# Introduction to Composites

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## Lecture – 18
## Ceramic, and Carbon Matrix Materials, and Filter Materials

Hello, welcome to introduction to composites. Today is the last day of this ongoing week and over this entire week we have discussed different types of matrix materials and the way we have classified this these types of matrix materials is based on their use temperature. So, we started discussing polymers as matrix materials, where the use temperature was at the most 300 degrees centigrade and within the polymers we discussed 2 types of matrices poly this thermo sets and thermo plastics and what we saw is that a lot of thermo sets cannot be used maybe more than 150, 170, 180 degrees centigrade. But, if we want to go for a little high and thermal temperature application, we can use matrices such as peek polyether ether ketone where that use temperature could be as high as high as 310 degrees centigrade. So, that is the first class of materials which are based on plastics.

Then, if we want to go up to even higher temperatures let us say 500, 550 degrees centigrade we have looked at metal based matrices and specifically we saw that 2 types of materials are more popular compared to others; one is titanium based alloys, the other one is aluminum based alloys. We can also use materials which are based on boron which are very light, but the limitation of boron based alloys is that they are highly reactive or boron as well as magnesium they are highly reactive particularly magnesium it reacts very vigorously with oxygen burns very fast. So, it is not that much popular, but both these titanium based and aluminum based alloys can get us up to as high as 510, 520 degrees centigrade.

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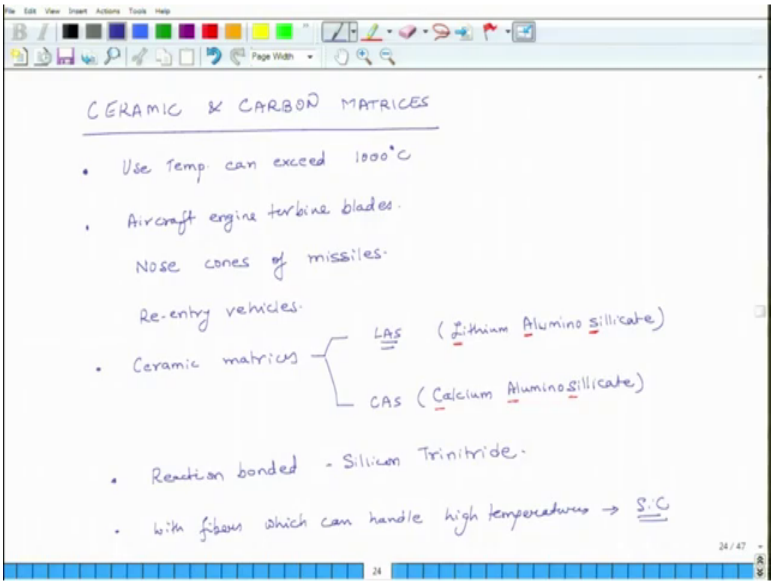


If our thermal requirement is even higher and we want to be in the 1000 degrees range then we go for ceramic and carbon based matrices. So, we will have a very quick overview ceramic and carbon matrices. So, all these are exotic applications, but it is just to have a good idea at least the awareness should be there. So, here the use temperature can exceed 100 degrees centigrade typically it does not exceed maybe 16 or 1700 degrees centigrade, but we can go to higher temperatures.

Some of the important typical applications are aircraft engine turbine blades, the temperatures are really high there or nose cones of missiles, re-entry vehicles and there may be some other applications. So, you may want to explore on the net what other possible applications could be for ceramic and carbon based matrices. So, these are some of the important applications

Now, I will give you a couple of names. So, a lot of times these ceramic based materials ceramic matrices they are made from two types of materials, two types of ceramics are used. So, the first ceramic which is used is known as LAS. So, L is lithium aluminum or it is Lithium Alumino Silicate, so, that is why it is LAS. Lithium alumino silicate this is one ceramic based matrix which is used, the other one again has a short form and it is known as CAS. What is a CAS? It is Calcium Alumino Silicate. So, again CAS and a lot of time these ceramics they are bonded to the fibers using silicon tri nitride. So, they are reaction bonded using silicon tri nitride and so, that is about ceramic materials and the last point about ceramic materials is you can use these materials with fibers. So, there is no point in using these ceramic materials if the fiber breaks down at low temperatures.

So, the real value of these matrices comes in when you use these matrices with fibers which can handle high temperatures handle high temperatures. So, a lot of times they are used with silicon carbide fibers. So, you have a carbide fiber and you have a ceramic matrix and the overall product is really high temperature resistant.

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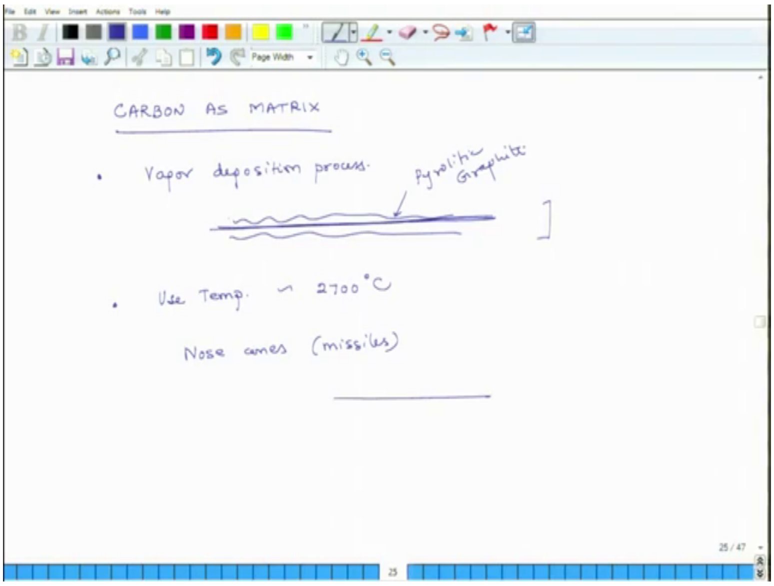


Next, we will look at carbon based matrices carbon as matrix. So, how do you design or produce this kind of a matrix? So, again we had discussed about CVD, this CVD process vacuum deposition process. So, it is produced by, oh sorry, vapor deposition process. So, it is produced by vapor deposition process. So, what do you have you have a graphite fiber. So, a lot of times carbon is used as a fiber and it is also used as a matrix. So, you have cover fiber running through a carbon matrix. So, you take a carbon fiber and then you deposit over it, the carbon as a matrix and how do you do it through this vapor deposition process. Here, what you do is, you have a pyrolytic graphite and then using some reactive process you deposit slowly the graphite over the fiber and these guys can take really very high temperatures.

So, use temperatures it can be as high as 2700 degrees centigrade and once again this is again used in nose cones missiles, re-entry vehicles and things like that, but while using these, you have graphite as matrix and graphite as fiber and it enters the atmosphere at

2700 or 2000 degrees plus temperature, it can right away burn. So, to make sure that it does not burn off and become carbon dioxide you deposit the entire thing coated with some something which prevents oxidation. So, that is an important thing to consider.

So, this is all we wanted to discuss in terms of carbon as matrix material. So, we have discussed ceramics. So, at the low end we have thermosets, then we go to peak then we go to metals as matrix materials, then we go to ceramics and if we really have to go and cross to 2000 degrees centigrade then we use graphite as the matrix material.

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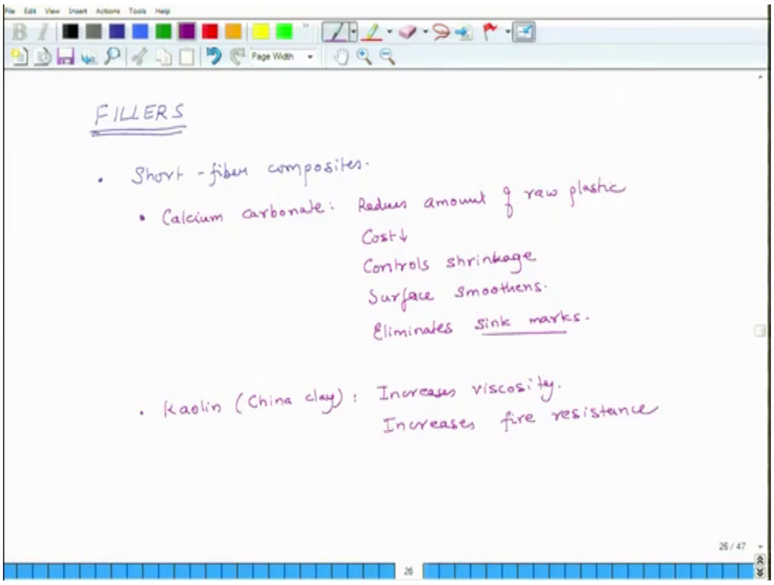


The last topic I wanted to discuss was about fillers. So, these fillers are typically used in short fiber composites and again the application is a lot of times for day to day applications chair, stools, pipes things like that. So, we do not use it for high end engineering applications these fillers, but these fillers do a lot of they provide for a lot of functions.

So, let us look at some of the important fillers. One filler is calcium carbonate. So, why do you use this? So, suppose you want to produce a lot of plastic and the raw material of plastic is expensive relatively and you want, but you if you have to make a chair you have to use a certain amount of volume, what do you do? You fill it with some extra stuff calcium carbon dust, so it reduces amount of raw plastic, which brings down the overall cost of the product. It also does besides that it also does something good it controls shrinkage, because if you remember a lot of these plastics after curing they shrink. So, it reduces shrinkage.

Surface smoothness, because in a lot of these day to day to day products you need a good surface finish for aesthetic reasons surface smoothness and it eliminates sink marks. So, what is the sink mark? It is a mark when you do injection molding there are places where you get sink marks. So, please and that comes out as a cosmetic defect. So, it eliminates those sink marks or at least reduces it. Another, filler is kaolin it is also known as china clay. So, what does it do? If you are the reason is very thin very it is viscosity is not high enough then everything will not form the shape correctly easily.

So, it increases viscosity. So, it all depends on what is your the application. So, if the viscosity is not too high if you inject it with fibers the fibers may pop out of the surface, but if viscosity is high they will not come out of the surface. So, that is there and it also increases fire resistance. So, that is kaolin.

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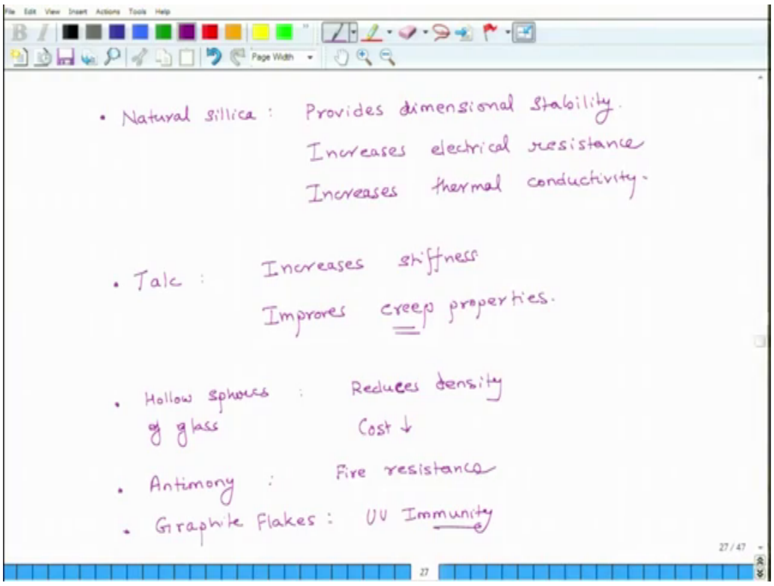


Then we have few more materials natural silica. Once the material comes out it contracts and because you have mixed it with fiber it may not contract everything, may not contract very uniformly because you may have fibers, short fibers are there they have some specific orientations associated with those orientations are specific CT’s, so, it will not shrink uniformly. So, you think that you will get a part like this, but when it comes out it may be a little bit deformed part. So, what you really want is that this type of part should come out. So, in other words, you want to provide it with some dimensional stability that is called dimensional stability.

So, this silica it has been found that it provides dimensional stability. It also increases electrical resistance and increases thermal conductivity because compared to regular plastic silica has higher thermal conductivity. So, you mix more of it is thermal can do particular. This is very popular filler talc; it is the same material which is also used in talcum powder the same thing. What does it do? It increases stiffness and improves creep properties and I will request you to please visit net and understand, what creep is. There are two types of creep phenomena one is temperature induced creep and the other one is stress induced creep. So, it improves these creep properties and it will be worthwhile to at least have an understanding what is meant by creep.

Another interesting additive is hollow spheres of glass. So, these are not large spheres they are micro spheres of glass and what does it do? So, you put hollow sphere of glass, it reduces the overall density of the material, it reduces because then you have air trapped inside the system and also it brings down the cost because now you use less plastic. So, it brings down the cost. To more antimony, antimony is used to provide fire resistance and the final thing is graphite flakes or actually to more and this is very popular graphite fight a lot of these plastics ABS, nylon which is used for day to day applications. They are very sensitive to ultraviolet radiations. So, ultraviolet radiations are present in sunlight they also present in tube light and things like that. So, you put a chair in the sun for 2, 3 months you will see that slowly it develops cracks you do not have to do anything and it slowly becomes weaker.

So, it is because it gets absorb exposed to UV rays and the UV rays slowly damage the molecular structure. Now, graphite has a way if you put graphite flakes into the material they protect it against UV. So, UV immunity, it is it actually does a very good job in making things UV stable.

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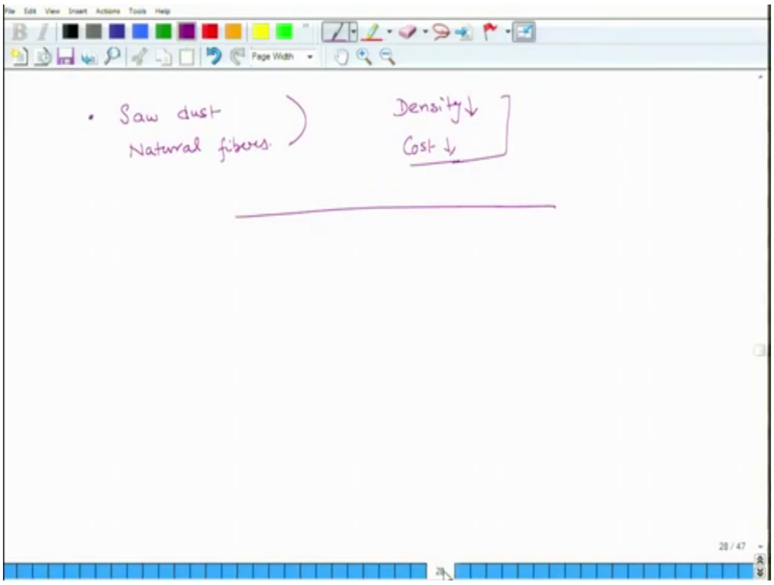


And, the last filler and this is getting increasingly used nowadays is, it can be any one of these saw dust or natural fibers. Now, wood, the density of wood is it can be as low as 0.6 to 0.8, 0.9 in that range. So, once you add saw dust to the material it brings down the density, cost, but a limitation of this is that saw dust natural fibers they absorb a lot of moisture. So, if you mix it with plastic the plastic by it default anyway it absorbs moisture now you could saw then it absorbs even more amount of moisture, but these are different additives which we use in especially in short fiber composites, calcium carbonate, kaolin, silica, talc, spheres of glass, antimony, graphite flakes, saw dust and there are several others, but these are some of the principal ones and the point I wanted to make was that we use fibers we use matrices, but especially short fiber composites we use a lot of other things also and that is what composites are made of.

So, this concludes our discussion on fibers and matrices and additives and also the discussion for this week. Starting next week, maybe in first couple of lectures we will discuss some of the important ways composite materials are produced and then we will start discussing the mechanics of composite materials. So, with that we conclude our discussion for today and have a great weekend and I look forward to seeing you next week, bye.