Fabrication Techniques for Mems-based Sensors: Clinical Perspective

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Lecture – 09
Mask Aligner

Welcome to this particular class and this class is focused on designing a Mask Aligner. Now what we have learned in the previous class is what is photolithography right and we have seen I think MJB4; operation of MJB4 mask aligner using the video that we had.And I am sure that you now know how the photolithography works, what are the positive photoresist, what are negative photoresist ,what are bright field masks, what are dark field mask, how to align the wafer right.

Now, to align the wafer mask aligner right and to expose the wafer UV source right. So, the cost of this system right now is close to like 50 lakh and we have MEMS based sensors or design or technology related course in lot of universities; isn't it? We learn it right; we learn it through books, but not all of us are having a set up within our university that we can go and see whatever we study in the book, how it looks like right.

And to bridge that gap we need to develop a technology so that every university can adopt a system which is at lower cost. So, here in this particular lecture; I will be telling you something related to what I am doing in my laboratory. And this is also a part of this lecture because mask aligner or photolithography is an integral part of any MEMS based sensor.

Now, what we are doing right? We want to reduce the cost of the mask aligner traditional mask aligner to a value that most of the universities, most of the colleges can afford right. If we see that photolithography processes; you take the wafer, how wafer looks like? You can buy a wafer it is like 1700 rupees or close to 2000 rupees. Now once you have the wafer right what you will do that; do with that? If you do not want to buy wafer you can buy a glass slide that is all. So, it is fine right what is a photolithography step?

Photolithography steps are first you clean the substrate, second coat the primer. So, you need a small spin coater; there are varieties of spin coater available in market at lower price, you can get one. Spin coat photoresist first we can spin coat primer or we can spin

core photoresist after spin coating photoresist; we have to pre bake you can buy a hot plate there should be hot plate in any chemistry lab in biology labs you put the wafer.

So, again you have to perform all these thing in a yellow room; small room which is required to ever the UV light. So, that the photoresist will not get exposed to UV before we actually align the substrate coated with photoresist. So what we require? After we spin coat photoresist, then you have to use a mask and load the mask on the mask aligner and expose it, then you have to have developer small wet agent and then edging the; if you have a metal you have to edge a metal right double you know the steps.

So, how about we develop our own mask aligner and it a very reduced cost and that can perform photolithography step to get you a design; at least a simple design like a heater, then you can connect that with the theory and probably understand how the photolithography system works. So, that is the idea behind developing a mask aligner with in my laboratory.

Now, when I will be teaching you this mask aligner steps you will also know and learn that you can also do the same thing in your university; try take is a project and try it right. We should start finding an alternative solutions if we cannot afford a particular technology right. Develop your own technology right we have to start developing things here in our country; it is a high time we use the knowledge that we have and put it together to develop technologies that are cheaper, that are affordable that that can go to the market that can go to the universities.

And all of us can get a better exposure to the education that we really deserve right. Having said that I am not telling that we are not getting enough exposure right all of us, all teachers and the management are trying best I am sure we are trying best to our abilities to help you have to understand the technology as much as we can help you.

But the lacking the gap that lies is to show you the technology; if I talk about mobile is this mobile can do this, mobile can send SMS, mobile can we can we can access a lot of social networker mobile, we can talk on mobile and we can see videos on mobile, but I do not show you the mobile then, but what if I just show you a simple mobile ok.

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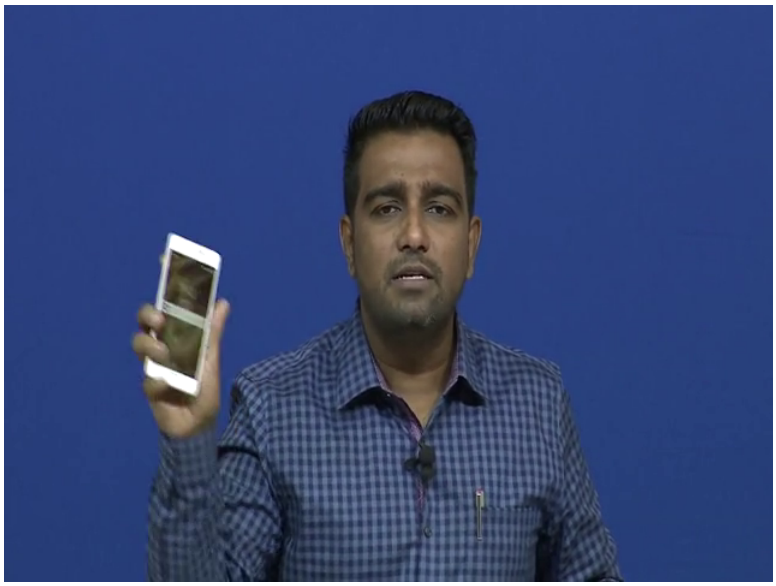

This is a mobile this is how it operates these are button right, this is how you can use it its easier know that is the idea that; show, whatever we are we are talking in theory in actual scenario. So, with that particular focus with that particular idea this today's lecture is framed. So, the name of the slide is mask aligner.

So, if you see the slide you see the screen we will be talking about mask aligner today and mask aligner is used for photolithography.

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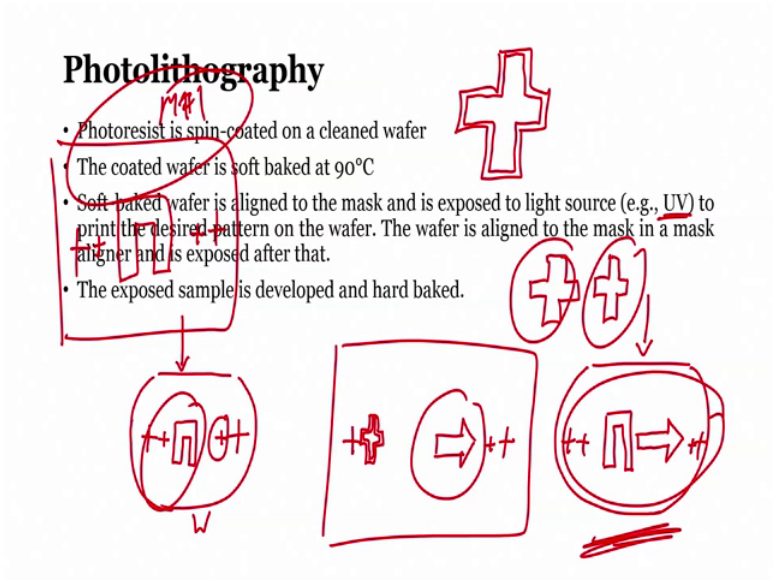

So, you have to see a slide and the photolithography; photoresist is spin coated and cleaned wafer, we know it. The coated wafer is soft baked at 90 degree we know it, soft baked wafer is aligned to the mask and is exposed to the light source UV light right to print the desired pattern on the wafer. The wafer is aligned to the mask in a mask aligner and exposed after that right.

So, what is alignment? So, let me just quickly tell you ok; let us say you have we need a pattern which is like this; in the final wafer this is what we need this is our final wafer. So, we have done photolithography with a mask, our first mask has let us say this pattern um. And with the help of this first mask we have used photolithography to design to get this pattern on the on the wafer right.

Now, this mark ma mask should have some alignment mark; what is the role of this alignment mark? So, you understand it we have first mask with this pattern and there are alignment marks right, this mask 1. So, our second mask 2 would have this pattern, this is our mask 2 right.

Now, I had to align this wafer this wafer; I have to align when I have to again perform photolithography with mass 2 such that I can have this kind of design next to my arrow. So, when I am going to align this masked, my wafer with mask 2 right, with mass 2 I had to load the wafer sorry I have to load the wafer and the wafer is already having this pattern right.

Now, this alignment mark here an alignment mark here should align properly. So, if I have my alignment mark on my wafer; looks like this and my alignment mark on my mask looks like this, they should align it. So, that if I see it; it looks like the mark of the mask is exactly in the mark of the wafer. With this alignment mark, we can align the pattern in the mask.

If the alignment is not proper then this can overlap right; if the alignment is not proper the wafer design, the design of the wafer can overlap this and will not get what we desire we will not get what we want right. So, it is very important how to align this thing; for that we require a mask aligner. So, this is just 2 mask process right mask 1; we form the pattern, mass 2 we form another pattern right; mass 2 was, if I remove this mass 2 was the another pattern using mask 1 and mask 2 we want to have this pattern.

So, the alignment mark roll is very important; another point you have to remember is always the alignment of the second mask is smaller than the first mask. If my mask one has an alignment mark right my mask 2 should be the alignment mark of a of my mask 2 should be smaller than my arraignment mark of my mask 1; that is very important to remember all right it is very important. So, remember these things; same way alignment mark for by mask 3 should be smaller than alignment mark of my mask 2. Alignment mark of my mask 4 should be smaller than alignment mark of my mask 3 ok; this is how we can perfectly align the different masks.

Now, the wafer is aligned to the mask in a mask aligner and expose; the exposed sample is developed and hard baked right and finally, we perform the etching. So, this is the photolithography we know it.

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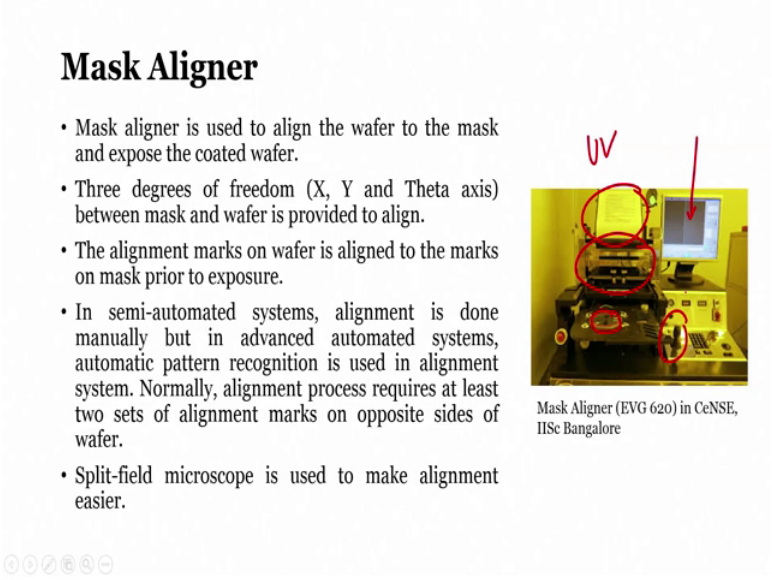

How the mask aligner looks like right? So, we see this is a mask aligner we have it in center for nanoscience and engineering at IISC and this is EVG 6 20. So, this is a mask aligner, you can see here in the display. You can see how the wafer looks like, what the pattern on the wafer looks like. This is the exposure unit right, this is the exposure unit this is where your UV lamp is kept; UV lamp is kept right we will require UV light to follow. This is a joystick to move X Y the wafer in X and Y; there is a theta direction for moving the wafer in theta. So, X Y theta right and of course, this is a mask aligner which is close to as far as I understand about 80; 90 lakh.

Some mask aligners are even like 1.5 crore, some are 2 crores right depending on the mask aligner. So, the point is mask aligner is used to align the wafer to the mask and expose the coated wafer right; coated wafer photoresist.

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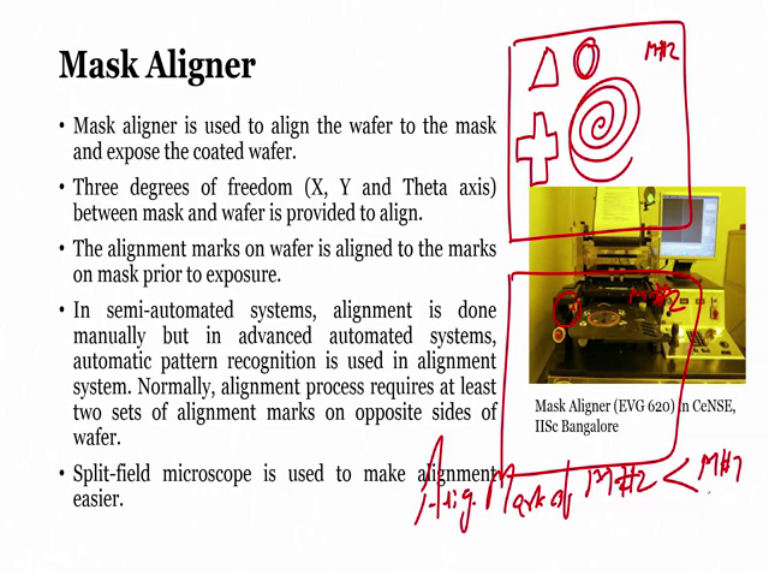

3 degrees of freedom we get always X, Y and theta right, if we want to much where we want to align the mask. So, you have to move the mask either in X, Y or theta or you move your wafer in X, Y or theta. So, I do you have 2 options either you the mask or you in the wafer; I would prefer to move the wafer you hold the mask move the wafer is there in X direction, Y direction or in the theta direction angle.

Now, next one is if you see the screen the alignment marks on the wafer is aligned to the mask marks on the mask prior to the wafer right. What is that? The alignment marks on wafer is aligned to the marks on mask prior to the wafer. So, that is what we have taken an example that the alignment mark of mass 2 should be smaller than alignment mark of mask 1.

In semi automated system alignment is done manually, but in advanced automated system automatic pattern recognition is used to alignment used in alignment system. Normally alignment process requires at least 2 sets of alignment marks opposite sides of the wafer. What does that mean? If I have the alignment mark right, whatever the pattern here is I require at least 2 alignment marks on the wafer.

Now, this does not mean that every time I had to draw a plus I do not whatever the pattern is there is a metal here my; alignment mark can be a plus can be a triangle, can be a circle, can be any design right. I just want to make sure that the mask 2 whena I make the if I use a circle here; I am using a circle here right this circle when I aligned with this one this should be within it this is mask 1, mask 2.

So, alignment mark alignment mark of mask 2 should be less than alignment mark of mask 1 should be smaller than alignment mark of mark of mask 1 that is very important to remember.

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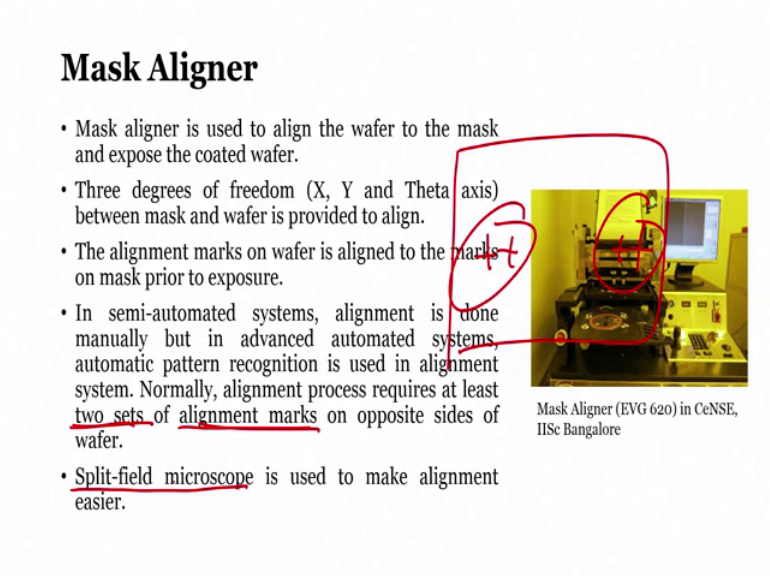

So normally alignment process at least requires two sets of alignment marks on opposite sides of the wafer, split filed microscope is used to make alignment easier; so, if we use split filed microscope at if you have the wafer or if you have the mask, at the same time you can see both the areas both the alignment mark at the same time you can use or see if we use split filed microscope um. So, that is another point that you need to remember when you are using a mask aligner.

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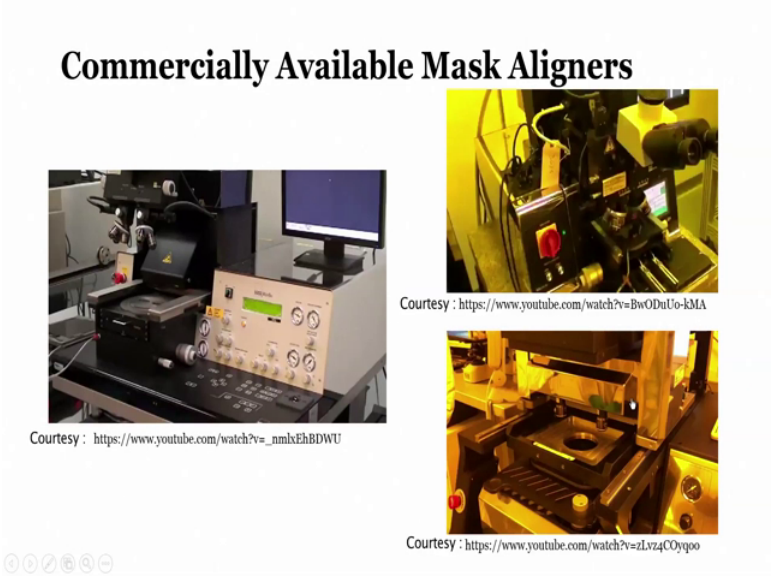

These are few commercially available mask aligner. There is a you can go to this YouTube link and look at this how it is operated right. And then it will be easier for you to understand what is the role of mask aligner and how we can design a mask aligner.

See in this case these are the lenses for the microscope right split field microscope, this is the UV exposure unit right and this is the X, Y and theta stage right X Y and theta stage; this is for the pressure for holding the wafer and exposure time what is the power that you are applying this electronics is right over here. This is to move manually X Y Zero, then in this particular case again here; what you see is you can see a mask holder right and you can see a wafer. So, there is a mask holder, there is a wafer, there is a split field microscope again here.

So, just go through it and see it; again you can see very clearly it is in yellow room it is in yellow room, this is in yellow room. You see everything whenever you use its always should be operated in a yellow room. There is a display always connected with it so that we can see the alignment, the alignment mark it will to see we have to adjust it accordingly right; if we had to see the pattern you can see the pattern as well. So, these are commercially aligned my mask aligner

Now, yeah this is a YouTube video. So, we will we will play each video when the time permits. So, just go through each of the video.

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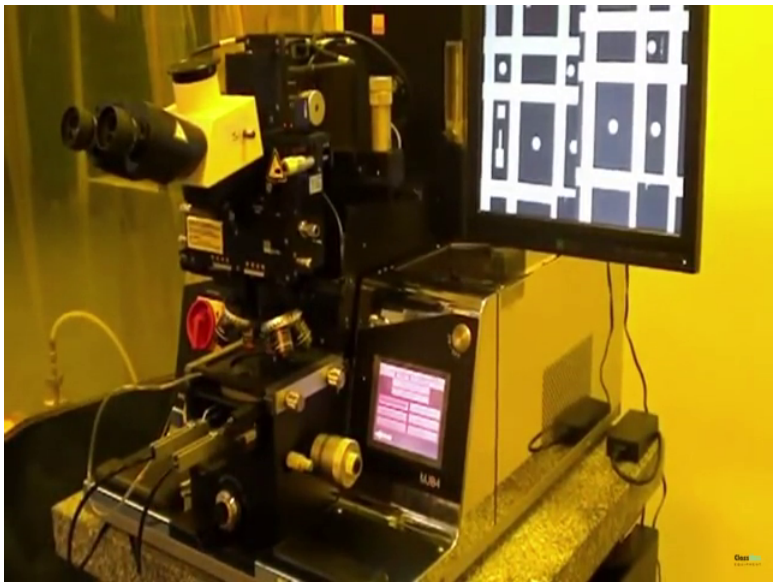

And you will understand how it is operated right. So, we have 3 videos here for Youtube observe and then let us play one by one all 3 videos.

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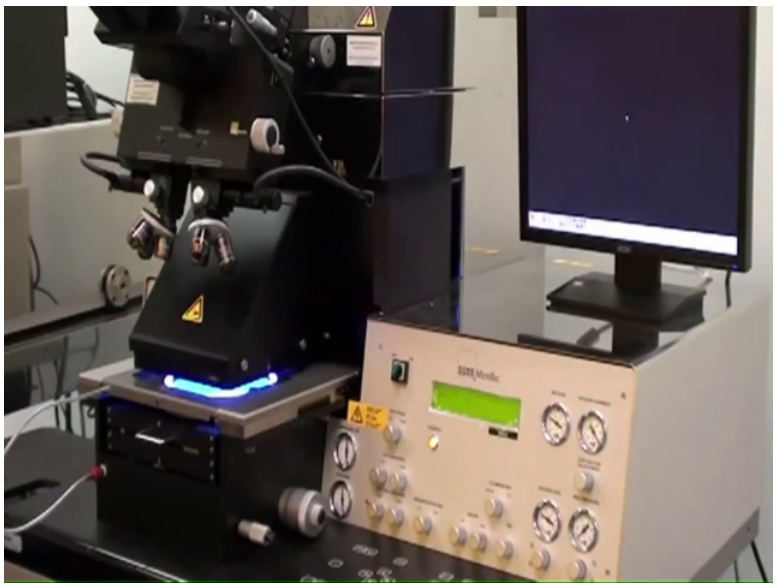

(Refer Time: 19:01) This is not a matched mask and wafer, but we should at least be able to see the alignment process; I am satisfied with the alignment. So, we will expose this now unload the wafer in one scene we print outside alignment them.

Do another 5 second exposure remember I today is April 14 2013; we are looking (Refer Time: 23:01) MJB4 ID number 33685; serial number 191 only this machines through the

refurbishment process and ready to be walked down for shipping. But first we will just demonstrate the operation by running a 4 inch wafer in high contact.

Responds that if the alignment and this is not match mass the wafer but we can at least demonstrate the alignment procedure almost back to (Refer Time: 24:02) that is the volume check it introduces nitrogen (Refer Time: 24:09) and now we can verify the crystal cells (Refer Time: 24:13) for alignment (Refer Time: 24:04) expose, (Refer Time: 24:21) double check that you want to expose ; (Refer Time: 24:43) unload, this machine is also set up with higher capability. So, make it run in same wafer if transmits by our rather than reflected light elimination with to demonstrate that and other parameters switch to ion. Now (Refer Time: 25:23) we are now reviewing international wafer by (Refer Time: 25:29) light from underneath the wafer; the alignment check doubt experts confirm that performance the first second third exposure (Refer Time: 26:08) ok.

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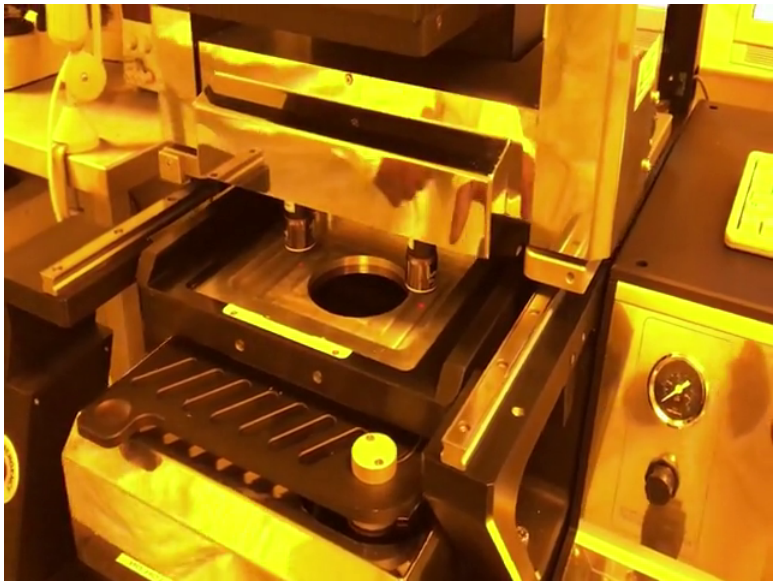

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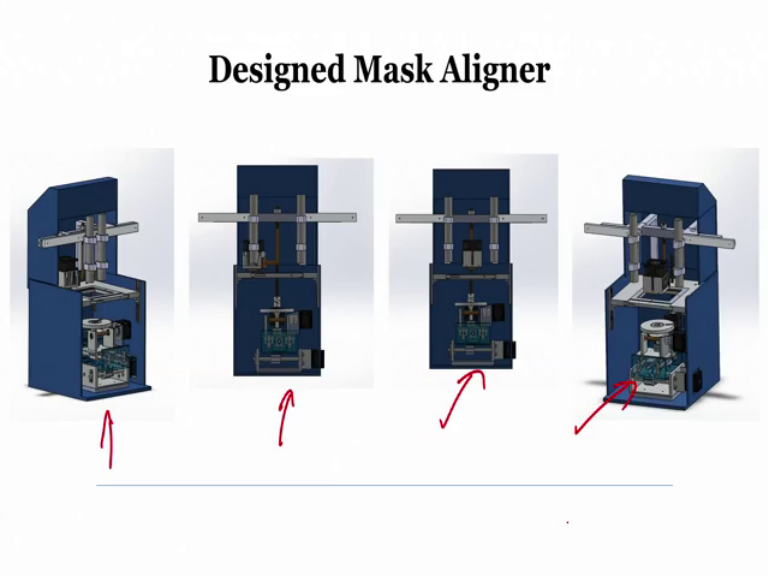

Now, since we know what a mask aligner looks like what; what are the designs right, there is a split field microscopy, there is a UV exposure system and there is a mask the holder and there is a wafer holder and we require X Y theta stage for moving it.

So, we can design the mask aligner accordingly right; so, this is our design this is our design and this is what we are working on; to make a mask aligner which is cheaper. And that can go and we can use it in most of our laboratories or most of our universities because this would be affordable mask aligner.

Now, to make it affordable first we are and the stage of designing it and we are stage of fabricating it.

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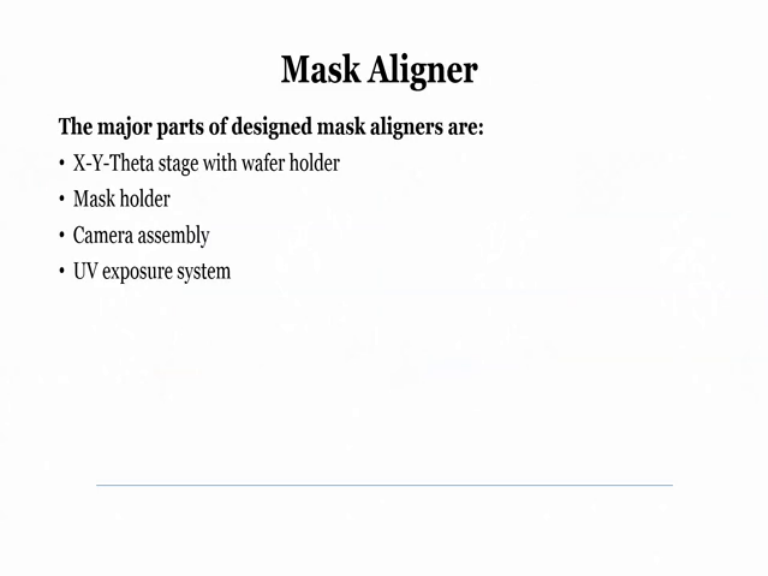

So, I will show you a few of the assembly that we have designed and then a video where how it is it is working. So, for the mask aligners; the major parts of the design mask aligners are X Y theta state with a wafer holder. We have a mask holder, we have a camera assembly and we have exposure system which is UV exposure system right.

So for X Y theta for moving the wafer; and it is it is attached with a wafer holder. So, that we can move the wafer in X Y and theta; we have a mask holder to hold the mask; I camera assembly to look at the alignment marks, UV exposure system the expose the wafer.

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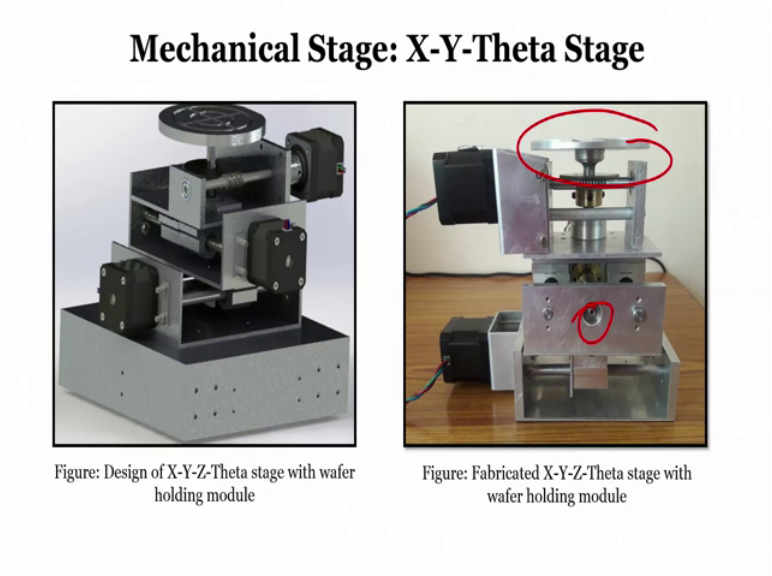

So, if I want to design this X Y theta stage right this is a 3 D model right using solid works you can design, using pro you can design right. And this is actual model this is actually fabricated X Y theta stage, there is a Z stage as well with a wafer holding body. So, we have now designed this X Y theta stage.

So, you guys have to understand that using knowledge of 3 D printing, using knowledge of workshop right we all go to a we have a course of attending a engineering workshop right; which we understand the design, we understand how the workshop technologies can be used. So, you can use a basic workshop technology design you can fabricate this kind of a setup; little bit of understanding about electronic modules and motors and drivers is required to further operate the system ok.

So, we have this wafer holding system; here you can hold the wafer and you have to connect it to a vacuum system so, that you can hold the wafer correctly and when it is it will not moves.

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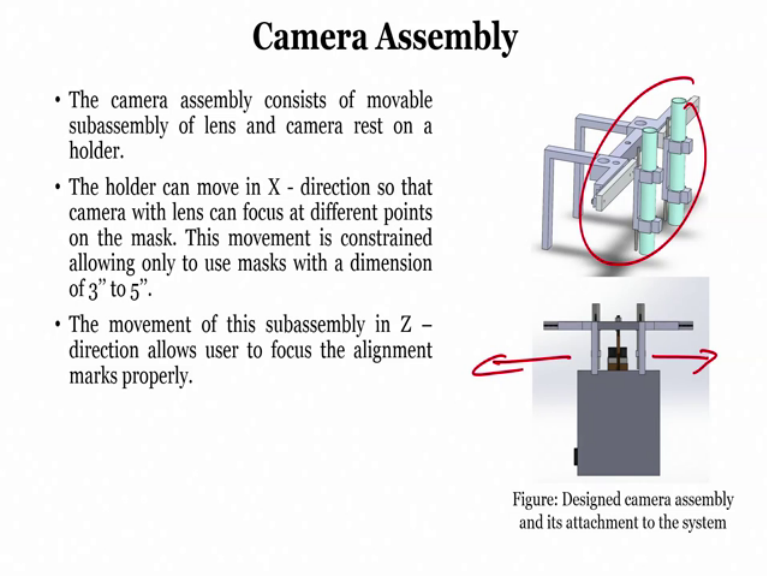

Then we have also designed a camera assembly what we require? Camera right; camera to do what, camera to understand the design to look at the pattern on the wafer and to align it; so, camera assembly consists of a moveable sub assembly system this can be moved right in a camera rest on a holder.

The holder can move in X direction so that camera with aligns can focus at different points and it will move in this direction or it can move in this direction or 2 older separately this moment is constrained aligning only to use mask with dimension 2 of 3 inch to 5 inch. So, we cannot use a mask which are bigger than 5 inch and or smaller than 3 inch. The moment of this sub assembly in Z direction allows user to focus the alignment mask properly right.

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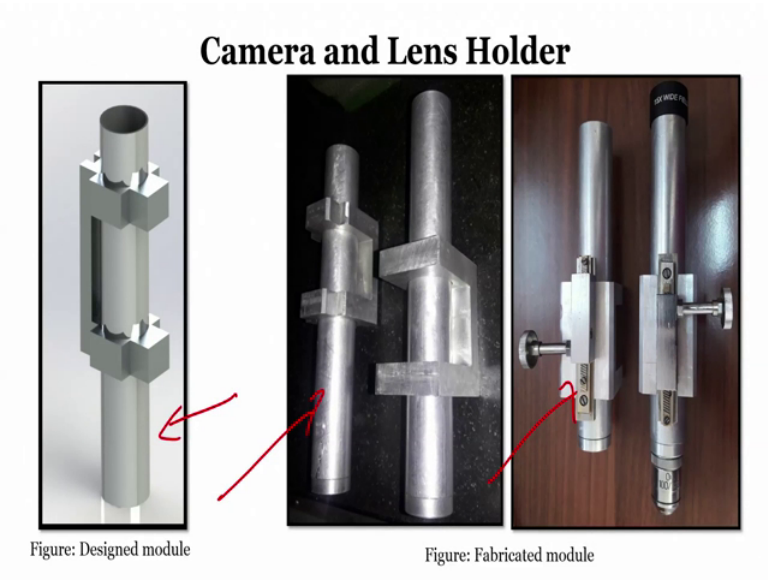

So, if you see the camera lens holder right; this is how the lens holder looks like in an actual system. You can see here this is a fabricated camera lens holder ; fabricated module and this is a design module. So, from design to fabrication you can do it in your laboratory, in your college there can be a project mini projects right.

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Then we have a mask holder. So, mask holder again you have to hold the mask; so, you have to create these holes for vacuum so, that the mass can be hold it perfectly. This is a design mask holder of 5 inch right left side is designed and right side is the fabricated

version. The mask holder slide inside the mask support so to support this mask holder we had to insert in the mask holder slide. Then mask holder consists of 2 basic parts as you can see mask holder and mass support right.

Now, this is what we are showing is similar kind of technology is used in actually available mask aligner right. Of course, with a little bit advanced version, but the idea is same idea is same. So, it is very important if you see this you will you understand what they have used in their particular system. So, the mask holder consists of mask basic parts; one is mask holder second is mask support,

Mask support is designed in such a way that it can house a mask with maximum dimension of 5 inch. Second is mask plates of various types can be used by using mask holders of different dimensions. Third one is the mass support can slide inside the mask holder and mass can be held within a mask holder by vacuum right; so, this is about the mask holder.

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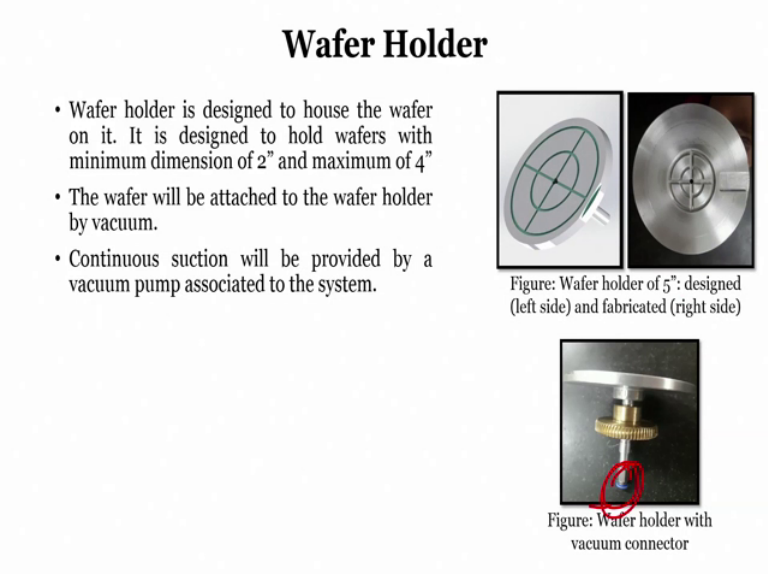

Now if we go further there is a wafer holder; once we have a mask holder we also require a wafer holder. Now how does exactly wafer holder works? Wafer holder is designed to house the wafer on it right. So, here you see here again we had to create a vacuum so, that the wafer can be holded this wafer holder of 5 inch design and fabricated. Actually the wafer holder we have wafer for 4 inch right where mask is of 5 inch.

So, it is designed to hold wafers with minimum dimension of 2 inch and 4; the holder can be 5 inch by the mask that we can load a maximum is 4 inch ok. So, it can hold 2 inch and 4 inch wafer; the wafer which we attach to the wafer holder by vacuum continuous suction will be provided by a vacuum pump. So, you had to connect a vacuum pump here right before holder with the accumulator, you can see here and this needs to be connected to a vacuum pump. So, to get enough vacuum to hold the wafer the it should not be such that the wafer will get crack or break ok, that is another thing that is very important that we when we design the wafer holder.

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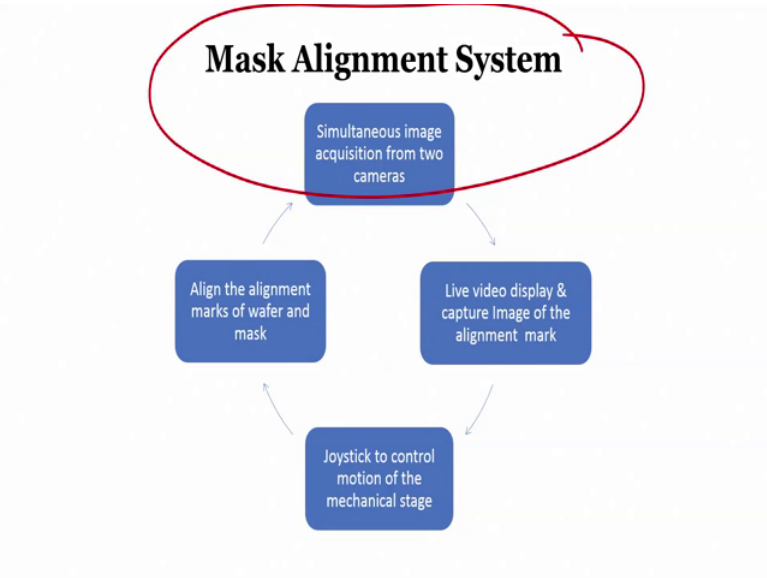

Now when you talk about the mask alignment system, what you see? You have to have a simultaneous image acquisition from 2 cameras right simultaneous acquisition of images from 2 cameras, then we should have a live video display and we should have a capability of capturing image of the alignment mark.

Then we should have a joystick to control the motion of mechanical stage and we should have aligned away; we have to align the alignment marks of wafer and mask right. These are the requirement requirements for the mask alignment system right; more or less of a mask alignment system. So, if we can address all these 3 requirements, we can design the mask alignment system.

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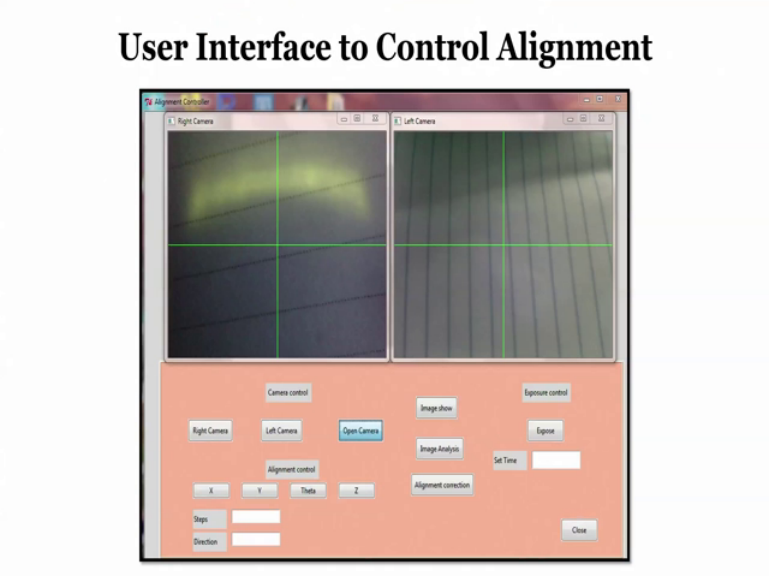

So, how we can design this mask alignment system and how we can interface this to actual display and then what kind of UV source we can design. So, that we will talk in the next module; for this module you understand that the mask alignment system the mask aligner as is a very important part of a photolithography system.

And we are learning how to quickly design a mask aligner or I am showing it to you how the mask aligner can be designed right. So, in the next module we will see the next portion of the mask aligner and see how it can be used in actual scenario. Till then you take care, look at the module I will see you in the next class, bye.