cooled.

It is essential to consider in temperature varying application to prevent operational issues. Metal hot water pipes should not be used in long straight lines, ok. So, that is how they always do. So, if you have a metal tube for example, which is used in your household applications, right. From the tank overhead (tank of your house), there might be pipe connections which come to your individual houses or flats; this is a tank, right.

Earlier what they used to do is, they used to have a stainless steel pipe or mild steel pipe which gets connected to individual flats. Today, everything is replaced by polymer because during a hot sunny day, the tank water, when it comes through the metal pipe, it always increases the temperature. When you get the water at your home, you get a hot water. In cold winter days, you get only a cold water. So nowadays what is happening, they are trying to replace this pipe with polymer so that there is no thermal expansion and contraction happens.

Thermal expansion and contraction is very important feature for wooden doors also. When it is a rainy day, the wood expands. When it is dry, it shrinks. So thermal expansion is very important parameter when you try to think of service condition. The other important thing is when you are trying to take lot of hot water, you should always have bend portions. Lengthy thing, it will expand and it will contract, so the connections might get broken.

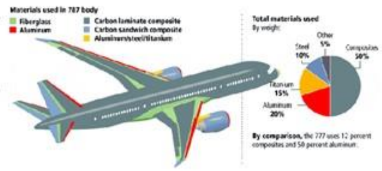


Construction industry, it is desirable properties are strength, ductility and versatility. Steel used in beam, column and reinforced for skyscrapers, bridges and infrastructure due to their high strength and durability. Means, skyscrapers provides strength for tall buildings. Bridges often flexibility and structure for long span bridges and then reinforced concretes are used again in buildings. So, these are bridges, these are skyscrapers.

Metals – Applications

2. **Automotive:** Key requirements include strength, lightweight, corrosion resistance etc.
- **Aluminum:** Used in body and engine parts to reduce weight and enhance fuel efficiency.
- **Steel:** Used for chassis and safety components due to its strength and impact resistance.

3. **Aerospace:** Requires high strength-to-weight ratios, corrosion resistance, and high-temperature tolerance.
- **Titanium:** Used in aircraft frames and engines for strength and corrosion resistance.
- **Aluminum:** Used in aircraft structures for its lightweight and mechanical properties.



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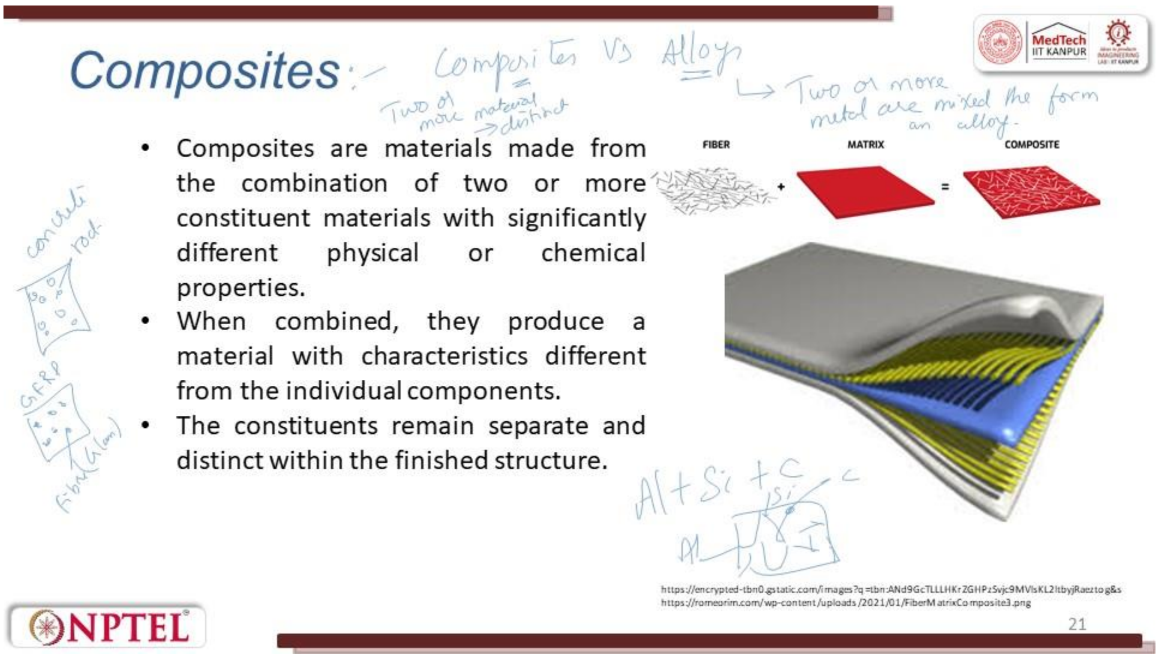
When we talk about automobile, you can see automobile will always include strength, lightweight, corrosion resistance. So, we look at aluminium steel as an alternative. When we go for aerospace, it looks for high strength to weight ratio. Then it looks for corrosion resistance and temperature tolerance.

So, we always go for titanium and aluminium. Landing here today is made out of aluminium.



Composites. This is a new area which is coming up in a very big way. Composites and alloys. Because till now whatever we saw was alloys. Two elements getting mixed. Iron, carbon, iron, silicon, iron, magnesium. So they form alloys. Alloys are generally what happens is when two or more metals are mixed.

They form an alloy, ok. Alloy the mixture whatever you have added the element, you will not be able to distinguish after the mixing process has happened I take aluminium, I take silicon, I take carbon. I try to mix them all. Generally, in room temperature, it does not happen.

So, you take it to high temperature and mix. Now, everything is mixed. So, once it forms a crystalline structure, it is very difficult for you to clearly distinguish and identify. This is C, this is Si, this is aluminium. Because it forms an alloy.

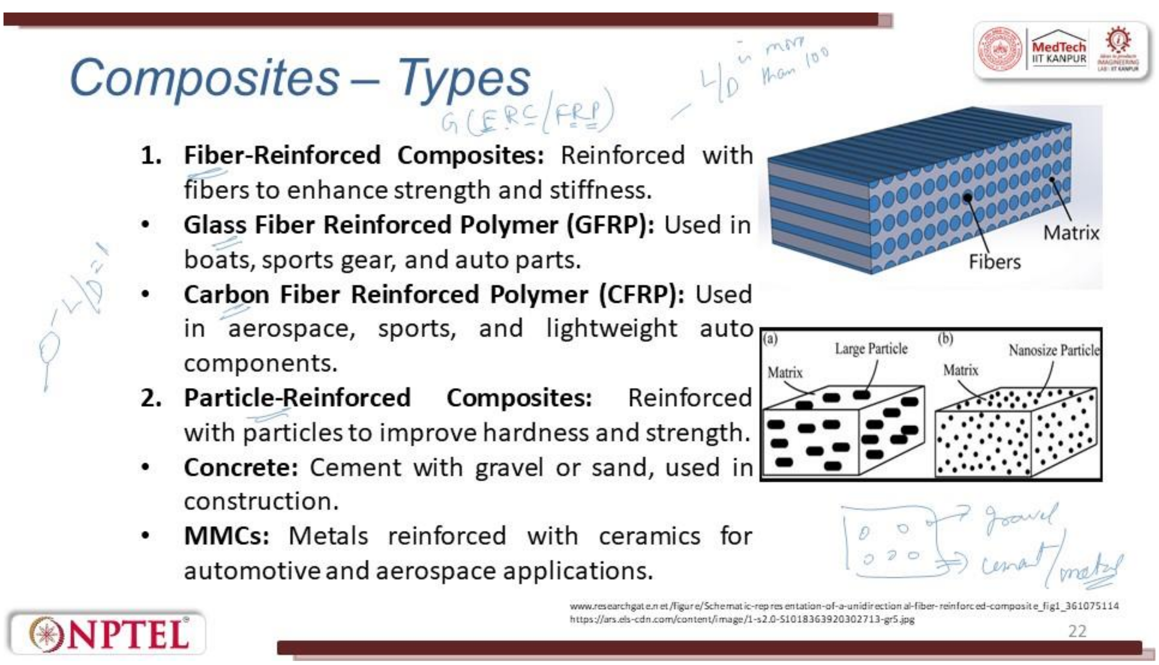
But whereas, in composites, wherein which again here two or more material are mixed together, they can be clearly distinct. After the formation, you take a concrete column. You can see concrete, you can see reinforcement. This is a composite wherein which when you take a cross section, steel is clearly seen, concrete is clearly seen. That is a composite.

When you take a glass fiber reinforced composite, you try to cut it, you try to see glass fibers. So, concrete, these are rods. This is GFRP (Glass Fiber Reinforced Polymers). So, you can see here, these are fibers made out of glass. When you take a cross section, you can see that in composites, it is clearly distincts that you have added two materials.

Now, these two materials are binded together and it tries to give a higher strength. So, composites are materials made from a combination of two or more constituent materials with significantly different physical or chemical properties. The mixing will have, for example, glass fiber will have a higher strength. It is glass as a ceramic material and polymer which is around it will be using as a matrix has distinct property. Polymer function is only to hold the glass fiber.

The glass fiber takes the load. Same here. Concrete is only to hold the rods and it takes compressive load. The tensile load is predominantly taken by rods. So, when we are talking about buckling, remember buckling.

So the rods play an important role. The concrete whatever is there does not take any deflection. So it immediately it shatters or it crushes. When combined, they produce a material with a characteristics different from the individual components. The constituents remain separate and distinct within the finished structure.



When we talk about composites, there are several types of composites. So, the reinforcement is fiber, the fiber can be made out of glass or carbon. Fiber reinforced composites which is otherwise called as FRC or FRP which is nothing but Polymer Reinforced Composite or FRP which are reinforced by fibers. So, you can try to add G in the front. So, it becomes 'Glass Fiber Reinforced Composites' or you can try to put carbon there or you can try to put Kevlar there.

So, K C is possible. So, when we try to talk about Fiber Reinforced Composites, the reinforcement with the fiber to enhance strength and stiffness. Glass fiber reinforced polymers are used in boats, sports gears, and auto parts carbon fiber are used in aerospace sports and lightweight components. The tennis racket are made out of carbon fiber reinforced polymers, the golf stick is made out of the stick, stem is made out of carbon fiber which is very lightweight, the crutches or the artificial limb which where strength is required, compression strength is required, they are made out of carbon fibers today.

So, these are some of the applications of Fiber Reinforced Composites. The reinforcement can be in the term of a fiber or it can be in terms of particulates. So, what are particulates? Particulates are like this. So, where the length L by D ratio will be almost equal to 1.

When we are trying to talk about Glass Fiber, the length by diameter ratio is more than 100 times. So that means to say the diameter will be very small, the length will be very long. So particulate reinforced composites, reinforcement with particulates to improve the hardness and strength. So concrete, cement with gravel or sand used in concrete, so that is called as Particulate reinforcement. So here you will have gravel.

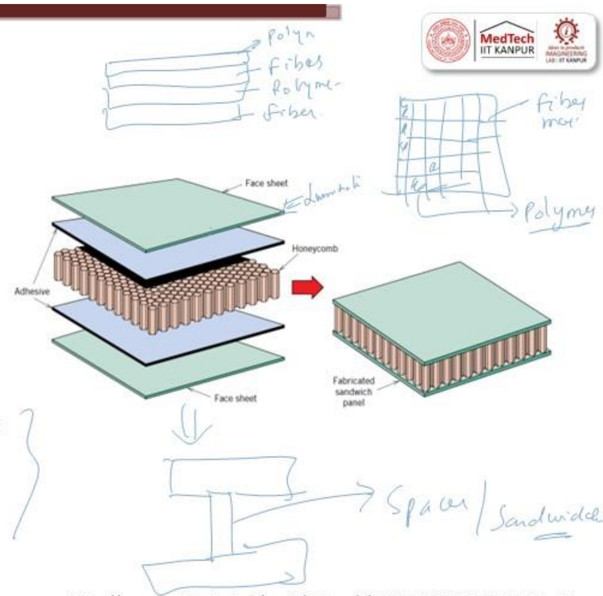
These are no reinforcement, where it is good for only compression. So in metal matrix composite, we are looking at the matrix is cement, right. So you can also have the matrix as metals. So you will have more ductility. So you can also have metal matrix composite.

Metal matrix composite is you will have a metal as a matrix and it is reinforced with particulate. These particulates can be nano sized, micro sized, meso sized. You can have a polymer material. Generally we do not have polymer. You can have ceramic which is getting reinforced.

So, metal matrix and reinforcement with ceramics. Why is it required? If you want to improve the fracture, a toughness behavior of the metal, we always go for metal matrix composites.

Composites – Types

3. **Structural Composites:** Designed for structural applications, often with layered or laminated structures.
- **Laminated Composites:** Used in aircraft wings for high strength.
- **Sandwich Panels:** Lightweight core between stiff face sheets, used in aerospace and automotive industries.



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The types of composites, you can have structural composite designed for structural application often with the layered. So, what we do is we try to have a layer by layer approach.

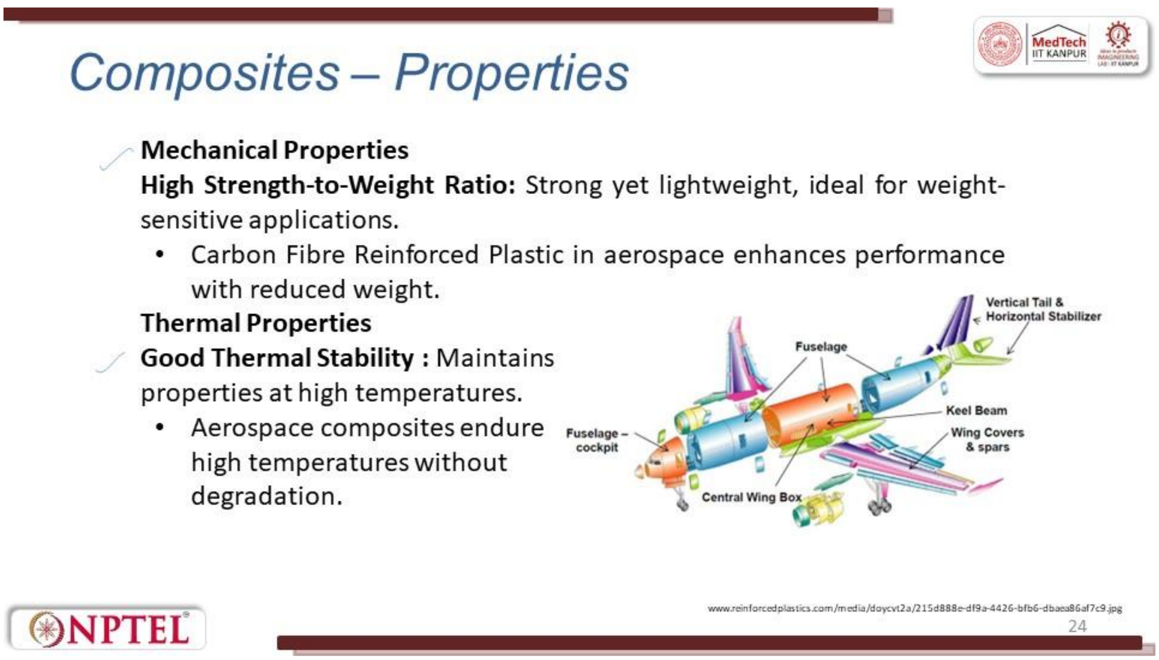
This is called as layer approach. So, here you can have polymer. You can have glass fiber, you can have a polymer, you can have a fiber separately or in one layer itself, you can have these are fibers, these are mat. You can have a fiber mat which is reinforced with polymer. These are polymers

like your handkerchief, when you soak it into water, the water seeps inside. So, when you keep it dried, what you get is a mat, wherein which in the mat itself you can have combinations. So, structural composites, we always try to use layer by layer approach. So, or we have laminated composite or we have sandwich composite. Laminated composites are used in aircrafts, wings and other thing, where these are called as Laminated composites.

Structural is layer by layer you can have. Sandwich composites are interesting. These are called as Sandwich composites. And these are called as, by the way if you use this alone it is called as Laminate. Sandwich composites are composites wherein which you have laminated layers on the top and you will have a spacer in between which tries to increase the thickness and try to give you strength also.

So, this is very similar to the analogy of your I-beam. You have a spacer, you have two flat things. This is a spacer. So, the spacer is replaced by a sandwich. So, here you have a honeycomb structure.

So, the honeycomb structure. So, more and more distance you want, you increase the spacing and the top and the bottom alone will undergo tensile and compressive. and the top and the bottom alone will undergo tensile and compressive. So, the laminate to be attached with the spacer honeycomb structure is done by an adhesive. So, if you try to make a composite like this, it is called a Sandwich composites. If you have all of them made out of laminates, it is called a Laminated composite.



So, compared to metals the mechanical properties such as it has a very high strength-to-weight ratio. So, the strong yet lightweight ideal for sensitive applications. Thermal properties it has a good thermal stability very high temperatures very it can withstand. So, these are some of the properties which make it more suitable for real time. So, you will have mechanical properties you have thermal properties.

Composites – Applications

1. **Aerospace:** High strength-to-weight ratio and durability.
- Carbon fiber-reinforced polymers (CFRP) in aircraft wings and fuselage for weight reduction and improved fuel efficiency.
2. **Automotive:** Reduces vehicle weight and enhances performance.
- Composites in car body panels and chassis components to improve strength and fuel efficiency.
3. **Sports Equipment:** Lightweight and high-performance.
- Carbon fiber in bicycles, tennis rackets, and golf clubs for superior strength and stiffness.

www.m-chemical.co.jp/carbon-fiber/images/case/aircraft/aircraft-item-img01.jpg
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So, the composite application is going to be, it has a aerospace application, automotive application, sports equipments, aerospace. It has a very high strength to weight ratio and durable. So, the carbon fiber reinforced polymers in aircraft wings and fuselages are made out of composites. Fuselage is the center portion, wings, right.

Automotive like the frames are all made out of it. Sports application, the carbon fiber bicycle, tennis racket, golf club stick, all of them are made out of composites today.

Glass

Glass is an amorphous solid, meaning it lacks a long-range crystalline structure. It is typically transparent and can be formed into various shapes and sizes.

Types:

1. **Soda-Lime Glass:** It is the most common type of glass, composed mainly of silica (SiO_2), sodium oxide (Na_2O), and lime (CaO).

Applications: Used in windows, bottles, and jars

2. **Borosilicate Glass:** It contains silica and boron trioxide, making it more resistant to thermal shock.
- **Applications:** Used in laboratory equipment, cookware, and high-intensity lighting.

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Next interesting material is going to be Glass. Glass finds its application because you are integrating all other mechanical properties + transparency. It is an amorphous solid meaning glass.

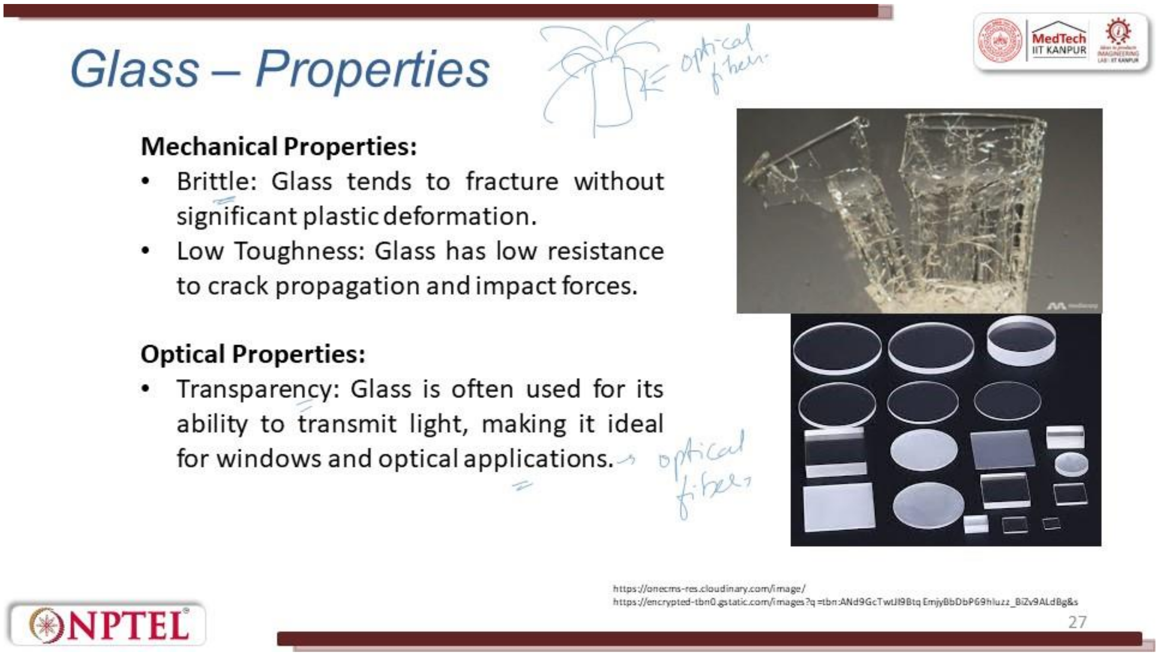
It lacks a long range crystalline structure which is very common in metals. It is typically transparent and can be formed into various shapes and size. So, when we talk about glass, Soda-Lime Glass, it is the most common type of glass composed mainly of silica and sodium oxide. Along with lime. So this is very commonly used. Soda-Lime Glass. So it is transparent. It is brittle also. So silica, sodium oxide. Lime are mixed.

So why I am telling you all the mixture? Here also it is an alloy which is getting formed. But we generally don't call it as an alloy. So Soda-Lime Glass as silica. The application is window, bottles, jars are made out of Soda-Lime Glass.

Slightly higher purified process glass are called as borosilicate glasses. When you buy borosilicate, thermos flask, they always write at the bottom borosilicate glass. When you buy all the apparatus for your chemical lab or chemistry lab, it is made out of borosilicate glass. It contains silica and boron dioxide making it more resistant to thermal shock. The microwave glass jars, microwave processable jars are made out of borosilicate glass.

Because it can withstand thermal shock. Window glasses cannot withstand and it is not required. Because the temperature may be typically in the north of this country can vary from maybe minus 1, it can go up to 50 degrees Celsius, minus 1. So, this can be a cold winter day and this can be a hot summer day. So it is a thermal shock, but here the shock range is not very high.

So it finds its application in laboratory equipments, borosilicate glass, cooking ware and high intensified lighting.



The mechanical properties are brittle. The glass tends to fracture without significant plastic deformation. So as I told you, you have to use the mechanical property to your advantage. When you try to take a glass, when you make an ampule, we fill the ampule and the glass is sealed, right.

So, here when it is used in the operation theatre or when your doctor does, he will always look for brittle fracture. So, it will have to fail faster. It has to seal 100% and it has to fail faster. So, there we look at brittleness. The glass tends to fracture without significant plastic deformation.

It has low toughness. The glass has low resistance to crack propagation and impact forces. The optical property is very good. So, it is very transparent.

Glass – Applications

1. **Windows:** Glass's transparency and aesthetic appeal make it ideal for residential and commercial windows.
2. **Optical Fibers:** Glass fibers are used in telecommunications for high-speed data transmission.
3. **Laboratory Equipment:** Borosilicate glass is used in labware due to its thermal and chemical resistance.
4. **Borosilicate Glass in Labware:** Borosilicate glass is used for beakers, flasks and test tubes in laboratories due to its durability and resistance to thermal shock.

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The glass is often used for its ability to transmit light making it ideal for window as well as optical application.

So, we have optical fibers. Made out of glass, right. And then we also have optical fibers are one. Now when you look at amusement parks, they have a tree and then around the tree, they have this leaf like structure. They are all made out of optical fibers.

These are all low cost optical fibers. All the transmission of data is happening through the optical fibers. The internet cables are made out of optical fibers. So, some of the glass applications are windows, optical fibers, laboratory equipments and borosilicate glass in lab wares or in kitchen wares. So, this is the typical optical fiber it goes.

So, you transmit light through an optical fiber. So, the optical fiber thickness will vary in between 10 microns to 50 microns and which is half of your hair size.

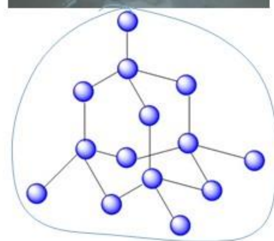
Diamond

- Diamond is a crystalline form of carbon where carbon atoms are arranged in a specific, highly ordered structure.
- It is renowned for its exceptional hardness and brilliance.

Structure:

Tetrahedral Lattice:

- In diamond, each carbon atom is covalently bonded to four other carbon atoms in a tetrahedral arrangement.
- This creates a three-dimensional network of carbon atoms, contributing to diamond's strength and hardness.



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Diamond is a crystalline form of carbon. We saw polycrystalline we saw amorphous, now we are seeing crystalline. Diamond is a crystalline form of carbon where carbon atoms are arranged in specific highly ordered structure because of that, it has a very high value, it has very high thermal conductivity and it also has thermal stability.

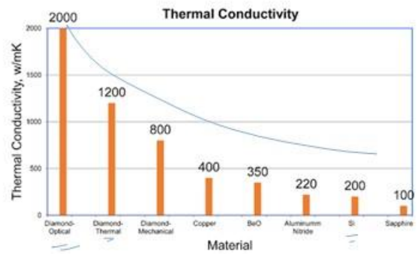
It is renowned for its exceptional hardness and brilliance, the structure it follows a tetrahedral lattice structure. In diamond, each carbon atom is covalently bonded; covalent is very strong to four other atoms in a tetragonal arrangement. This creates three-dimensional network of carbon atoms contributing to diamond strength and hardness. Because of its structural property, it demonstrates the hardness behavior. Today, diamond-like coating has come.

So, this diamond-like coating sticks very well to the surface of the metal and it also gives lubrication property, carbon has a very good lubricating property.

Diamond - Properties

2. High Thermal Conductivity:

- Diamonds exhibit high thermal conductivity due to the strong covalent bonds and low atomic mass of carbon atoms within the lattice.
- This property allows efficient heat dissipation, making diamond an ideal material for high-performance thermal management applications, such as in electronic devices where overheating can be detrimental.



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So the hardest natural material is diamond which holds the title of the hardest natural material, a characteristic attribute to its tetragonal lattice structure. So why am I talking more about this? The structure plays an important property as far as the mechanical behavior is concerned.

The structural impact, exceptional resistance to scratch and abrasion making diamond invaluable for cutting, grinding and drilling applications. As I have talked several times, the thermal conductivity property you can see for metals and you can see for diamond.

Diamond - Properties

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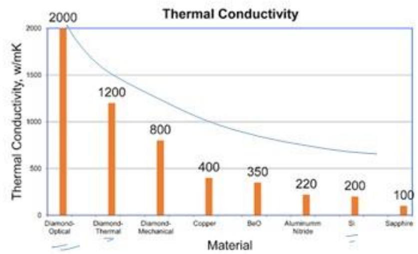

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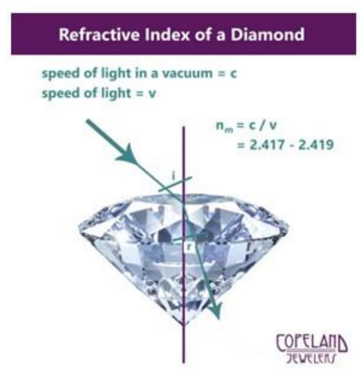
Diamond - Properties

Optical Properties

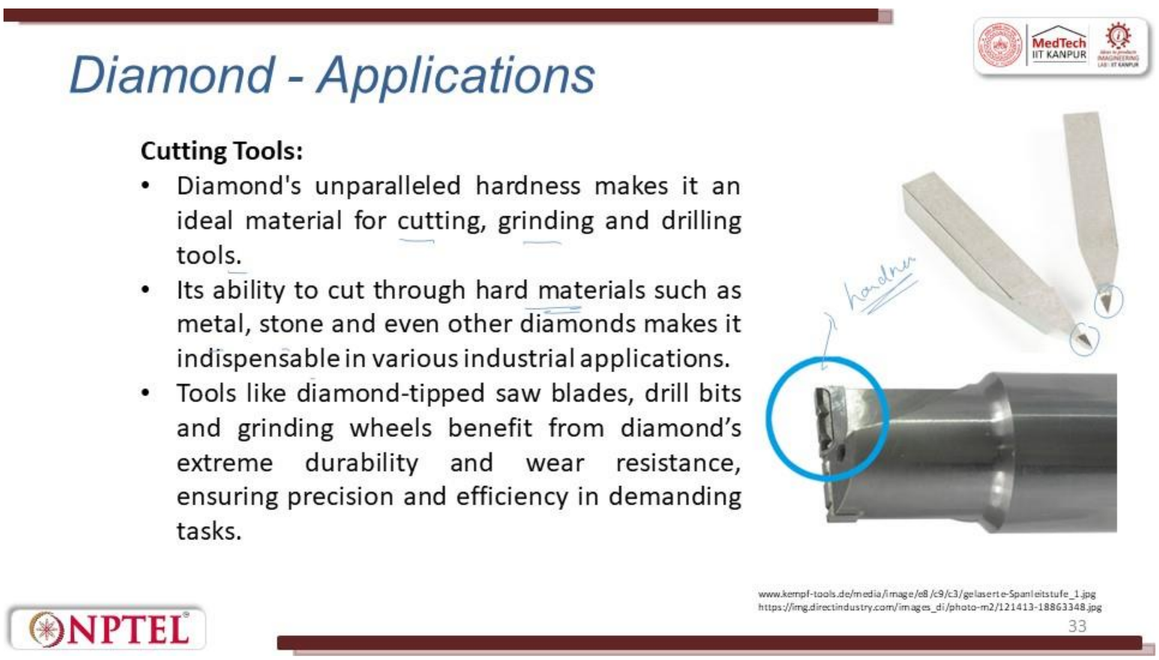
1. High Refractive Index:

- Diamonds possess a high refractive index, a measure of how much they bend light.
- This property is responsible for the remarkable brilliance and sparkle of diamonds, as they disperse light into its constituent colors.
- This optical property is highly prized in gemstones and is also utilized in specialized optical applications, such as high-precision lenses and laser technology.



Highly refractive index is there because of its structure. It also reflects light in a very nice fashion. So, high refractive index. Diamond possesses a high refractive index, a measure of how much they bend light. This property is responsible for the remarkable brilliance and sparkle of diamond.

This optical property is highly priced in gemstone and is also utilized in specialized optical applications such as high precision lens in laser technology.



In cutting tools, because of its high hardness, it is used as a material. So, we do not use the complete material of diamond. We make a tip and the tip is braced to the tool structure. So, you can have like pencil like structure. Diamond's unparallel hardness makes it an ideal material for cutting, grinding and drilling tools.

Its ability to cut through hard materials such as metals, stones and even diamond makes it indispensable in various industrial applications. Tool like diamond's tipped saw blades, drill bits and grinding wheels benefits from diamond's extreme durability.

Diamond - Applications

Jewelry:

- Diamonds are renowned for their exceptional brilliance and durability, qualities that have made them highly valued in the jewelry industry.
- The high refractive index and dispersion of light give diamonds their unique sparkle, making them a popular choice for engagement rings, necklaces, earrings, and other fine jewelry.
- Their ability to withstand scratching and wear ensures that diamond jewelry maintains its beauty over time.

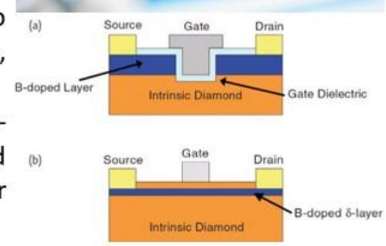
https://manubhai.in/SocialMedia/post_artworks/BJD-16-2Nov2023.jpg

It also finds an application because of its refractive index in the jewelry index. High refractive index and dispersion of light gives diamond a unique sparkling and property.

Diamond - Applications

Electronics:

- In the electronics industry, diamonds are used for their superior thermal conductivity, which is beneficial for heat dissipation in high-power electronic components.
- Diamond heat sinks and substrates help manage heat in semiconductor devices, improving performance and longevity.
- Additionally, diamonds are utilized in cutting-edge applications like quantum computing and high-frequency electronic devices due to their exceptional electronic properties



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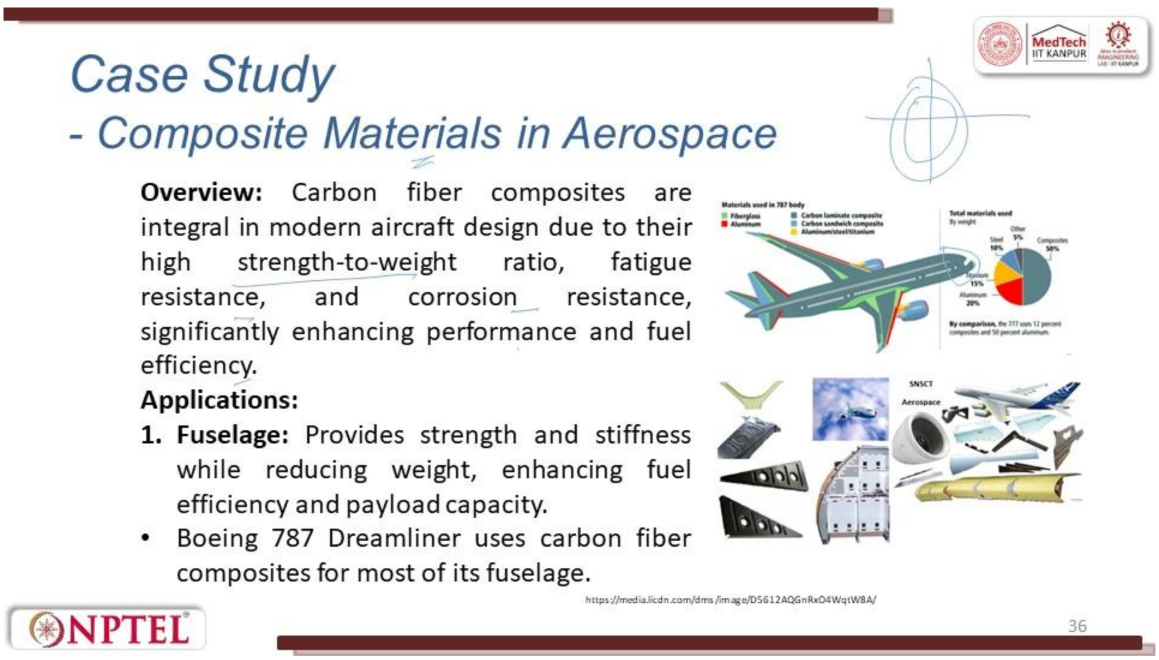
Electronics today are using diamond as an application because of its thermal heat dissipation property in high power electronic components.

When we talk about electronics, the size is very small. So, it has to be so many J/cm^3/cm^2. So many joules or millijoules. This area is very small because of that the density of heat is pretty high. The heat has to be dissipated, so that is diamond is used as a material.

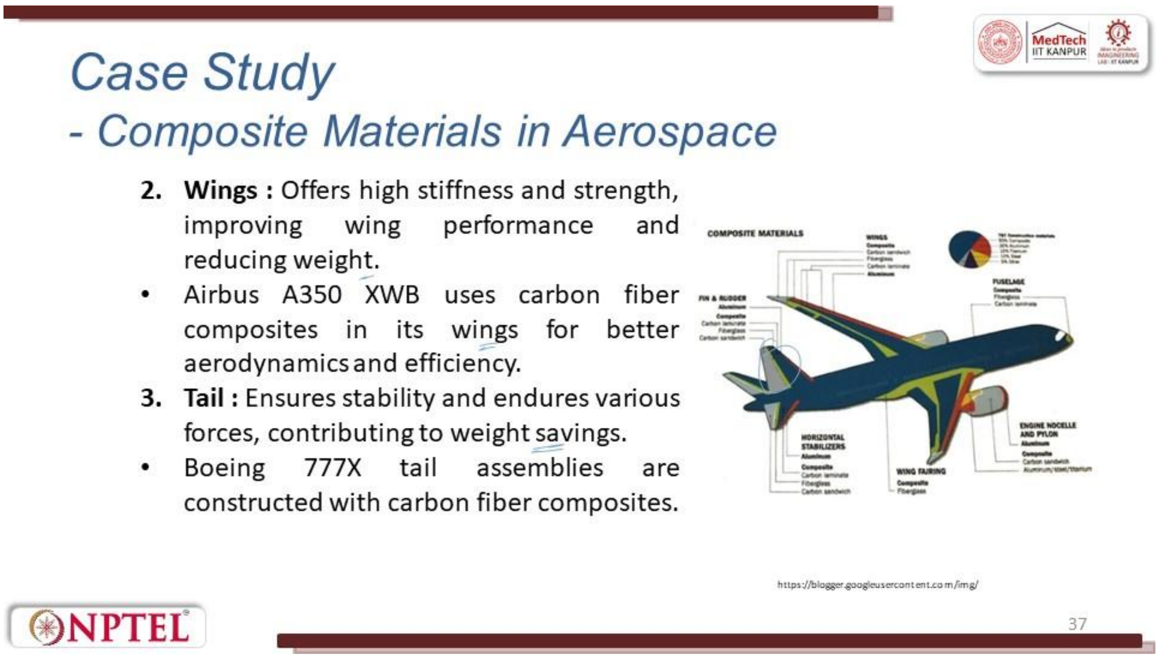
Diamond heat sinks and substrates help to manage heat in semiconductor industry. Diamond are utilized in cutting edge application like quantum computing and high frequency electronic devices.



Let us see a case study where composites is used in aerospace application. So, Carbon fiber composites are integral in modern aircraft design due to its high strength to weight ratio, fatigue resistance, corrosion resistance and significant enhancing performance and fuel efficiency. The Fuselage provides strength and stiffness.

What is Fuselage? It is a circular portion of a plane, cross section, right. It is never a circle, but I am just representing it. It will be a thin wall. This is called as a Fuselage, right.

So, it will have an axis. So, provides strength and stiffness while reducing the weight, enhancing fuel efficiency and payload capacity. Payload is a base load. Boeing 787 Dreamliner uses carbon fiber composite for most of its fuselage. So, it is last light weight as possible.



Then wings offer high stiffness because there is always a wind load which also makes it to deflect up and down, offers high stiffness and strength improving wind performance and reduced weight. So, if the wind performance is poor. For example, then the drag increases. Drag increases, the mileage reduces. Airbus 350XWB uses carbon fiber composites in its wing for better aerodynamic properties.

The tail which is there ensures stability and endures various forces, contributes to the weight saving. So, this is also made out of carbon fiber reinforced plastic.

Case Study
- Composite Materials in Aerospace

Benefits:

- **Weight Reduction:** Enhances fuel efficiency and reduces operating costs.
- **Strength and Durability:** Ensures structural integrity and longevity.
- **Corrosion Resistance:** Lowers maintenance costs and extends service life.
- **Improved Aerodynamics:** Allows for more efficient designs, reducing drag.

So, the benefits what we get because of composites are weight reduction, strength to durability, corrosion resistance and improved aerodynamic property. Why are we talking about aerodynamic property? Because of the profile whatever is there. You try to tear the air. When you try to tear the air, the efficiency and the mileage increases.

To Recapitulate

- What is the primary purpose of studying different engineering materials?
- What are the two main types of metals and give examples of each?
- What are three key properties of metals?
- What is a composite material and what are the three types of composites?
- What is a key advantage of composites over traditional materials?
- List two types of glass and their typical uses.
- Describe the crystalline structure of diamond.
- Why is diamond considered the hardest natural material?
- How are composites utilized in aerospace engineering?
- What are the primary benefits of using carbon fiber composites in aircraft design?

So, to recapitulate whatever we have seen in this lecture, we saw what is the primary purpose of studying engineering materials, what are the two main types of metals, ferrous, non-ferrous, what are the key properties of metals, what is a composite material, what are the different types of composite material, advantage of composite material. We studied about glass and its typical use along with the types. Then highest purity crystallinity is given by diamond.

Why is it used and where is it used? And finally, we saw a case study on usage of composite materials in real time.

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We have referred these books for preparing this lecture notes.

Thank you very much.