Industrial Inorganic Chemistry
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Lecture - 53
Speciality Ceramic Products

Hello, good evening everybody. So, we were talking about the different types of ceramic materials and one of the type we are discussing is the second category basically the Specialty Ceramic Materials.

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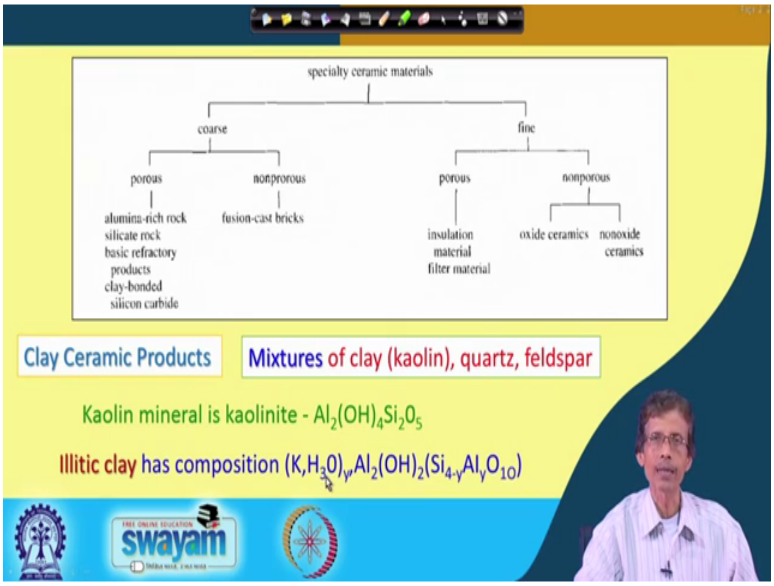

So, this is of the special quality. So, it can have also two different types; one is the coarse type, another is the fine type. And within this coarse variety, we have again subdivided into two like that porous and the nonporous part. And non-porous part which is a material also we get that fusion cast bricks the brick material. If, we considered that sometime some spatial purposes we can use this sort of brick material also which are coming under this category of specialty ceramic materials.

And what about the porous type; the porous type can have some of these as the alumina rich rock type, then silicate rock type. That we can also know and the basic refractory products are also under this category and the clay bonded silicon carbide. So, if you have some amount of clay in it and also the silicon carbide material can also be of this type. Then going to the other side; that means, the fine variety. So, fine variety can have also two types the porous type and the non-porous type. And under porous type it has different types of pores of different sizes, it can be used as the insulation material or the filter material. If we considered that you can have a particular type of pore size. So, that can be very much useful for a filtering material.

The way we use the sintered bed crucibles, the way we use the filter papers, we know that the different types of pore sizes are important. Even, if we know that the different types of filter papers what we use, the different types of filter paper can also give us, the corresponding filtration efficiency regarding the particle size what are there in a precipitate or some other material, which we are trying to filter out. So, for the nonporous which is little bit of other type where the porous thing is not there we simply use some of them as the typical oxide ceramics.

The name will also tell you that we will also find out that what are those oxide ceramic that means, they are basically the metal ion based or sometimes the typical oxide material of some non-metallic part also. So, we can have the oxide ceramics and the nonoxide ceramics when no oxygen is present; that means, other things are there it can be carbide, it can be nitrite.

So, how we get these basically from the broader perspective, that how we get all these clay ceramic products? So, the thing is that you can have the clay and then we just process it for getting a good type of ceramic material starting from the different, starting materials which are naturally available also. One of that material is the clay material simply kaolin, when kaolin is there we can mix it with quartz and we can mix with some amount of feldspar. So, the different composition of these material so, is basically a mixture.

Then we go for the processing of this particular material to get the ultimate finish product as the new ceramic product. So, if we consider that what is that clay and that clay how we can use it. So, the kaolin mineral as typically inorganic chemist what we always try to understand, that the typical chemical formula always we try to know that what are the element wise composition for that particular materials. So, it is nothing, but it is aluminum silicate or alumino silicate with certain amount of extra hydroxide of groups.

So, basically it is A l 2 O H whole 4 S i O 2 O 5. So, the basic building block is your disilicate material which is your S i 2 O 5 material. So, the disilicate material is your building block and on that basically we will be making all these ceramic products based on kaolinite or kaolin. Then, another variety of clay we can have is the illitic clay can have same type of composition, but is not the pure disilicate thing it is basically alumino silicate.

So, alumino silicate we all know very well that some of the silicon positions can be substituted by aluminium; aluminium as A l 3 plus. So, it can have a different property, it can have a different structure as well. So, when you get that; that means, when you substitute these S i 2 O 5 part by S i 4 minus y and A l y; that means, some of these silicons can be substituted by simply your aluminum. So, the equivalent amount of silicon sites will be substituted by aluminum and like that of your disilicate you can have again A l 2 O H whole 2.

Now, and also for charge balancing thing that it can have some extra amount of potassium as the potassium ion or sometime, simply the proton H plus which is solvated or having some water molecule attached to it we know that H plus plus H 2 giving you H 3 O plus. So, for charge balancing purpose is again very much related to that your y value y value is defined. So, y for aluminum y for number of silicon, less than 4 minus y and the number of y which is required for your charge balancing thing. So, the whole thing can be neutral considering that corresponding charge balance by the potassium ion or the simply proton. So, when proton is there we know that that particular material can be very much acidic also.

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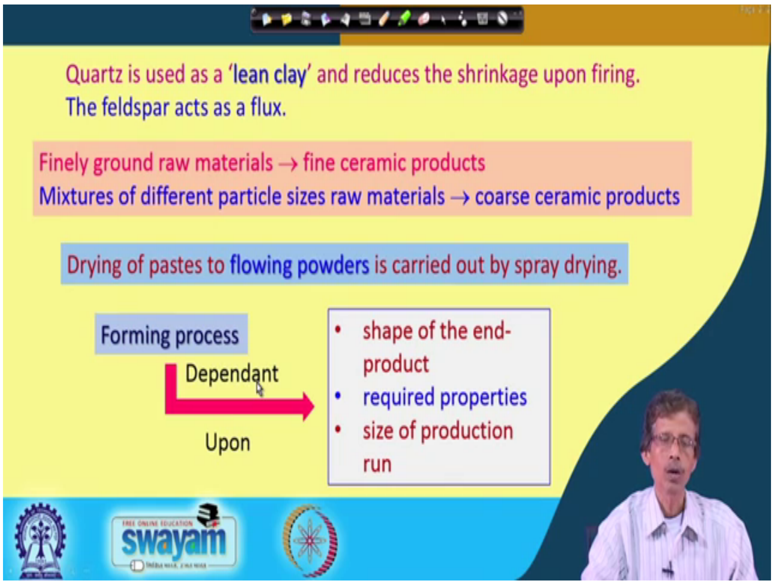

So, if we use this quartz material why we are use these the quartz is use basically as a lean clay, because this is a basically a clay material and we are putting some amount of quartz in it which is nothing, but your S i O 2 material. So, this S i O 2 material and is the purpose of this is that reduces the shrinkage upon firing. So, when we fire it the material is will be fired.

So, the shrinkage will be there; that means, it is basically shrinking that is the material which the voluminous one and when is going for the firing process, it basically going for the sintered bed formation or the sinking think. So, if the amount of quartz is more the shrinking process or the amount of shrinkage will be less and feldspar is basically acts as a flux material.

Because, we know that some of these fusion basically is basically sometime w can considered is as a fusion mixture. So, feldspar basically a some kind of fusion mixture and is also considered as a flux material during the fusion process. So, we can have the all these three components and these three components can be mixed to get a corresponding mixture and when the mixture is processed in such a way that you get basically a finely ground material.

So, the supply is that you have the finely ground raw material in your hand and that basically after processing give you the fine ceramic products. So, the particle sizes are less. So, you get a fine variety of that ceramic product if the ground doing process of the raw material is well and the particle sizes are less.

But, if you have something different which is having a mixture of different particle sizes, because you cannot have very uniform particle sizes, then you get basically the coarse ceramic products. And, that we also deliberately introduced the bigger particles which are non-uniform in nature which are not of finer category, because we want to introduce the porosity within the material. So, it is basically giving you the coarse ceramic products.

And, then once you get the raw material in your hand, the next step will be the drying to of these pastes to flowing powders. So, you get the material then you just dry it, because otherwise it can be a sticky material and that material can be used for the drying purpose, and the drying purpose, or the drying processes of that particular paste giving you if type of powder which is freely flowing.

So, the free flowing powders we can have and we basically to get that free flowing powder, we basically use the spray drying. So, the material is being sprayed and in a hot chamber it is being drying; so, then the next process after drying is the forming process of getting this particular ceramic material. So, what is that particular forming process? The forming process is basically dependent upon some of the special qualities, it is dependent on the shape of the end product what sort of product we are expecting.

So, the forming process can vary also, then always we can have some look for the required properties we basically a looking for some amount of that particular type of property. And the size of the production run, that how much material we are using for a particular run. And the particularly the volume or the size of the particular production thus is also important for this particular forming process.

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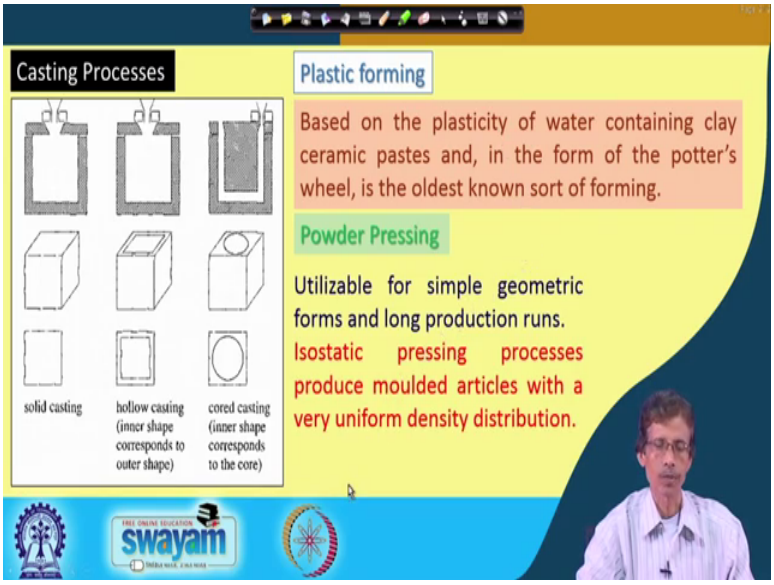

Then, after this forming process we will just proceed for the casting process, we know that the typical the casting how we cast a particular type of material? So, it is also true for your ceramic material. So, we can have a good particular type of mould, or particular type of template in our hand, and the casting is being done of three different categories.

The first one is basically is known as solid casting process. And in that solid casting process either it can be a plate light or slit like thing or it can be a three dimensional one. And we basically depending upon your mould or the template, we basically go for the casting process in a particular way that we put the material from the top.

Then this varieties it can be a solid block or sometimes we can go for this hollow block, also the hollow casting is there if it is in a two dimensional seat you get the middle portion as the hollow space. So, the inner shape corresponds to the outer shape. So, the type of inner shape what you can have.

So, on coating on all this positions we can get this particular one as the hollow casting process and the third category is your code casting. Again you can have a different shape of the inner mould, then inner shape corresponds to the code also and based on that particular code, where you have this particular code the circular thing this is there, this is this particular sectional view of this particular casting. And the sectional view will tell you that you can have a code casting process for them.

Then we get for the corresponding plastic forming process. Then plastic forming process is nothing, but is based on the plasticity of water containing clay ceramic paste. So, what we can have we can have the clay material we finely grounded it and the powder material is mixed with water, and then we can have mixing of that material giving you a paste.

So, the control of addition of water how much amount of water we put that we will dictate or that we will consider your the quality of that paste, and based on that plasticity is that particular paste can have a particular plasticity, and we can monitor or we can measure the plasticity of that particular paste also. In the form of the potter's wheel as we know that the potters made that particular pots, the earthenware pots that the clay pots, what we you know.

That it will be there and the paste is basically the clay paste or the clay material mixed with water is poured on this is therefore, the oldest known sort of forming process. So, this particular one is a typical example like that of your potter's wheel we know is a very old knowledge basically that can be utilized for that particular process and which you can be used for your forming process. And the material since in the material is present in a particular type of plasticity that is why it is known as plastic forming process.

Then other one can be a powder processing process. So, powder pressing process is that when we can utilize for simple geometric form; that means, the shapes are known with some geometrical objects, geometrical variety you can have and long production runs. So, the runtime for that production is long one, then we can use this powder pressing process, and is isotactic pressing process which can produce the moulded articles with a very uniform density distribution.

So, this particular pressing process, which is isostatic. So, this is this basically a same static process, isostatic process, and this particular isostatic pressing process giving the moulded articles which are utilized for the mould with a very uniform density distribution, because one part cannot be very high density one another part is the low density one. So, the uniform mixing is also very useful and that uniform mixing is basically giving you a corresponding utilization for your powder pressing process.

So, these are the different forms of this forming process and the pressing process which then can follow for the formation of the next step of the getting ceramic is your firing.

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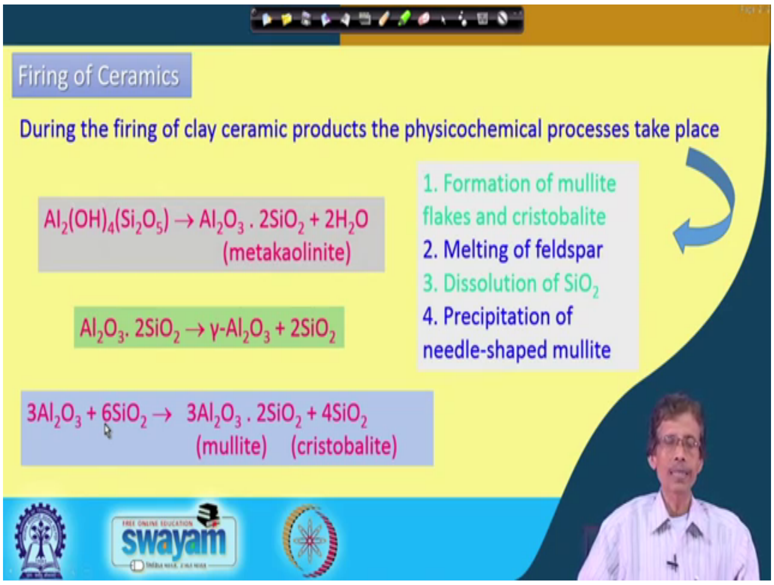

So, once we have this material we have this moulded one like that of your the potters make the different earthenware pots for us and that is when introduced for the typical firing process. And in that particular firing process what we get there is that your typical firing of the ceramics.

So, what we get there during that particular firing of clay ceramic products we can have so, is basically weight till. And the physicochemical processes can take place at that particular time, depending on some of the different types of these thing; that means, how we get these particular thing, that during the firing process the formation of mullite flakes and cristobillite.

So, the crystals basically the moralization for what we get basically, during the firing process basically, because this evaporation is taking place then high heat treatment basically, changing the material from one form to the other. And the two typical mineral variety we know that one is the mullite variety of flakes and another is the custobalite. So, these two varieties can take place there while changing the typical character of that material or it is physiochemical behavior or physiochemical property.

Then, as we have seen that basically the feldspar is basically the flux materials. So, the melting of the feldspar can also take place and during the molten feldspar, it takes basically all the other material in it and such that very high temperature you get some uniforms slurry material, and that slurry material is being then subjected for your firing process. Then at this time basically the other variety which is your quartz.

So, the quartz can also go and go for your dissolution in this molten state. So, basically whatever we are handling the way we go we mix in the chemistry laboratory, the solid sample then we put some solvent or other variety of in it we basically mix it you get the solution, but when we do that particular reaction in the solid state. Basically it is nothing, but your typical solid state high temperature solid state synthetic process.

So, at high temperature when everything is in the molten conditions managing of all this material all these parameters will be sometimes very difficult. And, also we know at what particular temperature feldspar is in the molten state your silica and your quartz is also in the molten state.

Then if we go for; that means, that lowering of the temperature that mean something will come out definitely as in the solid form. So, the formation of the crystals in the mullite flex basically the formation of the mullite flex the first variety is then taking place as a typically needle shaped mullite material.

The way we know that when a saturated solution is there and saturated solution as high temperature if you allow to come it to the room temperature or if we cool down to a room temperature the extra material which is not there, which is not allowing for their sufficient solubility of that particular temperature, we get back the excess solid amount as the small crystals. This is the basic fundamental theory behind it for the crystallization process, or similarly with the temperature variation in the molten state also, whatever is generated out of these things state is the your needle state mullite material.

So, the reaction what is being taken out from there is that what we have seen that, this particularly kaolinite or the kaolin material we have seen is the disilicate one, which is build having the building block of your S i 2 O 5. And that S i 2 O 5 during that particular firing process, we know that that has been converted to the metakaolinite.

So, the metakavolinite is basically is a alumino silicate structure having a particular type of alumino silicate structure with the removal of some amount of water molecules over there. So, A l 2 O 3 dot 2 S i O 2 is the basic formula of that particular material, but it is a endless 3 dimensional structure where the networking is there for S i O 4 unit the tetrahedral S i O 4 unit and the aluminate unit, which are entangled for a 3 dimensional structure, which is similar to that of metakaolinite. Then this particular one through the formation; so, the metakaolinite then at a other temperature at other higher temperature, it can give you the alumina the gamma variety of your alumina material. So, basically if we are taking that. So, alumina as well as silica is getting separated out of that particular mekaolinite variety.

Then the final thing; that means, the step number 4 basically and what we have seen that then the formation of mullite flex as well as the crista balite where cristobalite thing. So, the first part so, you can have that the mean A l 2 O 3. So, the gamma form of these A l 2 O 3 then is makes; that means, the further amount of S i O 2. So, the stoichiometry is basically now changing it is still 1 is to 2, but 3 units of A l 2 O 3 is being reacted with that of your 6 S i O 2 unit giving you two individual phases; one phase is for your mullite phase, which is your A l 2 O 3 S i O 2 with A 3 is to 2 composition, another is simply the cristobalite which is typically a silica variety.

So, these are basically in the solid state material these all will be there and we basically getting towards that particular ceramic formation out of this chemical reaction at high temperature.

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So, high temperature reactivity of these thing, these ceramic material basically giving us some good material. So, material definitely can have very useful applications. So, if you now look at the application once we get that from the starting material, the raw material we know and how we handle those raw materials for getting these reactions, then what are those chemical reactions at high temperature is taking place that also we have seen.

Now, if we simply categorize the properties and their applications it will be therefore, very much industrially important material, because to get all these things from the historically important fundamental knowledge of this making the different types of earthenware from the potter's wheel is basically historically these are all important part. It has gave birth to a particular area of industry, which we know that there is a typical ceramic industry and the engineering aspect of that ceramic industry will give birth of that of your ceramic engineering also.

How we will get the day by day how we utilize all this things whatever we have learned so, far from the historical perspective is in our hand. So, what we try the people will try definitely the new material, new application, and new properties out of this how you vary all these, simple inorganic chemistry reactions. So, the inorganic reactions will definitely be applied at a very high temperature to get the different types of materials. So, one of them is your fine earthenware.

What is that articles are porous in nature; they are white or ivory in colour so, that colour thing is also very important. And used in the manufacture of ceramic filters and diaphragms. Since, you have a particular type of porous material, that we have seen while we are categorizing all this thing, that we have seen that it can be used as a filtering material like your filter paper, or glass frit material, or the sintered bed material.

So, is can be your ceramic filter or the typical diahragm, then we know that the kitchenware's, or the household utensils also we can have from out of these earthenware's, and the sanitary wears are also very much useful out of these particular fine type of earthenware.

Then another variety which is very much similar to that of your stone variety; so, in that stone variety what we get the articles are impervious to water, because is basically stone it is stone like structures, stone like material and stone like property. So, it will basically repel the water. So, water will not go inside; that means, it is not a porous material it can not have some water absorption capacity.

And, it is also only lightly glazed because the other material can have higher glaze material and fractured and acid and alkali resistant. Since, it is very much a stoneware type of material because the stone utensils stone like utensils also, we know that how we make all this is the different companies are also, making this for our day to day use or some special purpose uses also.

So, the material it is corresponding property can also be improved by addition of barium oxide and zirconium dioxide also; that means, B a O or Z r O 2 like that of our other oxide material. So, what other oxide material along with your alumina or silica, because mostly these are material based on alumina and silica, but we can utilize some other variety of barium oxide or zirconium oxide to make the improved qualities such that your acid and alkali resistance power can also be increased.

Then, the other well-known property of that particular material we know that the how we make the porcelain? So, ceramic industry can also give rise to ask the different types of porcelain material. So, these porcelain materials; that means, the packing of this particles the finer particles while firing, the corresponding packing of those materials are very dense, this is white in colour and is also having a glassy surface.

So, surface nature is also very much improved. So, it is neither porous nor a stone like in pervious in nature, but it is typically a glassy and you can have a very thin walls and which is translucent and used in dental ceramics also. So, dental enamel can also may be made out of that that we also see because the enamel industries also another industry that will follow, after we finish this particular part; that means, the ceramic industry.

So, the dental ceramics, the dental enamel also we can make out of this, but out of that, if we can try to get first the ceramic not the enamel. So, the dental ceramic can also be made. So, is the initial casting of the dental surface is done by the dental ceramic, then that uppermost caste can also be given by the out of that our fluorapatite type of material, which is your typical dental enamel.

Then the different types of sanitary material also we can have the sanitary wares also we can have out of this porcelain, because that texture is completely different compared to that of your the first variety.

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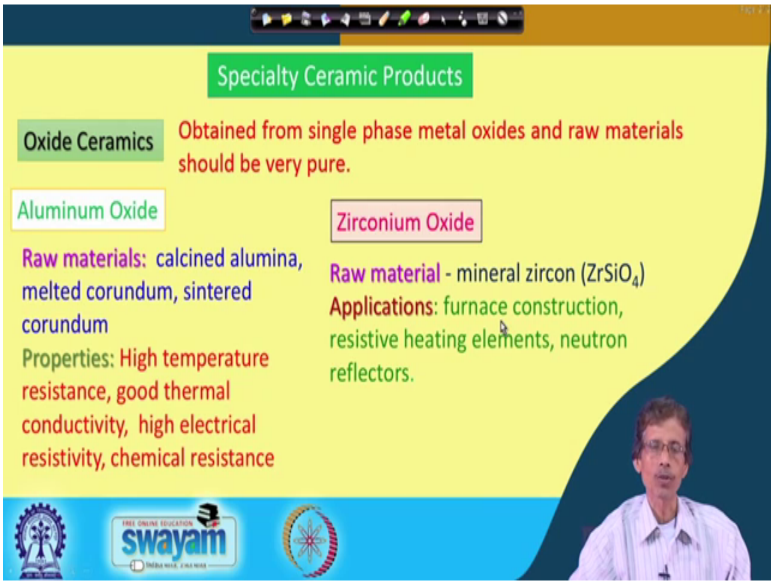

Then we go for the variety what we have started discussing our think, that is the specialty ceramic products what we can have in our hand and how we quickly make this out of this reactions, basically what we have that oxides ceramics. So, our starting material is therefore, your oxides we have seen all this things out of that your alumina, as well as silica, what other oxides we can use for this particular purpose.

So, it can have a single phase oxide material. So, single phase oxide middle line oxides are the raw materials and should be very pure in nature, because the purity is should be high, that is why the quality of that material the cost of that material will also go up, that is why we are considering these are the specialty ceramic products. So, these specialty ceramic products can be made out of your typical check in the purity. So, the first of this category can be your oxide material. So, that oxide material out of your aluminum, so, aluminum oxide what we have seen. So, we are utilizing alumina as well as silica in the bulk material.

So, this aluminum oxide typically can be used as the different raw materials. So, these raw materials what we can have is one is the heated or calcined alumina A l 2 O 3 not that you can have a particular variety, which is cheap also not that alpha you can have the beta, you can have the gamma, because the gamma variety if there is a not a good source, you can have the cost of the gamma variety will more than so, a particular so, the raw alumina form only. So, it can be a mixture of all the different varieties, then the melted corundum which is also the alumina A l 2 O 3, then the sintered corundum.

So, different types of corundum you can have, then these are the raw materials, because these aluminum oxide material can give you a high temperature withstand. So, it can resist a very high temperature for a particular use you can have the corresponding crucibles also, that aluminum oxide crucibles also, it can have good thermal conductivity, because it is not giving you a very bad thermal insulation high electrical resistivity. So, it is basically register in the electrical industry and you can have also for the chemical resistance.

So, the material we are making out of this aluminum oxide ceramic products. So, ceramic that ceramic products can be utilized for handling different types of material the container for handling the different types of chemical substances, because it is very much resistance to not only acids and alkali, but the other type of chemical attack.

For making the corresponding zirconium oxide based result is ceramic products we will use the zircon which is zirconium silicate. And we can apply it for furnace construction. So, special type of furnace we can have then resistive heating elements and neutron reflectors. In nuclear reactor sometimes we can use the we can reflect the neutrons and neutron flow is there the neutron as the particles which is flowing from one into the other. So, if we use some amount of reflection out for those reflectors, we used as the corresponding zircon material, it is nothing, but your corresponding zirconium oxide ceramic.

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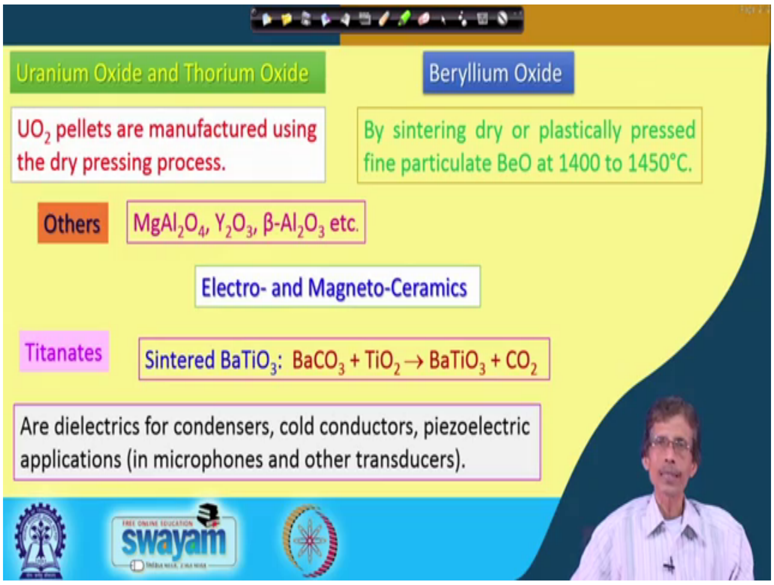

So, the zirconium oxide ceramic can also be utilized, then we can have the uranium oxide or thorium oxide based specialty ceramic material. So, that basically can give us using that uranium O 2; that means, U O 2 pallet us and a manufactured using the dry pressing process. So, in that particular process the dry processing pressing process is giving you the only another variety or specialty variety of that uranium based or the thorium based material.

Then beryllium oxide; so, beryllium oxide can also give rise for the corresponding sintering process, which can be dry one, and which is plastically pressed into fine powders or barium oxide. So, beryllium oxide which is B e O at a very high temperature of 1400 to 1450 degree centigrade, you get the corresponding material the ceramic material as the beryllium oxide material.

Then others we can have we can have the mix material like magnesium doped aluminate, then yttrium oxide or the beta variety of A l 2 O 3. So, when we get these as for the corresponding use of electro and magneto ceramics, for getting this as the different types of electro and magneto ceramics, what we use we can use the different types of titanates. So, these titanates are basically our corresponding process where we use the barium titanate, sometimes this barium titanates are the typical raw materials from the nature we get it.

So, if we get this from that particular one that how we make the corresponding barium titanate material, we simply take titanium dioxide which is your source of rutile. So, rutile is a fine white powder, which is naturally available also which is the most important, titanium ore basically so, the titanium ore as your rutile materials. So, the rutile material when it is burned in presence of your barium carbonate we get the barium titanate; that means the barium salt of the titanate. So, these titanates are utilized for electro and magneto ceramic material. And carbon dioxide will be removed and these are very useful material in electrical industry or the magneto electrical industry also.

Because, these are dielectric for the different types of condenser, because the small condenser we make we know that for the ceiling fans also we use the condenser, these are oil based condensers. But if we use the solid state condensers we can go for the different titanates for that particular one, then cold conductors then piezoelectric applications in microphones and other transducers; that means, single transducing process can be done with the help of making this particular material which is nothing, but your barium titanate.

So, you see that oxides you can have the different types of oxides we can have now the typical titanate. So, it is not a titanium dioxide based material, but it is a titanate one because titanium dioxide can have two oxygen centers attached to that at a if you put more titanium. So, you can have a different structure in it if you are putting more oxygen centers around the titanium and these are like your ferrites and other material is basically the titanates for a different types of applications ok.

Thank you very much.