Introduction to Mechanical Micro Machining
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Lecture - 03
Introduction (Contd.)

Good morning everybody, welcome to this new lecture on introduction to micro mechanical machining processes. In the last class we have seen some of the advantages of going for miniaturization of components, and those things are the less material consumption, low energy, light devices, increase sensitivities and cost performance issue as well as faster devices.

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Apart from that we have seen that what are the different trends in these manufacturing or micro manufacturing processes, and we have seen that there are lot of devices which are very small in size. We have to find out some processes which can be used for fabrication of these components, without compromising cost quality as well as energy requirements. And we have seen the what are different type of linkage in the machine so that we can do perform a different type of operation without any type of problem.

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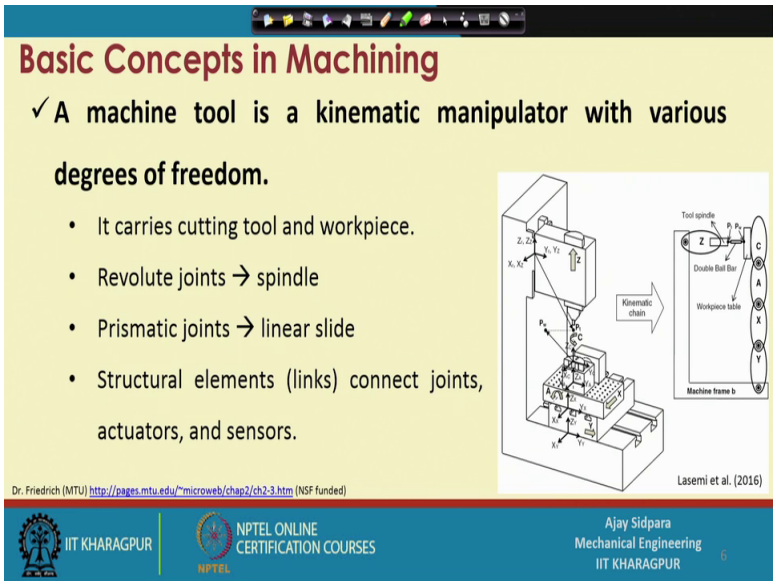

All linkage should perform it is task 100 percent otherwise you cannot get the required geometry or the features on the micro machine components.

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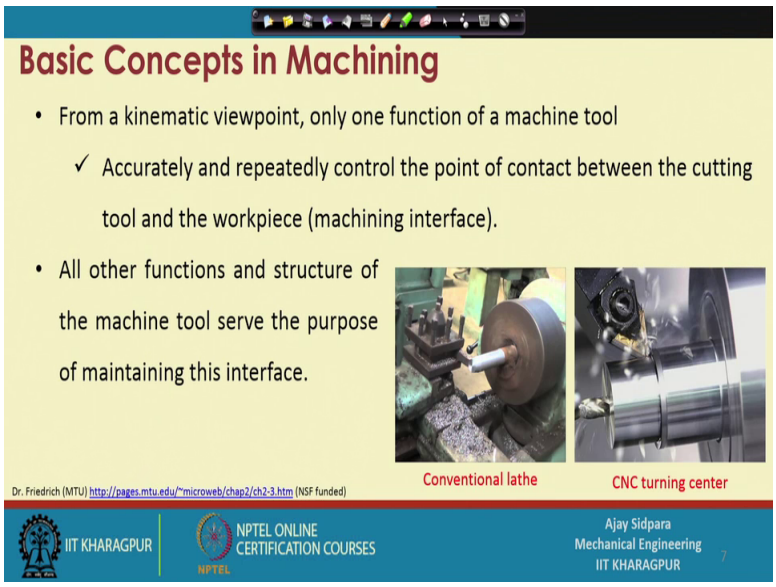

And then we have seen the different processes that how the machine also plays an important role in the fabrication of micro components.

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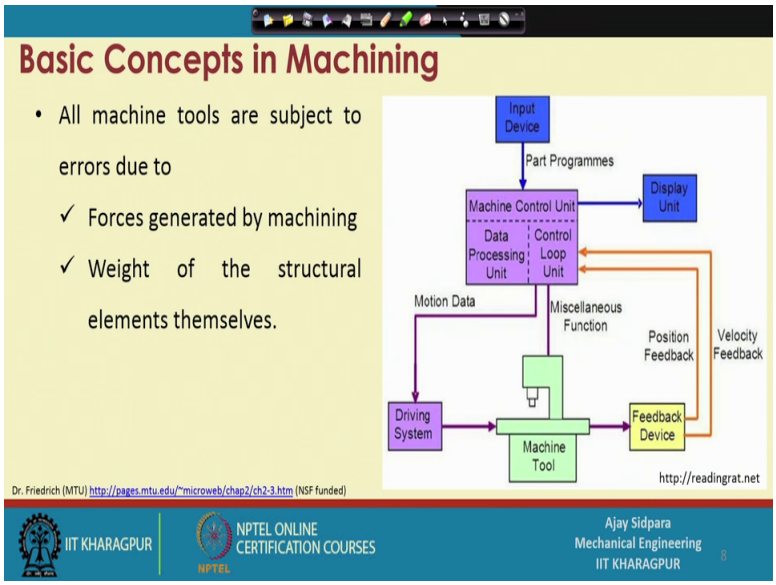

And then we have seen different type of application related to biomedical applications then aerospace, then watchmaker and jewellery.

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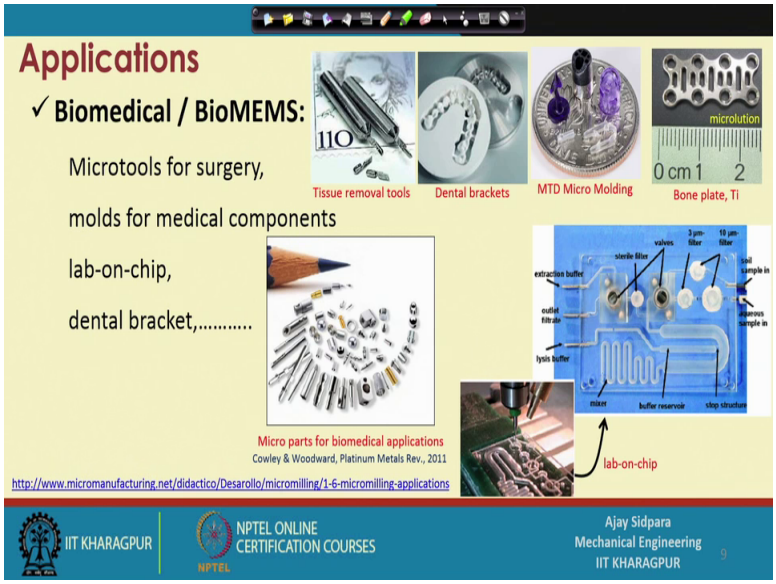

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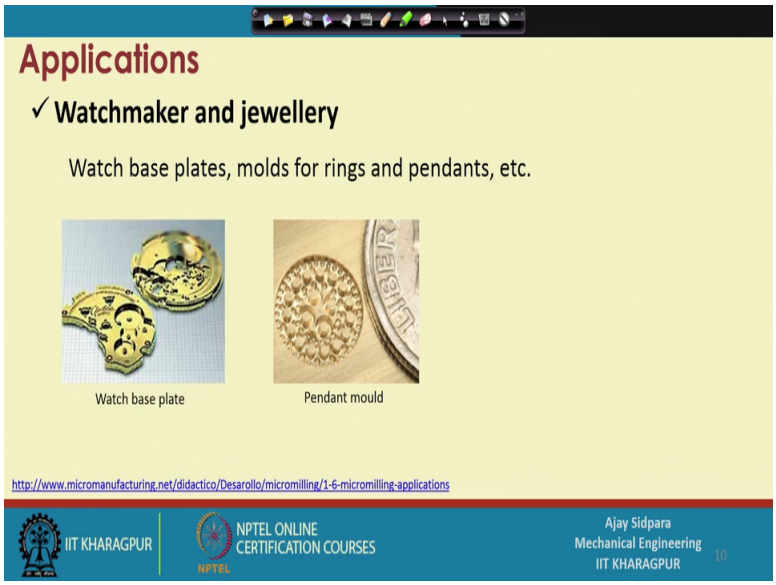

These are very old age applications of that automotives.

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That what are different sensors are used in cars and some other automobile for making it more comfort, and more safe.

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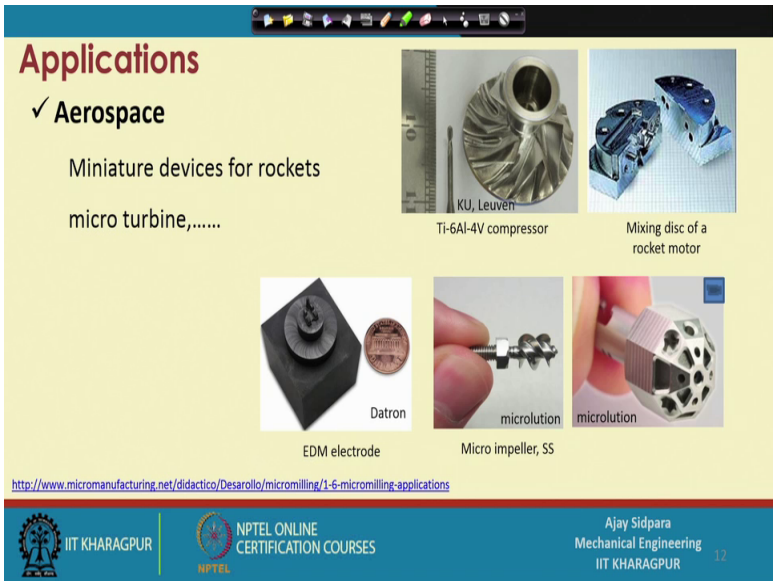

Aerospace also we have seen lot of applications and some other applications were also there related telecommunication information technologies.

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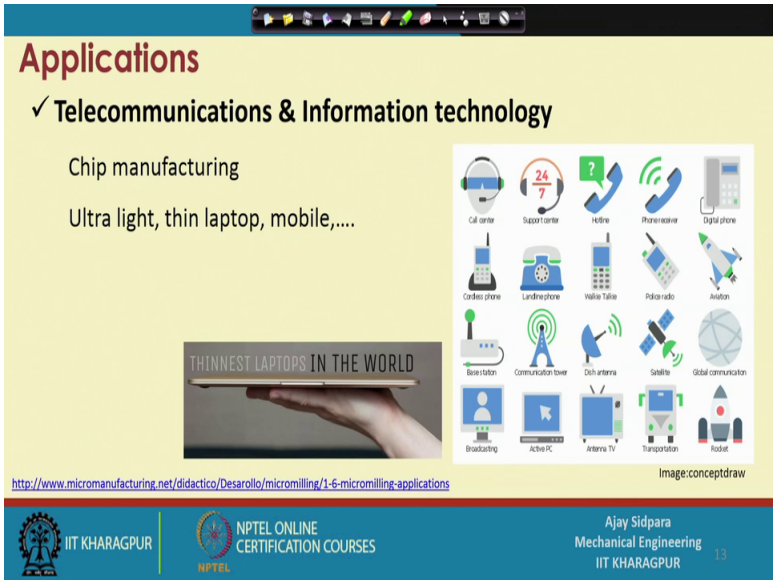

And some miscellaneous applications now, coming to the classification

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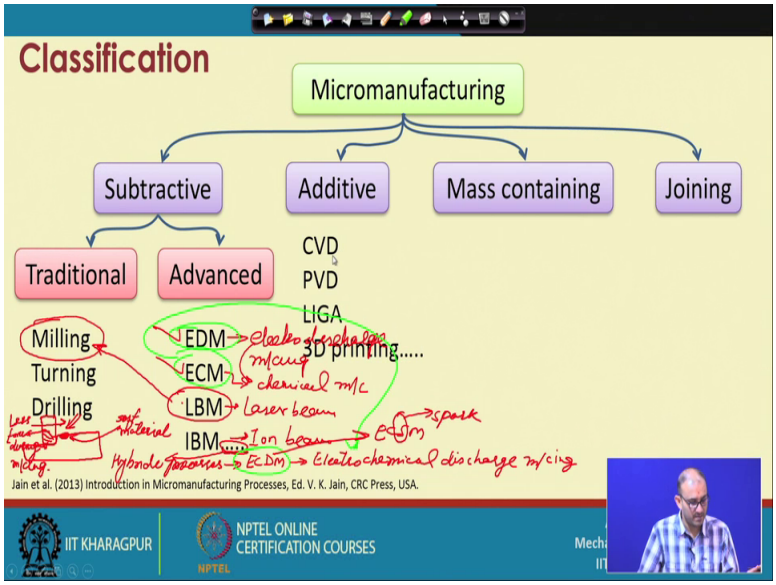

Now we have seen in the last lectures that there are many processes which are used for fabrication of micro components, not only the micro mechanical processes. We to have see that what are the other processes and where our micro mechanical processes are standing along with that in terms of the material requirement or in terms of the processes. Now, first there are many researches who have classified these processes in terms of different aspects. We will go through 2 or 3 different classifications, so that you can have a clear idea about the processes, which are used presently and how other processes are

different from the present processes which we are going to discuss. So this is the micro manufacturing.

Now, there is different type of categories one is the subtractive. Subtractive processes; that means, you want to remove the material from this particular case, another one is additive. Here we want to add material we do not want to remove material, subtractive subtractive processes are mostly related to those processes where we are removing material. Turning, milling, drilling operation all these process even unconventional machining also like EDM ECM all process also remove the material. All these come under the subtractive processes; additive means those processes where we add the components. This is the bottom of approach; that means you are starting from bottom and then you are moving from the top and while subtractive, there you are removing the material, you are going from top to bottom.

Then there are mass containing processes where we do not remove the material, but here in this case we just deform the component to make it in different shapes. And there are joining processes, we join 2 different processes, there are different processes available for joining also in micro domain. In subtractive processes we note traditional machining processes and there are advance machining processes, because of the material limitation we have found some application where we can do machining of any hard materials.

In the traditional machining processes, these are well known milling turning and drilling and our focus is also on these processes, but at the microscopic level advance processes there are many processes like electro discharge machining, electro chemical machining. This is the electro discharge machining this is electro chemical machining then laser beam then ion beam and other than these there are many hybrid processes available like. This is one of the processes where it is a electro chemical discharge machining.

This particular process is a combination of EDM process and EDM process. Why we need this process because we know EDM, it is mostly used for fabrication of conductive material, but there are some application where we can go with the some other than conductive materials. This is called electro chemical discharge machining or there is another name also there. So, this is called ECSM. S means stand stands for spark. Electro chemical spark machining. That is also one of the process, since by which we can get the advantage of ECM process as well as the EDM processes. Similar way there are other

processes available in combination of that that you provide a laser beam and then you do a milling operation.

What is the advantage of doing this thing so that when you do machining by milling only, at that time you have to pass through the very hard material. But if you provide a laser beam like that, suppose this is your milling cutter and this is your work piece and this is your milling cutter, and you are moving in this direction and you provide one laser beam here. This particular material becomes little bit soft and then you continue machining. You do not need to provide more amount of force on this particular milling cutter, less force during machining. In that way there are different combination of the process, those processes are called the hybrid processes.

And there are processes like a chemical vapour deposition, let me clean this part first.

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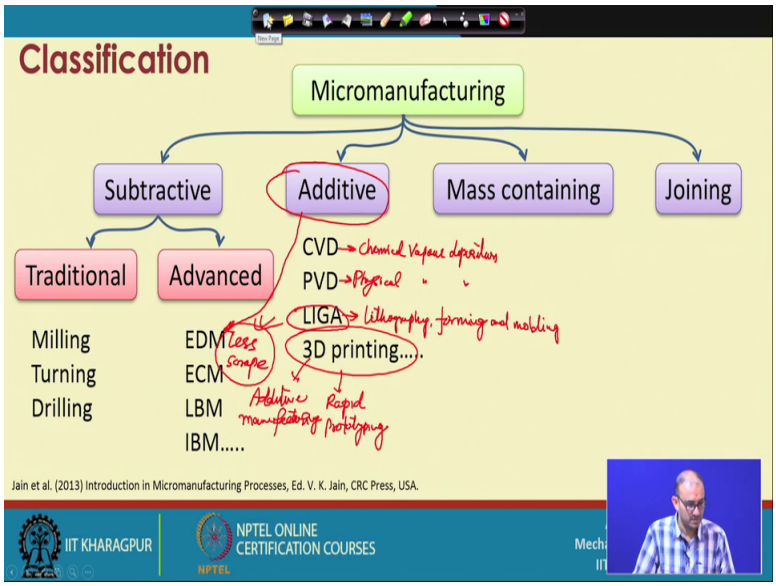

Here this is called chemical vapour deposition this is physical vapour disposition, this is also 1 of the process LIGA it is a German name and it is a combination of lithography forming and molding and 3 D printing there are different names available those are additive manufacturing then we can also called it as rapid prototyping. What is the advantage of additive manufacturing that you do not need to give additional (Refer Time: 09:33) the scrape is very less in this case. This is one of the advantage of these particular categories.

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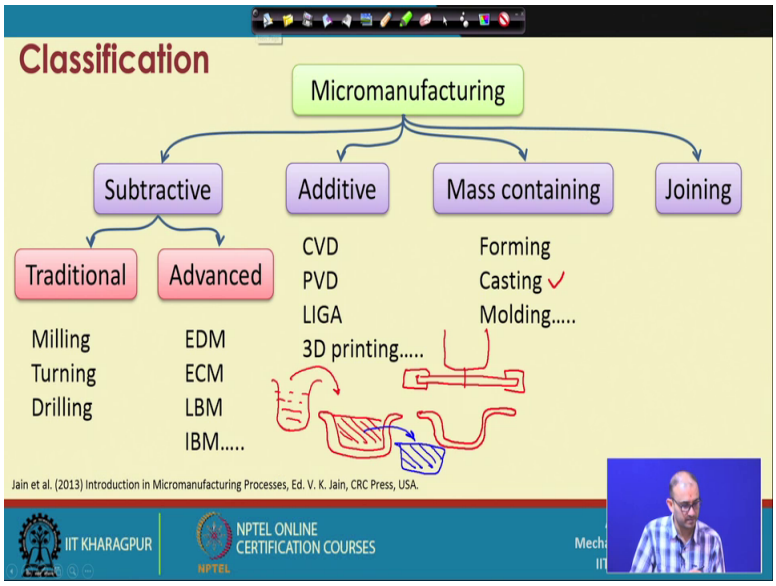

Now, coming to mass containing of forming casting and molding are the mass containing processes. Here what we do that we have a sheet and then we hold the sheet and then we have a punch which will deform these parts. What we get we get one type of shape out of this thing. Why we call is mass containing because we are not adding any material we are not adding a we are not removing anything out of it just we are deforming.

That we can get the required shape out of it, this is the process for forming a similar way we can use casting also. Casting what happened that we use a molten material and we have a mold or the cast and then we pour everything in this thing. It will settle down here and whatever we are getting out of it. This is our final product from this particular process similar molding is also use for the plastic materials casting is used mostly for the metallic parts and joining are also the welding soldering bonding.

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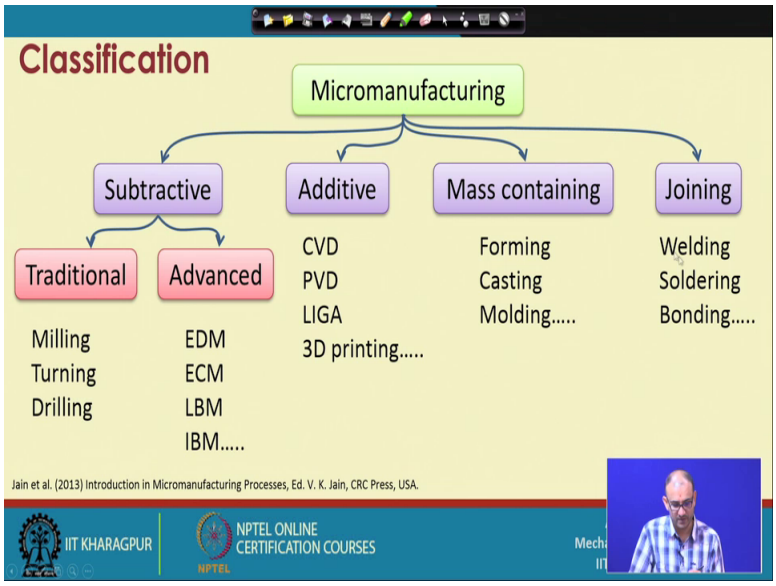

These are the processes which are used for joining 2 different materials, but here we are discussing all these processes in terms of micro manufacturing; that means, the dimension or the features characteristics will be in the micron dimension.

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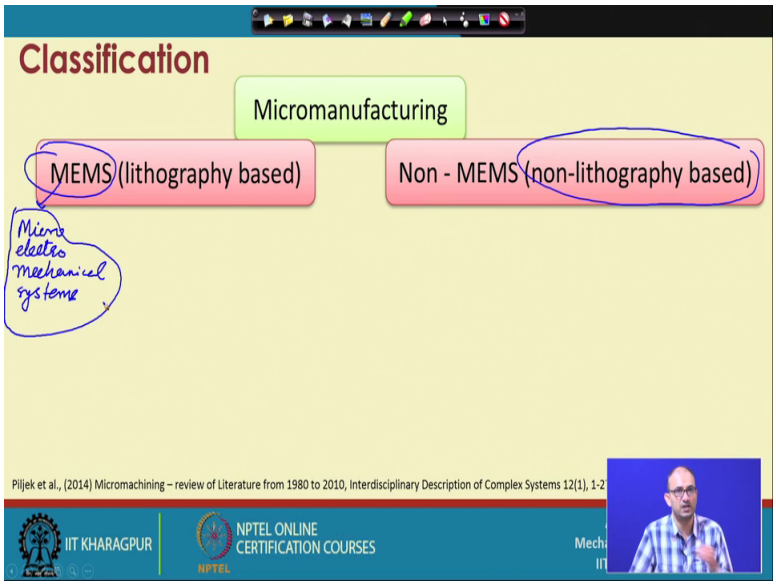

Then there is another classification. Again we divide these processes into 2 different groups the one is the MEMS. So, lithography base and there is a non MEMS. Here what is this MEMS. So, MEMS is micro electro mechanical system. This is called MEMS and this particular subject has a one separate domain which we are not going to cover in this

particular case or in this particular course, but these processes are mostly a 2 dimensional or 2.5 dimensional processes if you have seen different type of sensor accelerometer or some gyroscope in our mobile phone.

Those processes are used for fabrication of those small scale components which are mostly the flattened surface not the z dimension will be very small in this case and here non MEMS processes; that means, non lithographic processes or non lithographic processes here all the processes which are not used in the main sources that covers in this particular part.

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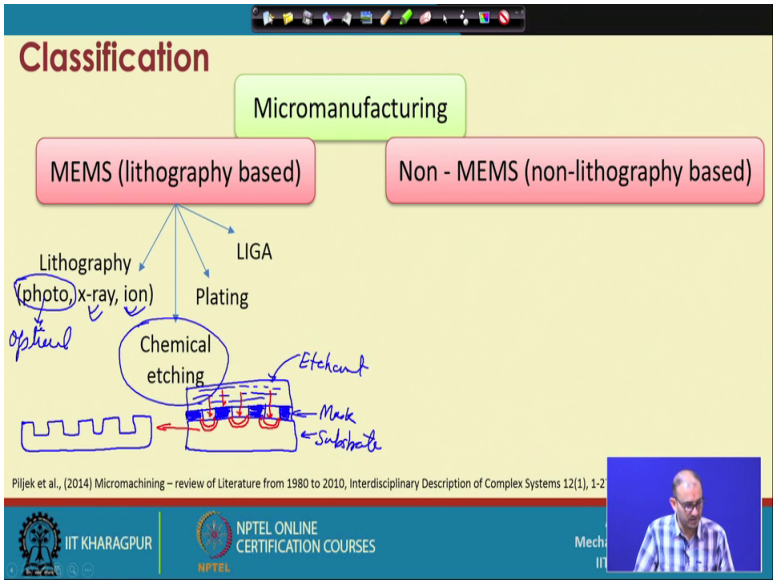

Here 1 is the lithography process second with the chemical etching part third 1 is the LIGA that we have discussed in the last classification also and there is a plating.

Here main is the lithography process lithography process is many thing one is the optical lithography that is called photo lithography and if you want to go with a very high resolution or we can say the small dimension then we have to go with the x ray lithography and the ion beam lithography and chemical etching is also one there suppose you have one component you want to create this component this (Refer Time: 13:29) then you have to take one solid part like this and then on the top of that you have to provide one mask and wherever you want this particular thing the mass will be opened from that location. This part will be covered with the mass material. There is another part this is the 1 2 3 4 like this. These particular locations are covered in one type of in that

material. This is called mass and this is called subtract and then you put a chemical on the top of this etchant.

What etchant will do etchant will attack from this particular location because now etchant can enter and come into contact with this, but here it cannot at a because this particular material is a inert with this because it has no any chemical effect with respect to this particular. It will start etching this material and you can get some type of material removed from this location. Ultimately finally, you can replicate whatever features you want to desire you have something in your mind or some design parts. In this way chemical etching will work and LIGA also we have discussed in the previous slide.

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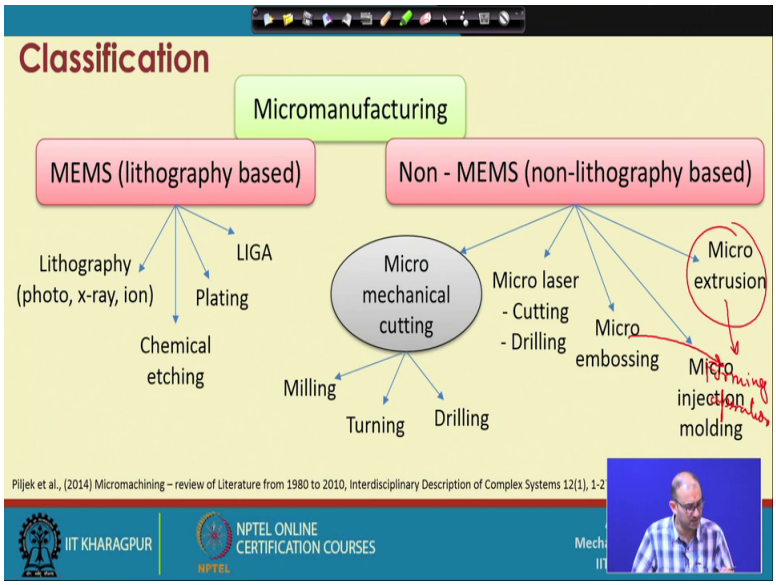

Now, in MEMS basis now here this classification is little bit different because here the processes which are used for fabrication of a 2.5 D processes 2.5 D products or related to the MEMS product then only we are discussing. Here micro extrusion is coming and micro extrusion is actually one type of forming operation then micro injection molding micro embossing is also one type of forming operation then micro laser cutting and drilling can be taken can be done by these processes.

That we can create some features related to the MEMS product then our processes come that is the micro mechanical cutting operation. Here our milling turning and drilling processes come. Now, if you compare the earlier classification this classification there are lot of differences because earlier classification was in terms of the material parts that

how what we are going to do with the material either we want to remove the material we want to add the material we want to contend the mass or we want to join the material, but these classification is based on the other principal that we want to just categorise manufacturing micro manufacturing processes in terms of 2 parts one is the lithographic base and another one is the non lithographic base. This is another form of classification.

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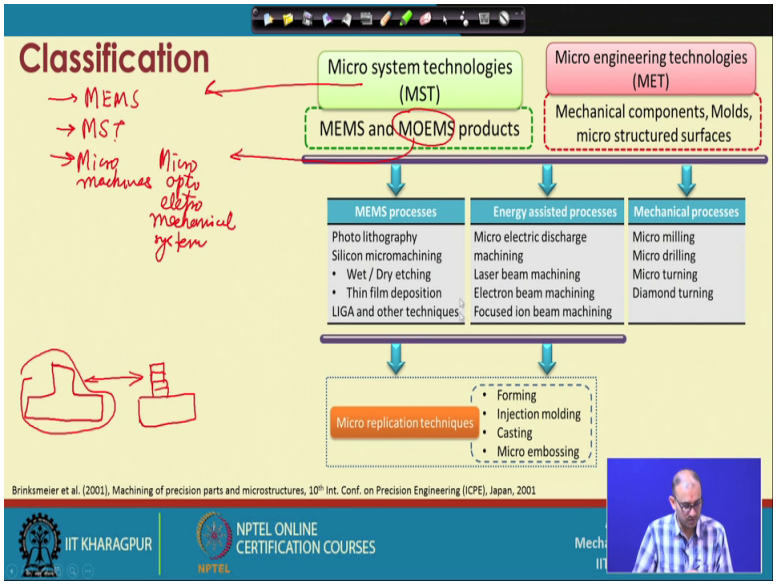

Now, third classification also moreover is related to the MEMS product. This is called micro system technology. Micro system technology is also 1 of MEMS part. Some where it is called MEMS some where it is called MST and some where it is called micro machines also, but all 3 types of processes come under the same domain that is called MEMS. Here it is a MEMS product another is the MOEMS. This is the micro opto electro mechanical system.

This is also, but here objective is to create some type of switching for pleasing transforming light source from one location to another location, that is called micro electro micro opto elcetro mechanical system by here it is a some type of system which can be used for fabrication of different sensors and activators now what are the processes again the same thing will come here. Here photo lithography is there other than photo lithography we have ion beam lithography x ray lithography electron beam lithography also silicon micro machining we can do micro machining by itching also that we have seen in the last slide and thin film deposition.

Suppose now you want to create this features this is the features you want to create then what you have to do that you create a you take out a subtract material then deposit a small layer on the top of that and then you can actually replicate the particular product which you want to make it. This is way you can do a thin film deposition and you can create different type of material properties also on a some different material LIGA and other techniques which are MEMS based.

Then energy assisted where you are using some time electrical energy or the mechanical energy to do machining process. Electro discharge machining process laser beam electron beam and focus ion beam machining, we have discussed this thing in the advance machining processes in the first classification and mechanical processes where we do not use any energy like in terms of the spark energy or the laser energy electron energy or ion energy here we do a mechanical cutting that is by means of a physical contact between the cutting tool and the work piece material. These are the 3 milling turning and drilling processes and another process is the diamond turning which is mostly used for fabrication of non ferrous material and glass and lens and mirrors and like there we will cover these process more detail in the later half.

Now, other than that we have seen that we have some process where we can contain the mass we do not do any type of removal or addition. These are called replication techniques in this particular classification, but it is similar to the earlier 1 which we have seen in the last. It is a forming injection molding casting and micro embossing, these are the processes available.

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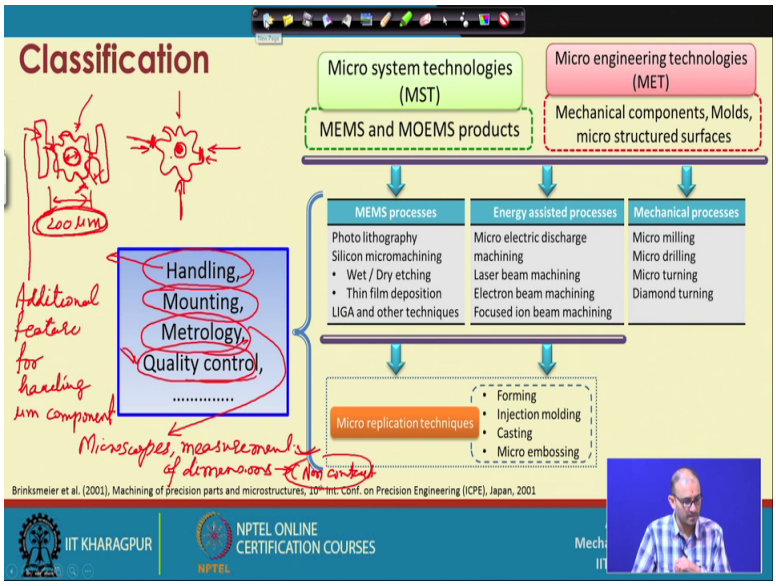

Now, other than that now what we need we need something extra. These classification gives another extra part which is more important in this case because handling is very problematic in the micro component because once you create a micro component it is difficult to handle or difficult to move from one location to another location. That is the reason this handling is important now how we do handling that for handling a component either we use some type of pneumatic chalk or pneumatic handling. That you cannot physically touch the component or you create one type of additional feature which is particularly used for fabri handling purpose only and later on once the component is transport to the original other location then what you do you remove those components.

Now consider that suppose you have one gear, now this gear dimension you consider it is around 2 hundred micron now you want you have fabricated now you want to transfer these gear to some sub assembly now if you transfer directly from here to here; that means, by your hand or some other type of greaper then there is chance that it may deform or it may break in different locations. What people do that when they are making this particular things by molding or casting they provide one additional feature here something like this.

Now, you are not touching the gear, but you are actually handling by the particular additional feature or handling micro component. Now, you have transfer to this. Now, suppose now your gear is here and then you actually remove this thing by some type of

soldering cutting laser cutting or some other processes or mechanical just bending because here contact is very small. Even if you bend little bit it will remove from this. Now, your part is ready to perform a sub assembly or the final operation, in that case handling is important.

Now, coming to mounting, handling is done now how to locate that location where it is being assembled in this location. At that time you need some type of reference surfaces that reference surfaces you have to create here that suppose these are the 4 points. You have to align with respect to these 4 points and then there are some robotic assembly also comes, or some type of pneumatic gripper will come. It will all these particular gear by vacuum and then place it and then vacuum will be switched off.

Then metrology is one of the most important part here because we have we know that 2 100 micron gear it is difficult to see by naked eye. We need micro scope each and every location when you are making this component you need a microscope. What are these metrology consists of. There are microscopes then measurement unit measurement of dimension because we know that we want to create a gear with a 200 micron.

Once the fabrication is over then we have to do measurement that whether it is exactly 200 micron or not what is this diameter of this particular part and what are the characteristics of classification of this particular teeth tooth profile. Everything should be measured. We need some type of measurement you need. These are the contact type also and non contact type also, but mostly we prefer for non contact type because we do not want to touch these particular component for a later stage because otherwise it may get some type of scratches or some type of dimensional changes

Then quality control after all the measurement we have to see that whether the dimensions all features are as per our drawing or not and then quality control person will this particular drawing. This is one of the way of classification that in this particular the research says has added this additional features or additional parameter that is handling mounting metrology and quality control.

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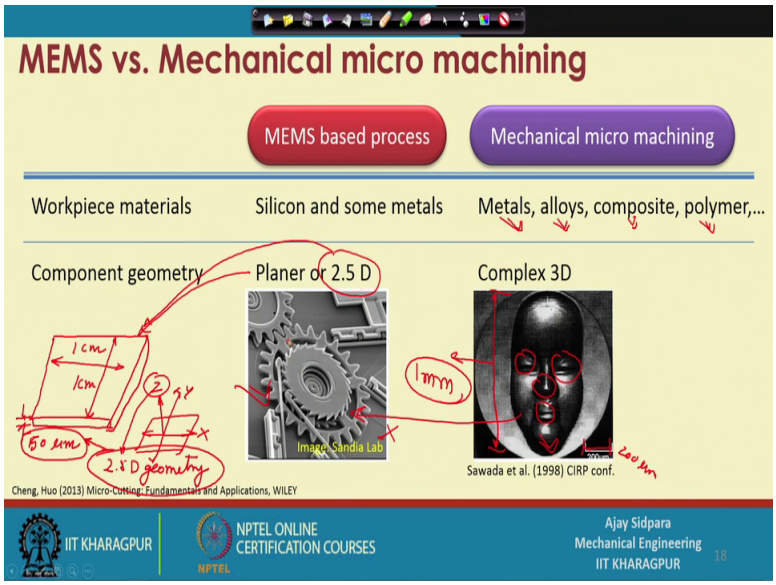

Now, after this classification what we have to do that we let us see that how this micro mechanical processes are different than the MEMS product now we have seen that MEMS has it is own domain related to mostly the health care and some type of fabrication of the micro actuators micro sensors like that and micro mechanical machining processes these processes have their own domain because it can create a real 3 D component that was not possible in the MEMS product or some other processes and here advantage of micro mechanic processes.

Because we know the process very well because we everybody knows about the milling machine lathe machine and the drilling machine and we know the operations also different types, but MEMS says it is different part because where we do use lithography etching deposition techniques and those processes are not the conventional processes and we have to create some type of clean room requirement also and the cost comparison is very different in both the cases. Let us see that how these processes are our mechanical micro mechanical processes are different than the MEMS processes.

First is the work piece material now if you see the work piece material mostly in MEMS base silicon and some metals say mostly the copper and tongs 10 are the metal which are used for fabrication of different components and if you see mechanical here probably there is no any type of restriction on that only thing we have to make sure that our tools should be harder than the work piece material. It covers almost all the things. If you see

the metal it covers all the thing alloy we also we can do machining composite polymer and some type of other materials which can be fabricate or which can be machine by the micro mechanical machining processes components geometry. Here it is mostly a planer surfaces what are 2.5 D surfaces, now see this is the one of the components fabricated by the MEMS product by etching and the deposition different type of lithographic processes.

Now, what is this planer surface is this planer surfaces means suppose now you have 1 plate and it has some thickness now consider this dimension is in centimetre let us say 1 centimetre and this dimension thickness let us consider fifty micron. Now, if you see the dimension difference it is very large. It is in centimetres scale and it is in micron scale.

Basically the thickness is mostly neglected even though it is a little bit of thickness, but generally you can tell this is the planer surface or you can say that 2.5 D surfaces because 2.5 D surface is you have a 2 D surface this is y direction this is x direction, but z direction has a very small thickness. Generally we do not consider z as a full, but we cannot ignore also. Because of that it is considered as 2.5 dis component 2.5 D geometry. This 2.5 D geometry means the z it is very small or it can be neglected also and compared to the planer surface that is called x and y.

Other than that, here in this case you can do a complex 3 D components. This is 1 of the component is shown. Here if you see this dimension this particular scale is 200 micron now if you see this 200 micron then this whole thing is probably within one millimetre. This 1 millimetre you can see that all the features our eyes is visible nose lips everything is visible.

It is a purely 3 D component that is not possible to fabricate by these type of MEMS product or MEMS processes that is mostly lithography etching and all these things. That is the advantage of using these particular processes. It has a particular application and these are also a different application for fabrication of this part. Our objective is to learn that how to create a pure 3 D components which are difficult to fabricate by the MEMS product. Let me finish this class here we will continue from the next slide in the next class.

Thank you very much.