Lecture-17

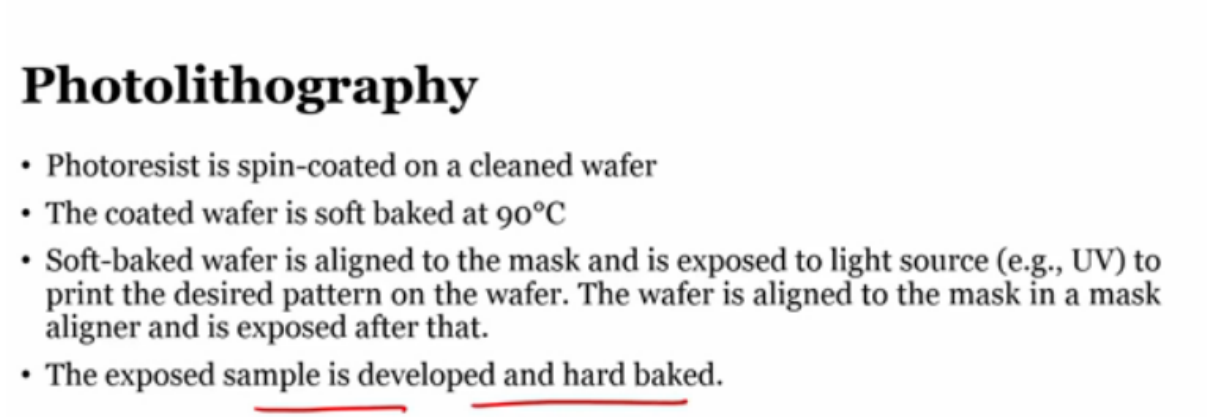
Photolithography:

Mask Aligner

Hi 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 photo lithography is right? And we have seen, I think MJb4 operation of MGb4 mask aligner using the video that, we had and I'm sure that you now know how the photolithography works. What are the positive photo resist? What are negative photo resist? What are right field masks? What are dark film ask how to align the wafer right? Now to align the wafer mask aligner right and to expose. The wafers UV source right, so the cost of this system right now is close to like 50lakh. 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 book. 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'll 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 to reduce the cost of the masculine, traditional masculine to a value that most of the universities, Most of the colleges can afford right. If we see that okay, photolithography processes you take the wafer however, looks like you .can buy your wafer it's like 700 rupees or close to 2,000 rupees. Now once you have the wafer right what you will do that do with that if you don't want to buy before you can buy a glass slide that's also is fine right, what is a photographic 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 photo resist first, we can spin coat primer or we can spin core photo resist. After spin coating photo resist we have to pre-bake .you can buy a hot plate there should be hotplate in any chemistry lab in biology labs .You put the wafer so again, again you have to perform this entire thing in a yellow room, small room. This is required to Evert the UV light, so that the photo resist will not get exposed to UV, before we actually align the array in the substrate coated with photo resist. So what we require we after we spin coat photo resist. 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 gear to edge submitted right double you know the steps.

So how about, we developed our own mask aligner and at a very reduced cost and that can perform photo lithography step to get your design at least a simple design like a heater. Then you can connect that with the theory and probably understand how the photo lithography system works. So that is the idea behind developing a mask a learner with in my laboratory. Now when I will be teaching you this mask and inner steps. You will also know unlearn 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's a high time we use the knowledge that we have and put it together to 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 it all offers all teachers and the management are trying best I'm sure we are trying best to our abilities to help you out 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 , mobile , mobile, 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 don't show you the mobile . Then but what if I just show you a simple mobile ok this is a mobile this is how it operates these are button right , this is how you can use it it's easier no that is the idea. That so 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 masculine also if you see the slide you see the screen we will be talking about mass calendar today and mask aligner is used for photolithography .
Refer Slide Time :(7: 31)

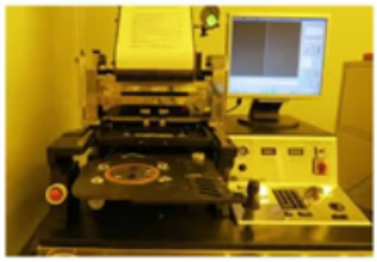


so you have to see a slide and the photo lithography photo resist is spin coated and clean wafer, we know it the coated refer is soft baked at ninety degree we know it soft baked wafer is aligned to the mask and exposed to the light source UV light right ,to print the desired pattern on the wafer. The 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 okay, let's say you have we need a pattern which is like, this in the final wafer this is, what we need? okay, this is our final wafer ,so we have done photolithography with a mask our first mask has let's say this pattern and with the help of this first mask ,we have used photo litho graphite design to get this pattern on the on the wafer right ,now this mark ma mask should have some alignment mark .What's the role of this alignment so you understand it we have first mask, with this pattern and there are alignment marks right this mask one .So our second mask , mask too would have , this pattern this is were mass too right ,now I had to align. This wafer these wafers Ito align when I have to again perform photolithography with mass to such that I can have, this kind of design next to my arrow. So when I'm going to align this mask my wafer with mask to right with mass to 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 arraignment mark on my mask looks like this, they should align it. So that if I see it, it looks like the, 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 ,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 will not get what we want right .So it's very important how to align this thing for that ,we require a mask aligner .So this is just to mask process right mask one, we form the pattern mass two we form another pattern right, mass to was if I remove this mass to was another pattern .Using mask one and mass 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 mass 2 should be the alignment mark of a member of my mass 2 .Should be smaller than my arraignment mark of my mask one that's very important to remember all right, it's very important sore member these things same way alignment mark ,4 by mass 3 should be smaller than alignment mark of my mask to alignment mark of my mask for should be smaller than arrangement mark of my mask 3 okay ,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

Refer Slide Time :(13: 11)

Mask Aligner

- Mask aligner is used to align the wafer to the mask and expose the coated wafer.
- Three degrees of freedom (X, Y and Theta axis) between mask and wafer is provided to align.
- The alignment marks on wafer is aligned to the marks on mask prior to exposure.
- In semi-automated systems, alignment is done manually but in advanced automated systems, automatic pattern recognition is used in alignment system. Normally, alignment process requires at least two sets of alignment marks on opposite sides of wafer.
- Split-field microscope is used to make alignment easier.



Mask Aligner (EVG 620) in CeNSE, IISc Bangalore

we know,it how the mask aligner looks like right, so we see this is a mask aligner we have it Centre for na no science and engineering at IASC and this is EVG 620 .So this is a mask aligner, you can see here in the in the display, you can see how the wafer looks like what the patterns are 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 K prime. You require you will ,like to follow this is a joystick to move X ,Y the ,the wafer in X&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 8090 le k some mascaras are even like 1.5 corer, some 2 corers 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 with what photo resist 3 degrees of freedom .We get always X ,Y and theta right, if you want too much. Where - In 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 have two options either remove the mask or you route the wafer I would prefer to mode paper ,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 prop mask prior to the waiver right, what is that ? the alignment marks on wafer is aligned to the marks on mask prior to the wafer .So that's 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 arraignment process requires at least two sets of alignment marks. Opposite sides of the what does that mean ,if I have the alignment mark right, whatever the pattern here is I require at least two alignment mark, on the wafer now this does not mean, that every time I had to draw a plus .I don't whatever the pattern is there's a metal here my element 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 ,to when I make the if I use a circle here I'm using a circle here right, this circle when, I align it with this one this should be within it this is mask one mask. So alignment mark , alignment mark of mask . Should be less than Ellenville mark of mask one ,should be smaller than alignment mark of mark of mask . One that is very important to remember okay, so normally Ironman process at leas requires two sets of alignment marks on opposite sides of the if a split field microscope

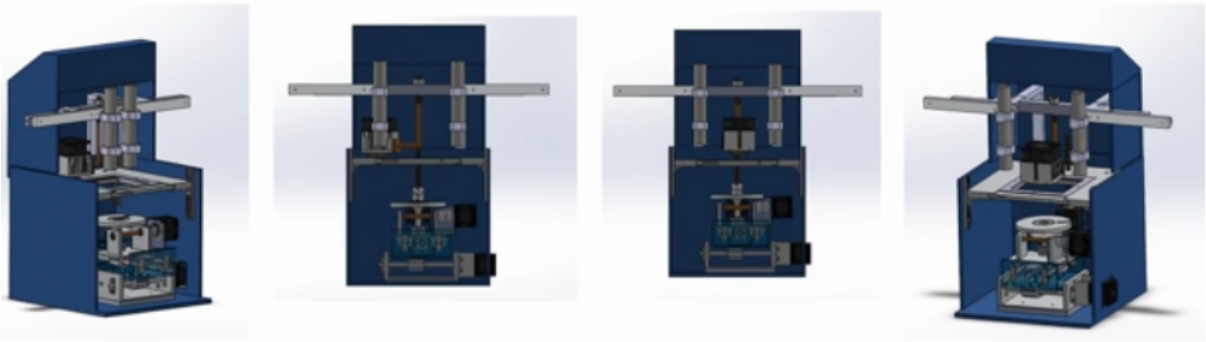
is used to make and I meant easier. So if we use split film microscope, at if you have the wafer or if you have the mask at the same time. You can see both the areas both the alignment mark at the same time. You can use or see if we use split film microscope so that is another point that you need to remember ,when you are using a mask aligner

Video Start Time :(17: 14)

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's 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, this electronics is right ,over here this is to more manually X,Y,Z and 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 that is a wafer there's 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 row ,this is in yellow no you see everything whenever, you use it's always should be operated in a yellow .There is a display always connected with it so that we can see the alignment the alignment mark ,wait to see we had to adjust it accordingly right, we had to see the pattern, you can see the pattern Elizabeth . So these are commercially owned by mask aligner ,now yeah this is a YouTube video. So we will play each video when the time permits, so just go through each of the video and you will understand. How it is operated right ,so we have three videos here for you to observe and then let us play one by one all three videos . This is not a matched master wafer ,but we should at least be able to see the alignment process and I'm satisfied with the alignments. O we'll expose ,they load the wafer and run the same wafer in topside alignment we'll do another five second exposure you know today is April 14. 2013 and we are looking use e.g. d/ID number 3 ,3, 6, 8 funny serial number 1, 911 this machine's through the refurbishment process ready to be walked down for shipping. But first we'll just demonstrate the operation by running a four inch wafer in her contact there's one thing ,this is not a match press alignment check underneath . The wafer now we can verify that we're still satisfied with our line you say double-check that ,you want to expose who's ready to unload this machine is also set up with iron capability. Could run the same wafer transmitted by our rather, than with to demonstrate that go to parameters my armload we're now viewing the manlike me Jay and performs five seconds ,but okay? Video End Time :(27:20)

Refer Slide Time :(27: 21)

Designed Mask Aligner



Now since, we know what a mask aligner looks like what, what are the designs right, there is a spirit-filled microscopy ,there is a UV exposure system and there is a mask 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 am ask 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 masks and I know now to make it affordable first, we are and the stage of designing it and we are stage of fabricating it.

Refer Slide Time :(28: 04)

Mask Aligner

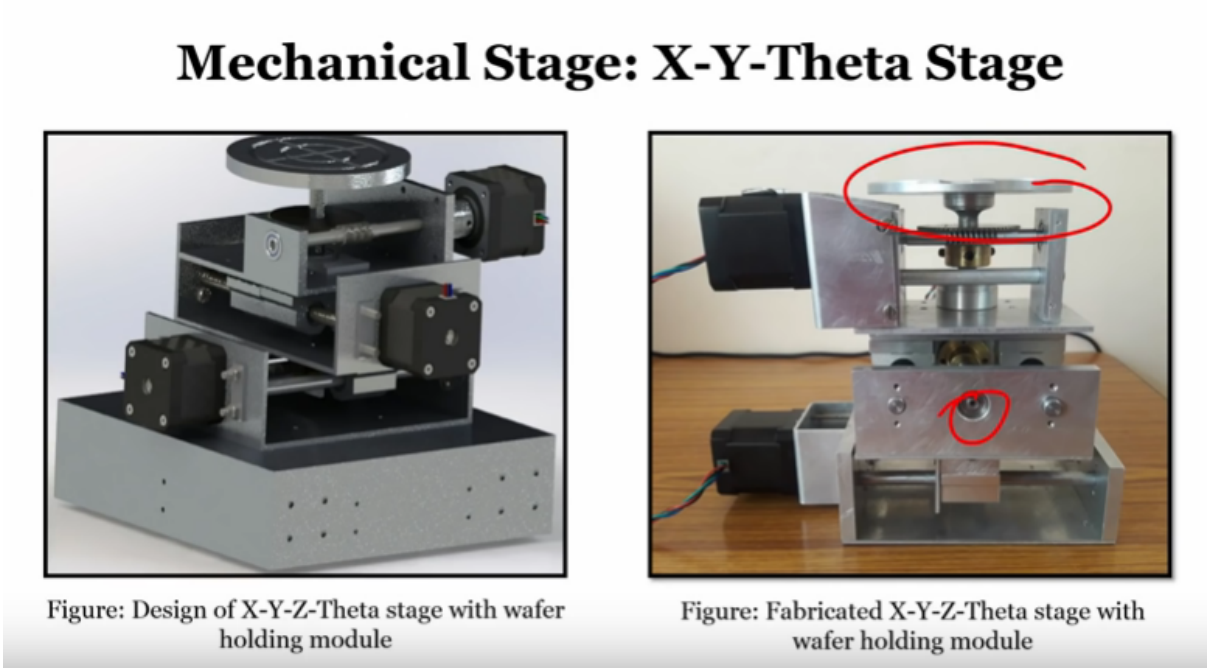
The major parts of designed mask aligners are:

- X-Y-Theta stage with wafer holder
- Mask holder
- Camera assembly
- UV exposure system

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 renders 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 you Expo system right, So for X ,Y Theta for ,for moving the wafer and it is attached with a wafer holder. So that we can move the wafer in X ,Y in the test theta ,we have am ask

holder to hold the mask can I come in I assembly to look at the Iron Man marks we ,we expose a system to expose the wafer.

Refer Slide Time :(28: 59)



So, if I want to design this X,Y theta stage right this is a 3d model right, using Solid Works you can design using Pro II . 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 way for holding model. So we have now designed this X ,Y theta stage, so you , you guys have to understand ,that using knowledge of 3d printing there is 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 box of technologies and you can fabricate this kind of set up a little bit of understanding , about electronic modules and motors and drivers is required to further operate the system okay, so we have this wafer holding system here you can hold the wafer and you have to connect it to vacuum system. So that you can hold the wafer correctly and when it is it will it will not move

Refer Slide Time :(30: 15)

Camera Assembly

- The camera assembly consists of movable subassembly of lens and camera rest on a holder.
- The holder can move in X - direction so that camera with lens can focus at different points on the mask. This movement is constrained allowing only to use masks with a dimension of 3" to 5".
- The movement of this subassembly in Z – direction allows user to focus the alignment marks properly.

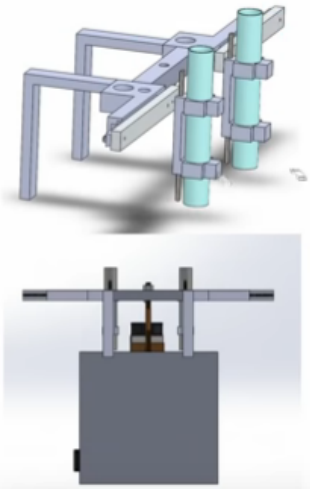
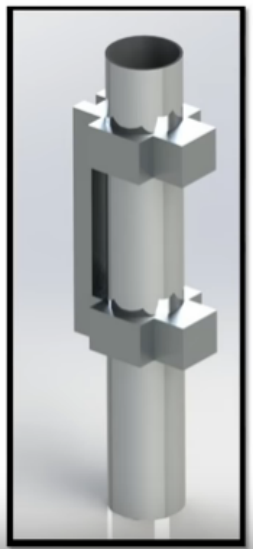


Figure: Designed camera assembly and its attachment to the system

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 movable 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 lens can focus at different points and it will move in this direction or it can move in this direction or two older separately this moment is constrained allowing only to use masks with dimension to of three-inch to five inch .So we cannot use am ask, which are bigger than five inch and or smaller than, three inch the moment of this sub assembly in Z Direction allows user to focus their Edmond mask properly right ,

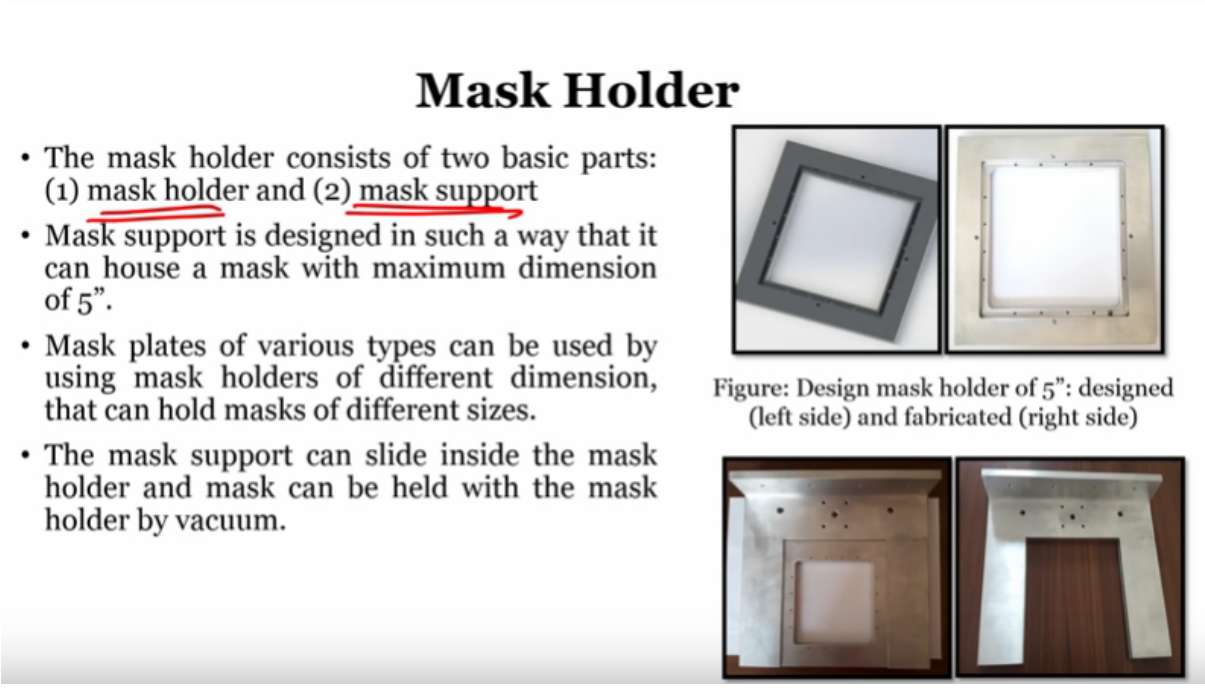
Refer Slide Time :(31: 06)

Camera and Lens Holder



so if you see the camera lens holder right, this is how the lens order looks like in an actual system you can see here this is a fabricated camera lens holder hmm. 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?

Refer Slide Time :(31: 31)



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 five-inch right, left side is designed and like right , side is a 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 . The mask holder consists of two 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, but the idea is same idea is same, so it's very important. If you see this you will you understand, what they have used in their particular system so the mask holder consists of mass basic parts one is my camera, second is my support ,my support is designed in such a way that it can house a mask with maximum dimension office inch ,second is mask plates of various types can be used by using mask holders of different dimensions their done 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 , Rafi's go further

Refer Slide Time :(32: 48)

Wafer Holder

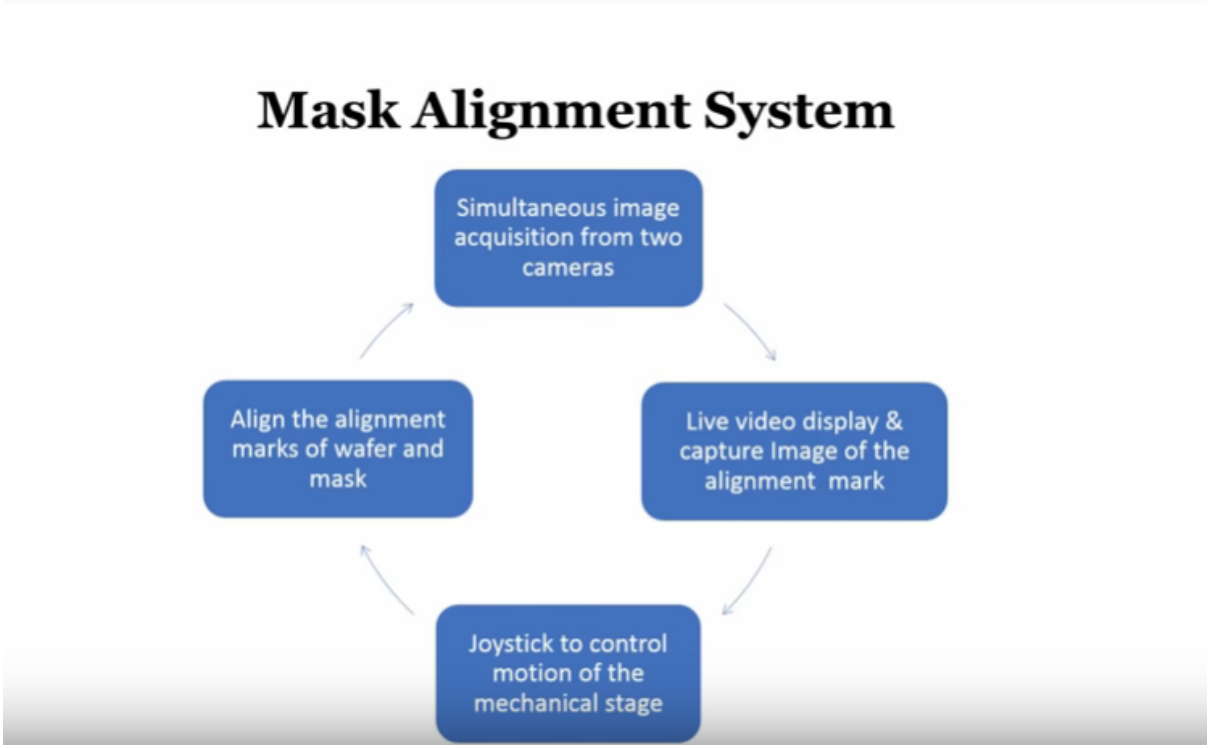
- Wafer holder is designed to house the wafer on it. It is designed to hold wafers with minimum dimension of 2" and maximum of 4"
- The wafer will be attached to the wafer holder by vacuum.
- Continuous suction will be provided by a vacuum pump associated to the system.

Figure: Wafer holder of 5": designed (left side) and fabricated (right side)

Figure: Wafer holder with

there is a wafer holder once, we have a mask holder we also require a wafer holder , now how does exactly wafer holder works paper 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 hold it there's a wafer holder of five inch design and fabricated actually the effort holder we have wafer four, four inch right ,wear mask is of five inch . So it is designed to hold efforts with minimum dimension of two inch and fourth holder can be 5-inch by the mask that we can load a maximum is 4 inch okay 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. Okay? There's another thing that is very important that we when we design the wafer holder

Refer Slide Time :(33: 53)



now when You talk about the mask alignment system what you see you have to have a simultaneous image acquisition from two cameras a simultaneous acquisition of images from two cameras then , we should have a live video display and we should have 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 then away , we have to align the alignment marks of wafer and mask these are the requirement requirements for the mask alignment system right , more or less of am ask alignment system . So if we can address all these three requirements we can design the mask alignment system show we can design this masquerade do main 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 is a very important part of photolithography system and we are learning how to quickly design a mask aligner or I am showing it to you how the mask render 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'll see in the next class. Bye.