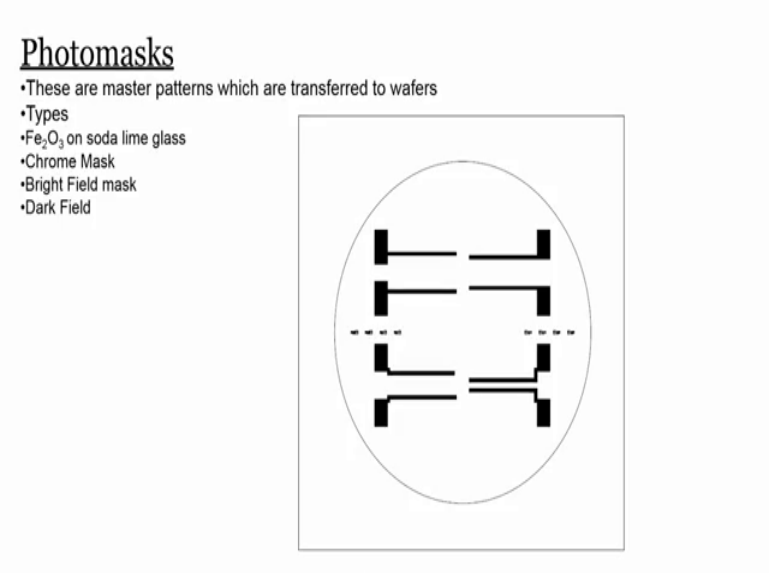
Sensors and Actuators
Dr. Hardik J. Pandya
Department of Electronic Systems Engineering
Indian Institute of Science, Bengaluru

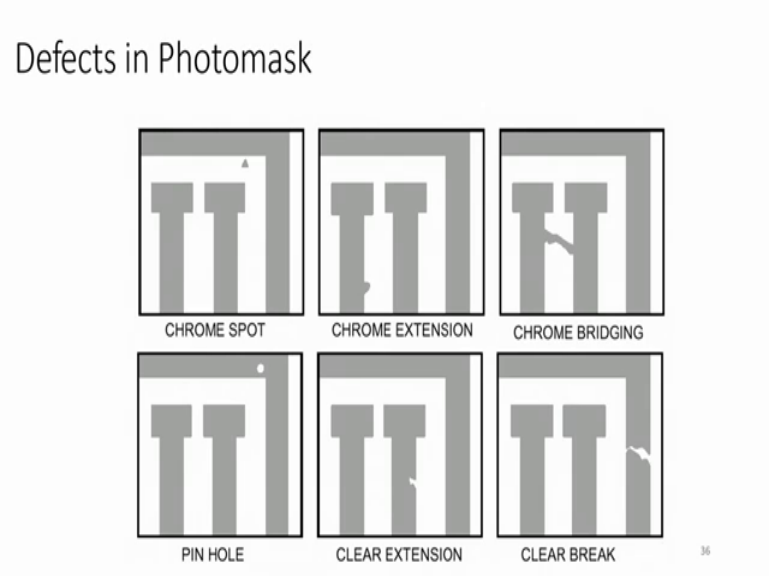
Lecture – 39
Photolithography – Part 3

(Refer Slide Time: 00:28)



Hi, welcome to this particular module. We talked about photomask right pause bright field photomask and a dark field mask. So, this mask are master patterns which are transferred to wafers and the types of photomask are the Fe 2 O 3 on soda lime glass. It can be a chrome mask, it can be bright field and dark field as you know.

(Refer Slide Time: 00:48)



These are some of the defects that are available that are generally, you know, observed in a photo mask, one is a chrome spot. Now, why it is not important; why it is very important? particularly when you fabricate MOSFETs then within this area you will have few thousands of devices that you are, that you will be killed, killing because of that effects in that photo mask which is your chrome spot.

If you see the second image, you will see the chrome extension. Suppose I fabricate a heater, then this extension will create a different resistance compared to what I have calculated. Same thing; if this is a short it is not acceptable because two lines will be short, if it is a metal it is not at all acceptable. In other cases also, it will be a lot of problem.

If you have a spot, then this particular area again you are killing the chip. This crack will cause or clear extension or a crack will also cause the change in the resistance if it is a resistor; the other properties are also affected when you have this kind of defect. Finally, a clear break is not at allowed because you are if it is a conducting lines and you are just breaking the connection. So, all this kind of defects are generally observed in a photo mask. So, before you use a mask, make sure that this kind of defects are not there.

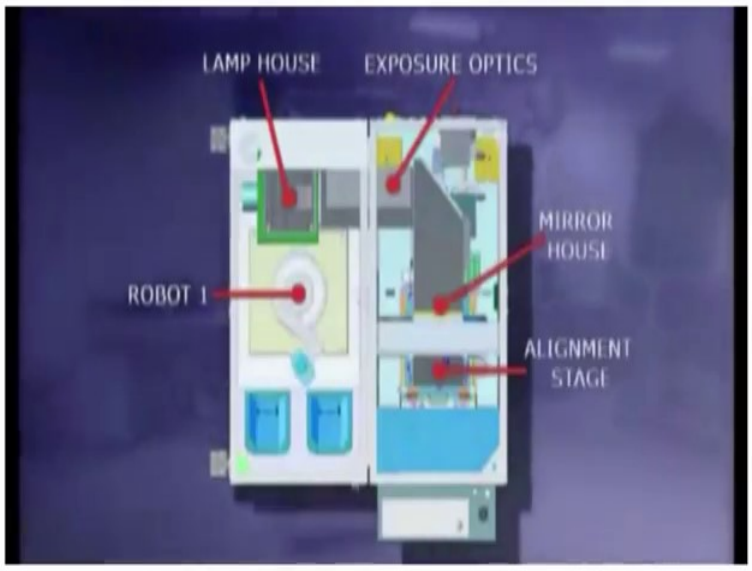
So, now, let us understand and see the lithography videos where you will be understanding two types of lithography – one is automated one and second is semi-

automated one. There is something called front to back lithography, once we look at the video will be understanding what is front to back. Let me first play the first video.

(Refer Slide Time: 02:50)

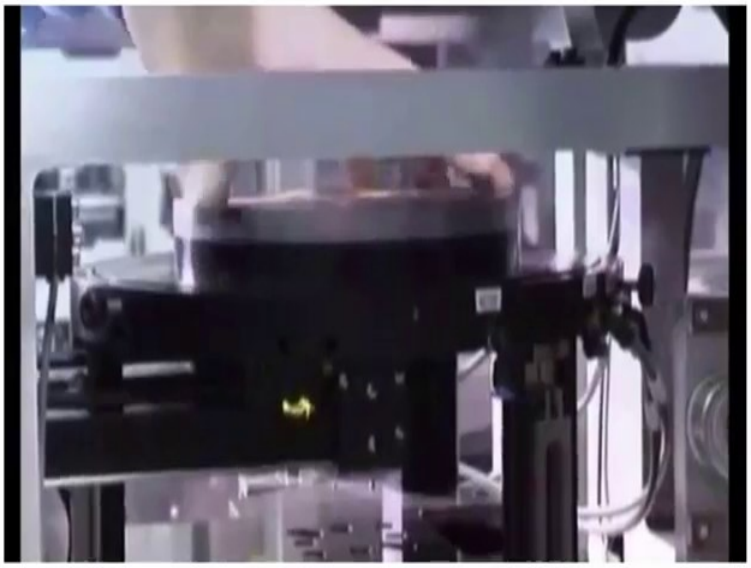
Hello, my name is Bernard from the SUSS Micro Tec development team.

(Refer Slide Time: 02:52)



Today, I would like to present our new generation of production aligner, the MA200 compact which offers an advanced technology design, unmatched precision and a high degree of flexibility. See for yourself how easy it is to operate. The chuck is stored in the bottom part of the aligner and is quick and easy to load.

(Refer Slide Time: 03:10)



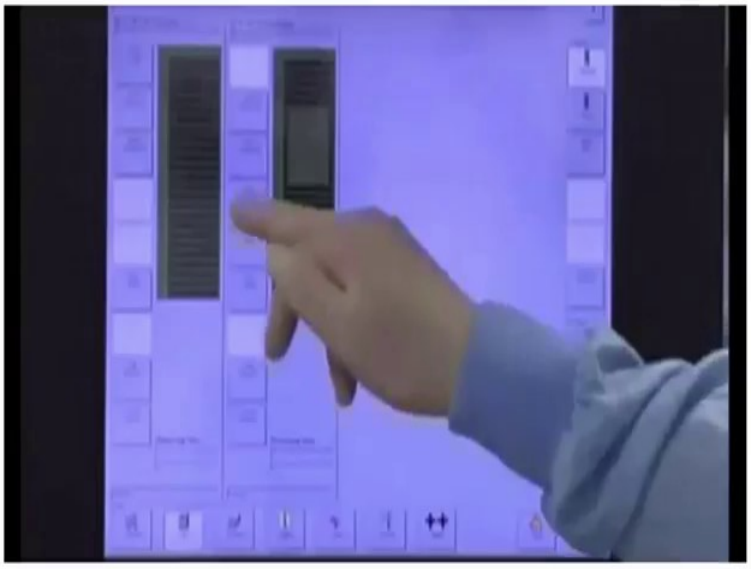
(Refer Slide Time: 03:18)

Equally easy to insert are the mask holder and the mask.

(Refer Slide Time: 03:25)

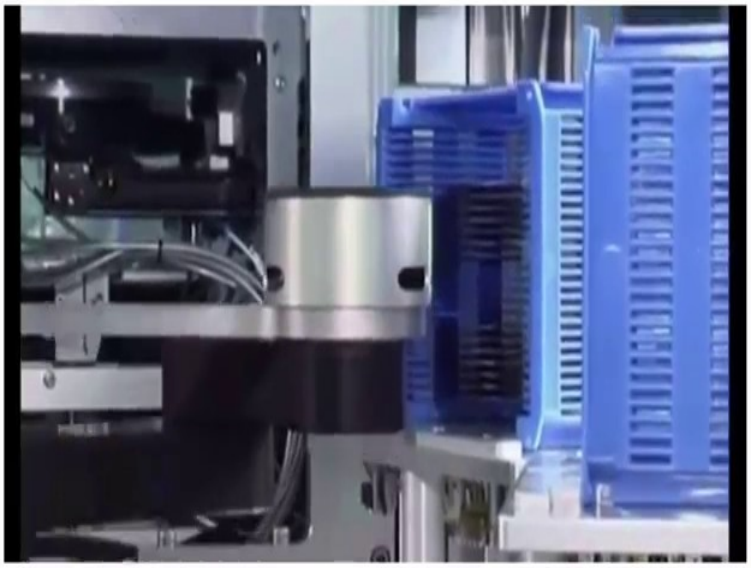
Now, I load the carrier. That is all there is to it and the MA200 compact is ready for operation.

(Refer Slide Time: 03:43)



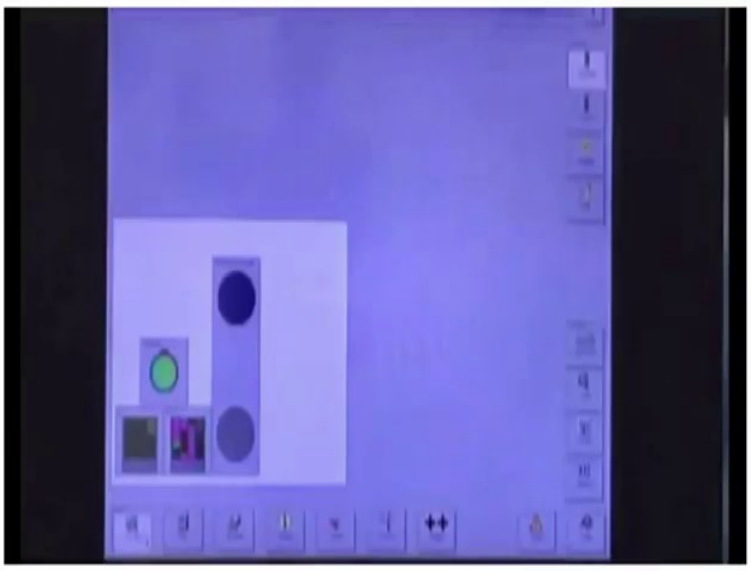
The processes of the MA200 compact can be controlled via touch screen. For some processes, you can select between fully automatic and manual operation.

(Refer Slide Time: 03:50)

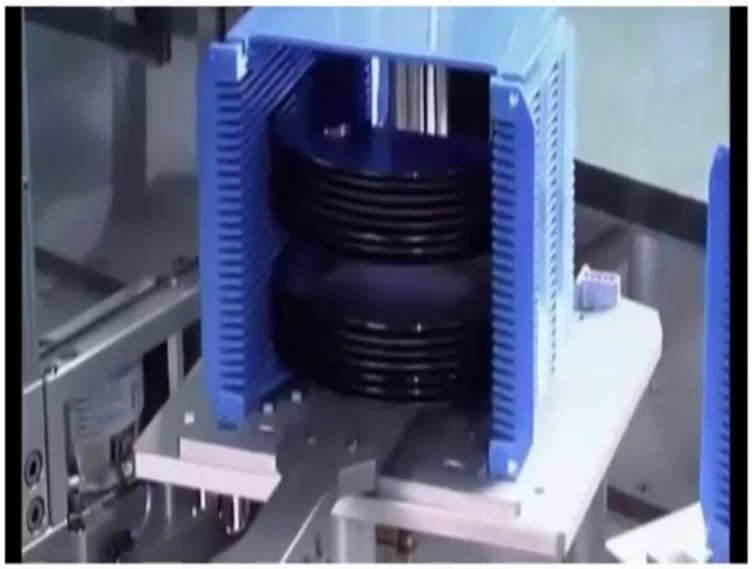


A robot scans the wafers and determines their quantity, position and size and the processing begins.

(Refer Slide Time: 04:06)

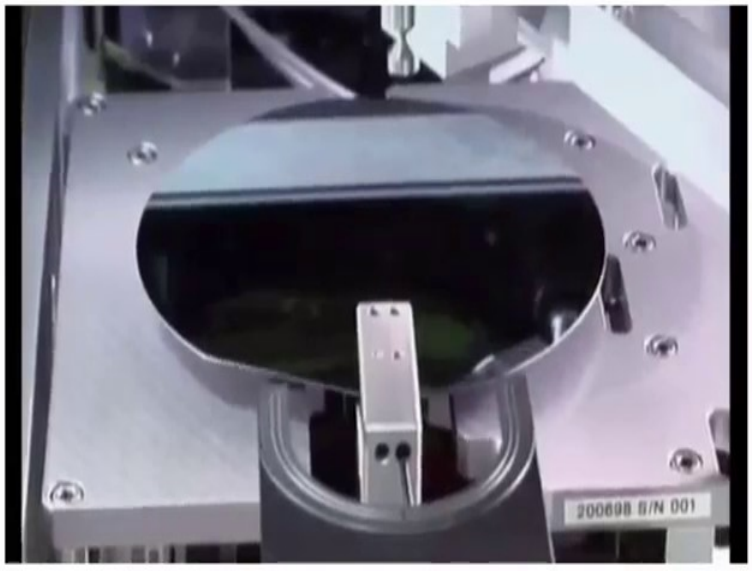


(Refer Slide Time: 04:09)



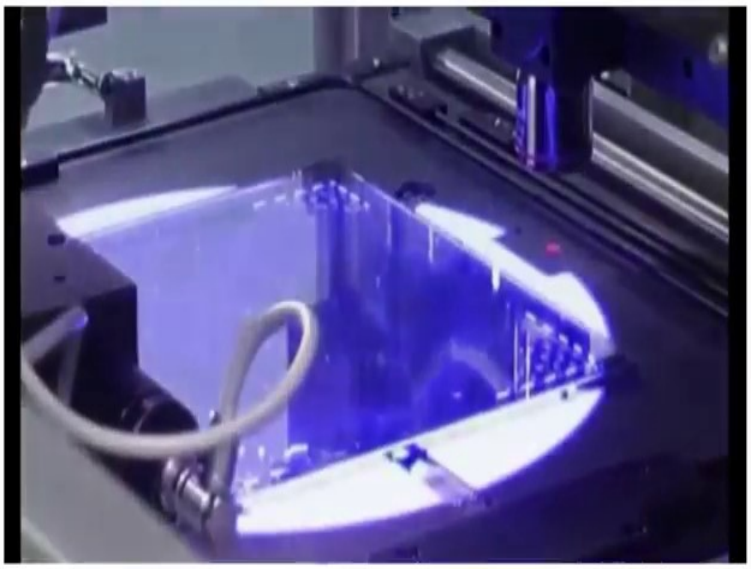
The MA200 compact processes wafers and substrates up to 200 millimeters regardless of their material, size, shape and thickness. The machine runs and adjusts fully automatically.

(Refer Slide Time: 04:21)



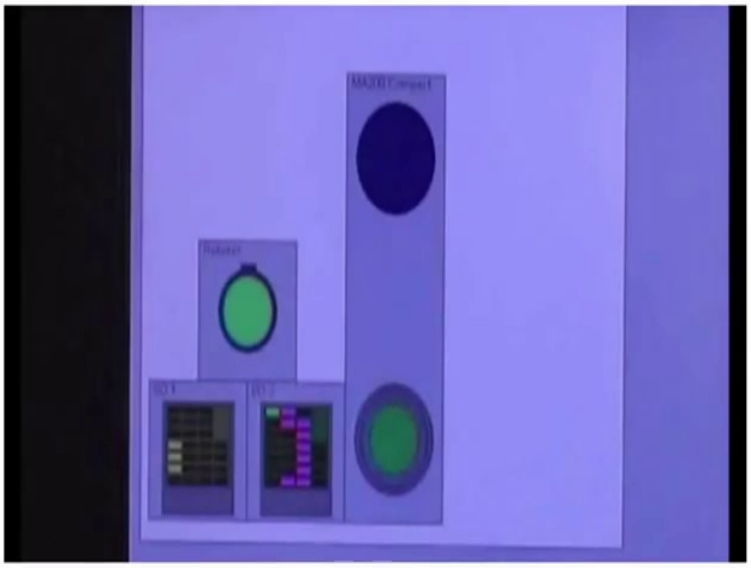
And is optimized for the processing of thick resist such as with thick resist flip chip bumping, wafer level packaging, MEMs, nanotechnology or telecommunication devices.

(Refer Slide Time: 04:34)



The big advantage over steppers is the exposure of the entire wafer in one step.

(Refer Slide Time: 04:41)

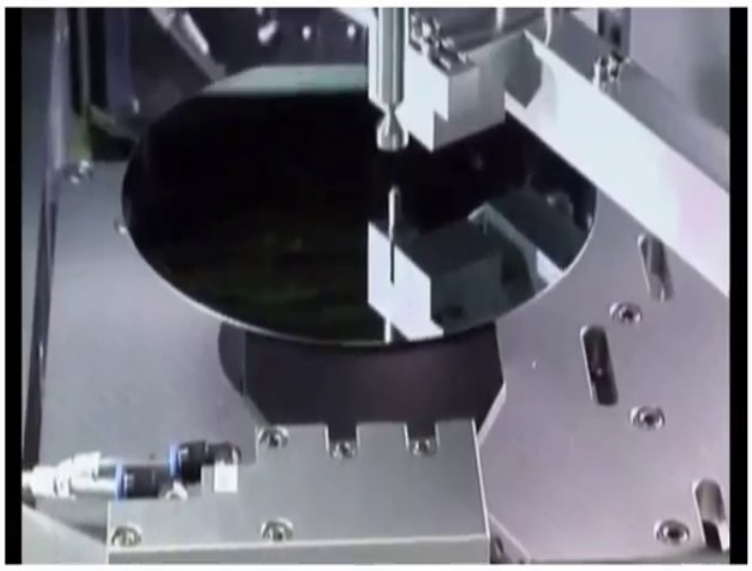


Thus, a throughput of more than 100 wafers per hour can be achieved with an overlay accuracy in the submicron range. Now, let us slow the process down and take a closer look.

(Refer Slide Time: 05:02)

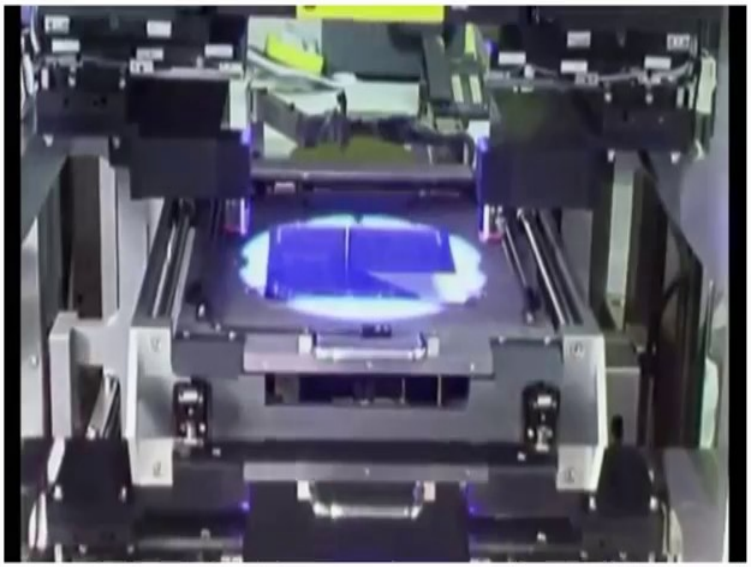
First, the wafer is pre-adjusted onto the pre-aligner in preparation for the ensuing alignment.

(Refer Slide Time: 05:10)



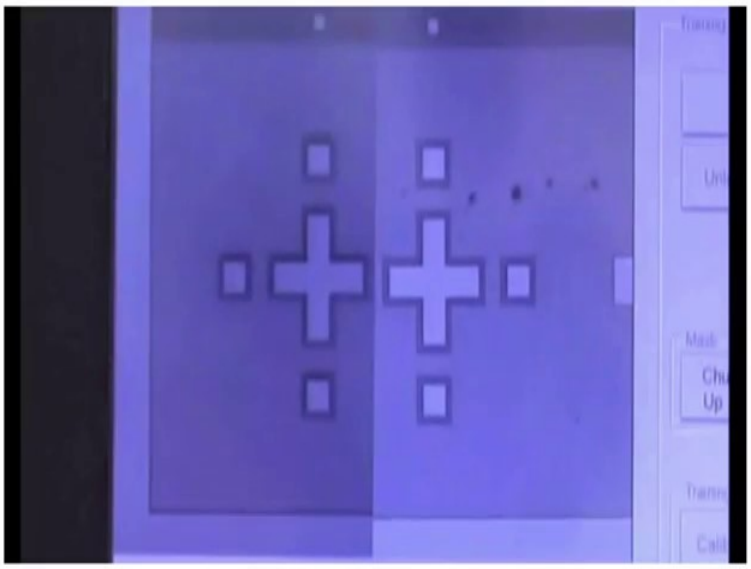
A linear transport system loads the wafer onto the exposure chuck which together with the robot arm guarantees the optimal and the flexible handling of the substrate.

(Refer Slide Time: 05:24)



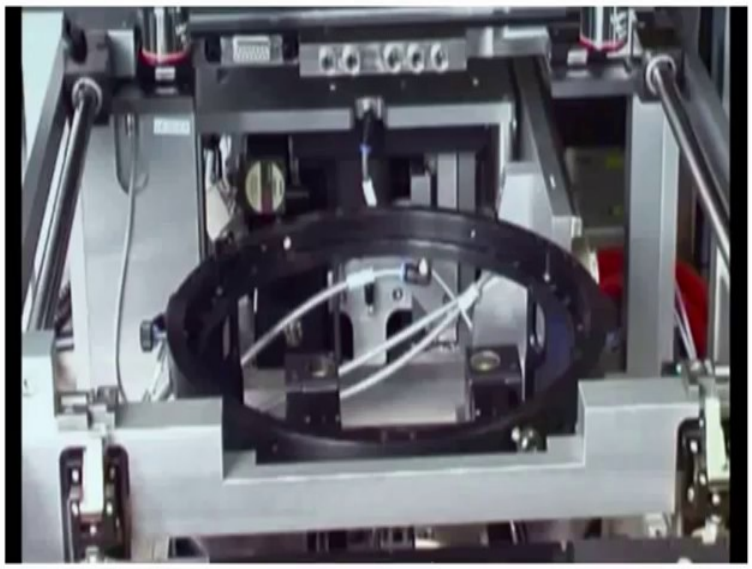
No other mask aligner on the market offers a higher degree of alignment accuracy than the MA200 compact. With the use of the recently developed and patent pending direct align option from SUSS, the mask is aligned directly to the wafer guaranteeing an overlay accuracy of up to 0.5 microns at 3 sigma. The structures of the photo mask are conveyed via shadow cast. The patented wafer leveling system from SUSS compensates for topographic variations and wedge errors, thus guaranteeing perfect alignment and exposure results.

(Refer Slide Time: 06:04)



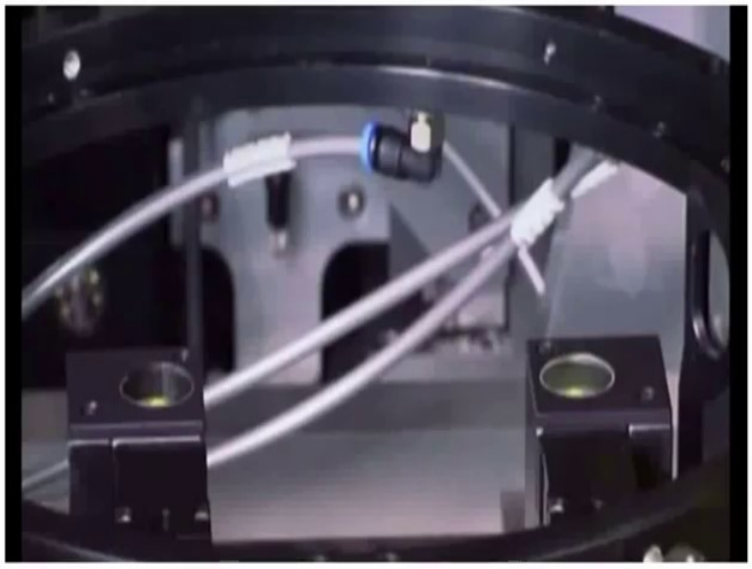
And, the entire process is easy to monitor here on the touch screen.

(Refer Slide Time: 06:14)



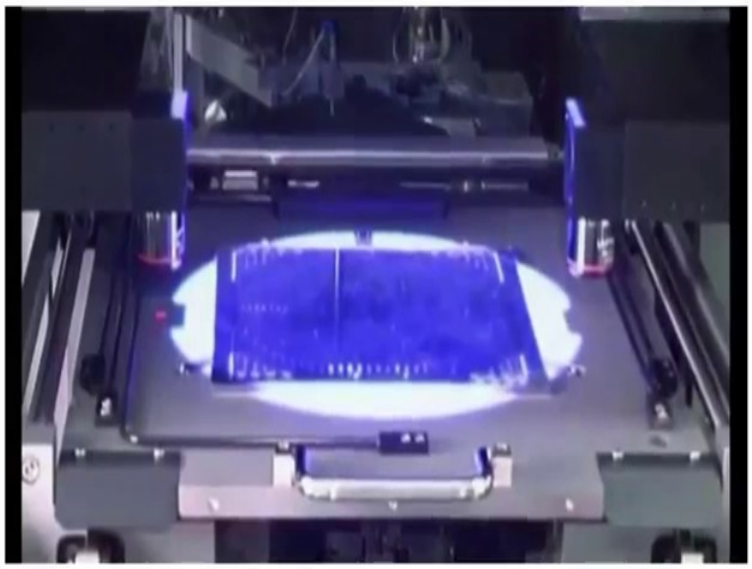
Because of the MA200 compacts newly designed microscope.

(Refer Slide Time: 06:18)



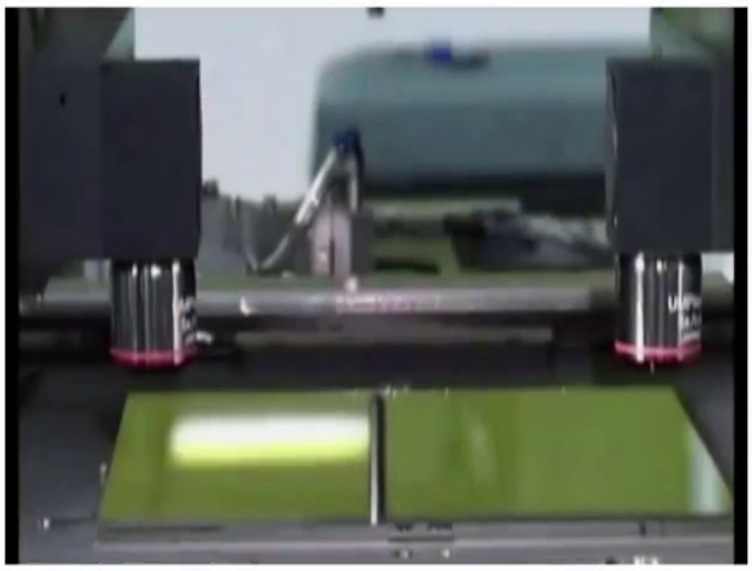
During exposure the mirror housing does not move forward.

(Refer Slide Time: 06:23)



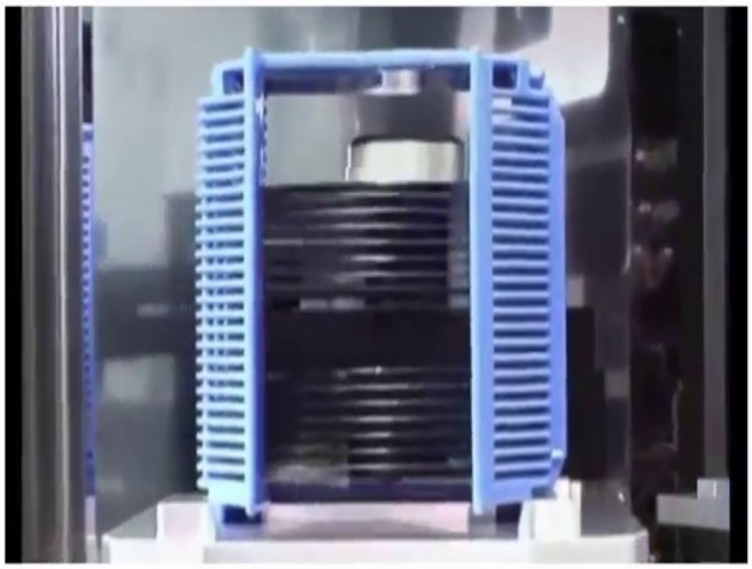
The microscopes only move sideways, thus reducing the vibrations of the alignment stage to a minimum resulting in far greater accuracy.

(Refer Slide Time: 06:34)



The optics of the MA200 compact are optimized for thick resist processing. In thin resists, it achieves a resolution of 3 microns in proximity mode and a sub micron resolution in contacts printing. A microscope for bottom side alignment is optionally available.

(Refer Slide Time: 06:55)

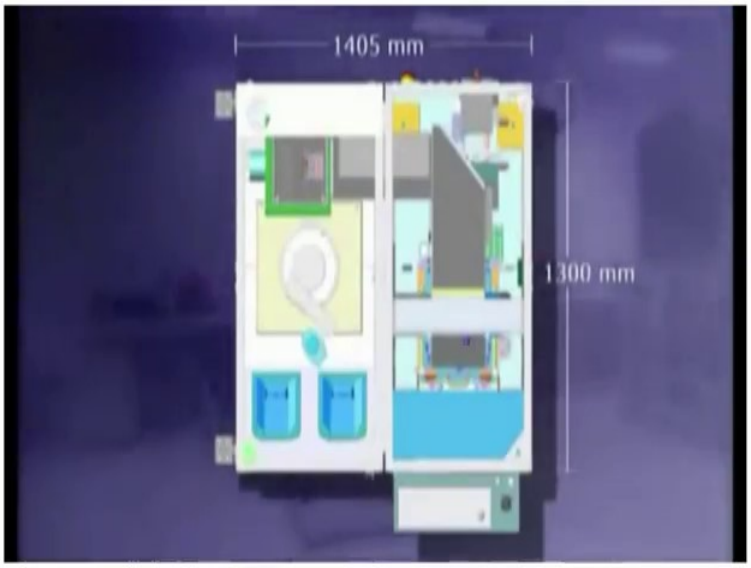


It can process substrates with thicknesses of up to 4 millimeters. The MA200 compact is a master when it comes to detail.

(Refer Slide Time: 07:15)

Our idea while designing it was to create a device that is both, user and maintenance friendly. In order to further reduce your operational costs, the electronics and all-important components are easily accessible as well as being arranged in a clear and logical manner.

(Refer Slide Time: 07:30)



Because of its compact size, it also saves valuable space in the clean room. The MA200 compact is the ideal exposure system for application areas with high demands in terms of package densities and micro mechanical structures. I can only recommend that you take a closer look at our new mask aligner in person and would like to invite you to do so today. The MA200 compact from SUSS Micro Tec.

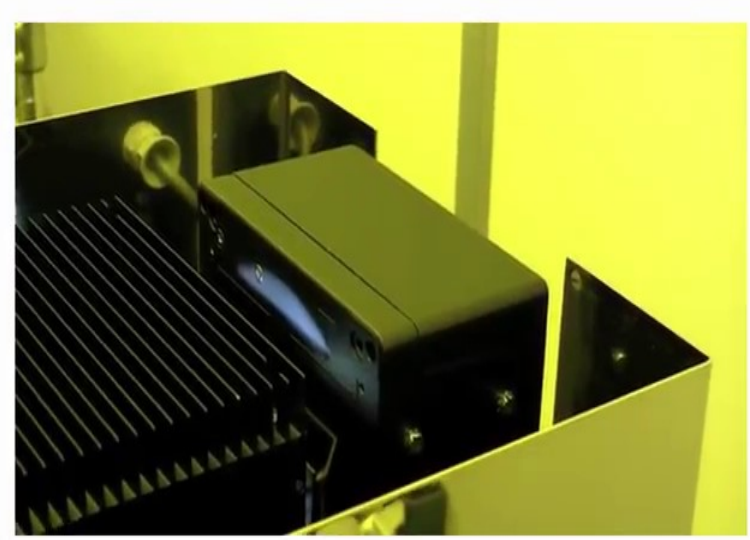
So you have seen the first video where it is about the automated kind of lithography system where the robotic arm will pick up the wafer and will spin coat the wafer and the exposure will be done while the second video that I am going to show you now is a semi-automated system where the clean room user will show it to you, how to expose the wafer from front side as well as if I want to do front to back alignment, how to go for backside exposure. So, you I play this video.

(Refer Slide Time: 08:37)

(Refer Slide Time: 08:42)

This is the MA6. It is used to expose a UV light to your substrate that has, you know, the photoresist on it. So, before we run the machine, the first thing we got to do is make sure the light bulb is turned on or even not blown up.

(Refer Slide Time: 09:03)



So, we come out to the back and you can see the lights turned on by the reflection air or you can see the light glowing.

(Refer Slide Time: 09:20)

So, you know that the light bulb is on but in addition to that you want to find out how many hours are left on the light bulb. So, you check the power supply. You hold this button called DS. It says 3226; it is how many hours the bulbs being used. So, the bulb has a lifespan of 4000 hours. So, when it is over 3500 we would notify staff and tell them

to change it. So, we are pretty close to that. Now that the bulb is ok to use and there is nothing wrong with the bulb and the power supply, we want to log into the system.

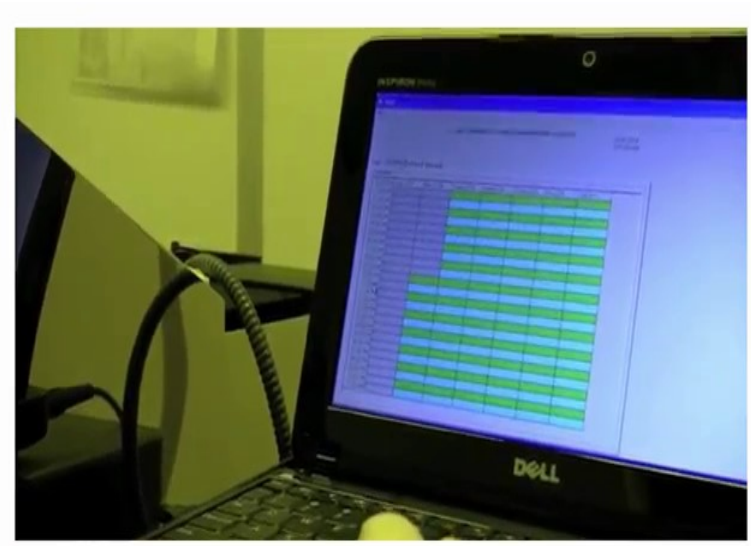
(Refer Slide Time: 09:57)

So, before we log in, we check the logbook and the logbook would say that the last person who used it was Monica on 221 and then I would check what notes she had or anything was wrong. So, you see there is nothing wrong. So, we are ready to turn the machine on and login.

(Refer Slide Time: 10:12)

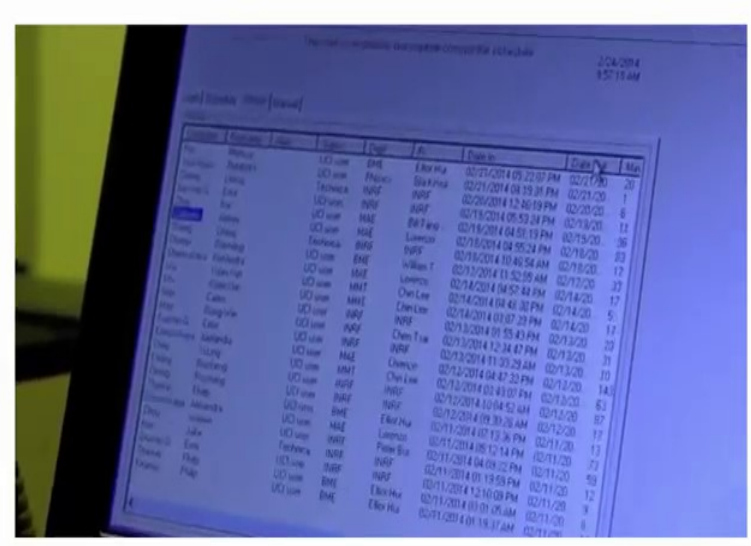
So, the login computer is here, you have to login to use the machine otherwise it will not turn on and the login has a several functions. The first screen is the login, where you type in username and password. You can schedule to use a machine of different hours, also you can you should check this to make sure nobody else is using it.

(Refer Slide Time: 10:33)



So, today is a 24 and it is 10 AM and there is nobody using it. So, we're free to use it.

(Refer Slide Time: 10:42)



Also, there is a history tab where we can see the last user and you can see that Monica was last user and she was the last one to write on logbook.

So, once we know the machine is ready and so use, we just login. So, once you have logged in the machine will be able to power up and what we do now is we turn the ON switch on here.

(Refer Slide Time: 11:03)

So, we just turn it to the ON switch. Now, you can see the machine starting up and it is important to read the screen, it tells you a lot of information. So, it says ready for start, press load button. So, the load button is right here. Now, we press that and now it says watch out machine is starting load.

You know when the machine is ready for load and started up when if the information says ready for a load. So, before we run the machine, the one thing we can do is change the parameters. See hit this button called edit parameter and now, even you can adjust the parameters such as time and gap distance and type of exposure.

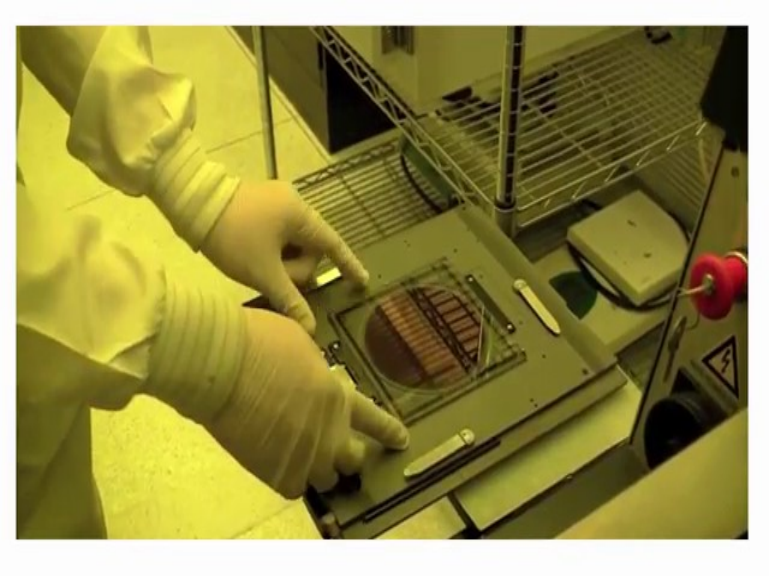
So, how do we edit the parameters? I will change the difference parameters. We use the x left and right. So, we move this way you can change the gap, change the type of contact and then change exposure type. So, let us change the exposure time first. So, it is at 5 seconds now, we can change it to 25 seconds. If you hold fast and up, you can change it faster. So, it is at 25. Let us make it 26.

Now, we want to go slower. So, we do not hit fast you just. So, that way we adjust the exposure time. Let us change the alignment gap, let us make that 40 and it has changed

the tempec; it's making soft contact. Now, your parameters have changed. There's different type of exposure types from soft, vacuum, hard if you look at their supplemental to get more information but we will right now set it soft. So, once your parameters are set, you hit edit parameter.

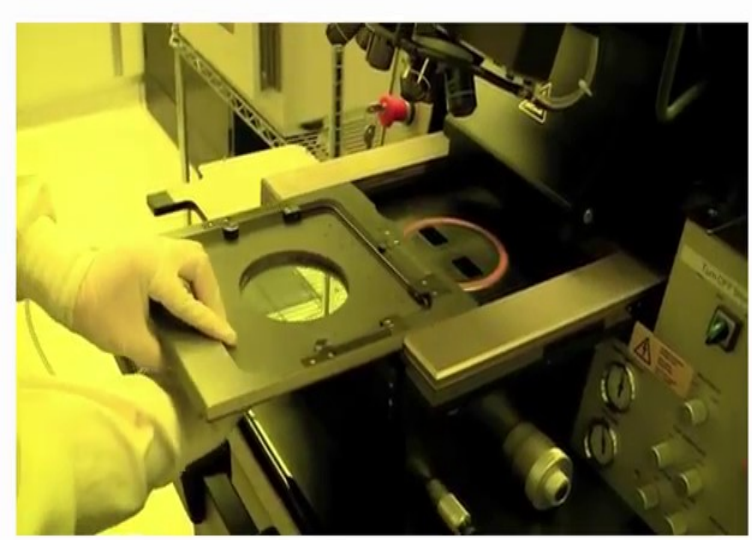
What we are going to do now is load the mask. So, how do we load the mask? We put a, we press the button form change mask on the screen. So, we hit change mask you are ready to load the mask. So, we put it in here.

(Refer Slide Time: 13:10)



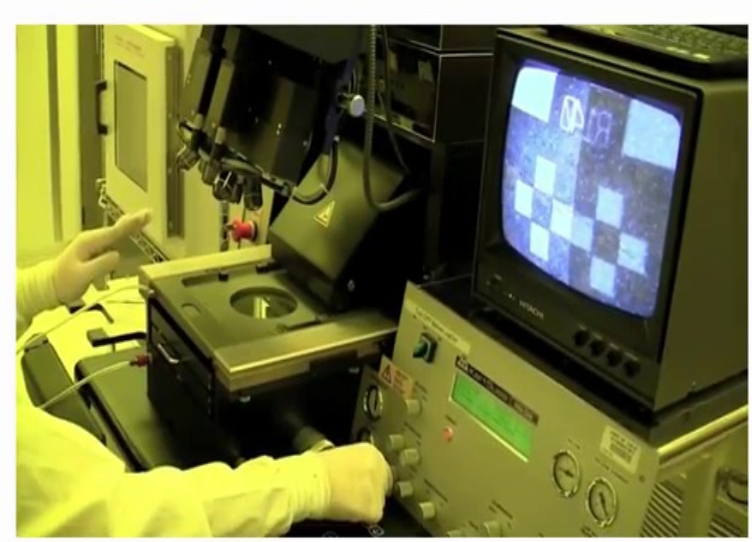
So, would you load your mask in here by lift, lifting this clip here and putting it in and when it is in nice, you hit this button called enter; you can toggle the vacuum. So, right now the vacuum is off. Then you press enter now the vacuum is on when you come back you can see that it is it is vacuumed in and is stuck pretty well. So, now, we are going to put this in here.

(Refer Slide Time: 13:40)



So, we carefully carry it. We will place it all the way in and when it is in, we press change a mask and that is how you load your mask. We are going to be doing a backside alignment now. So, what this does is it aligns features on the back of your wafer to your mask and how you do it is a microscope from the bottom. So, the first thing we do is we have to have a mask loaded and then we turn the screen on.

(Refer Slide Time: 14:14)

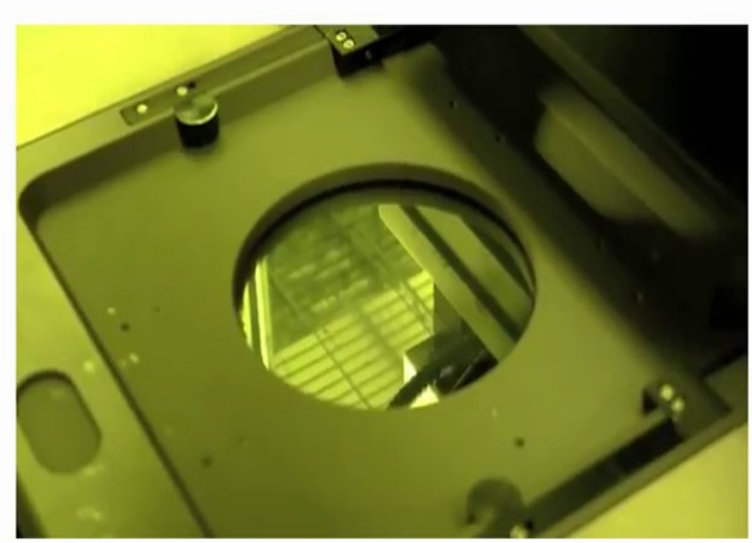


Now, we make sure this thing says backside alignment microscope is on. So, it is on, but also, we need to change this to backside alignments. So, it can be either top side

alignment or it can be a backside alignment. So, this is an illumination. So, now, the light is coming from the backside.

So, if you look in here, you can see the light hitting the features.

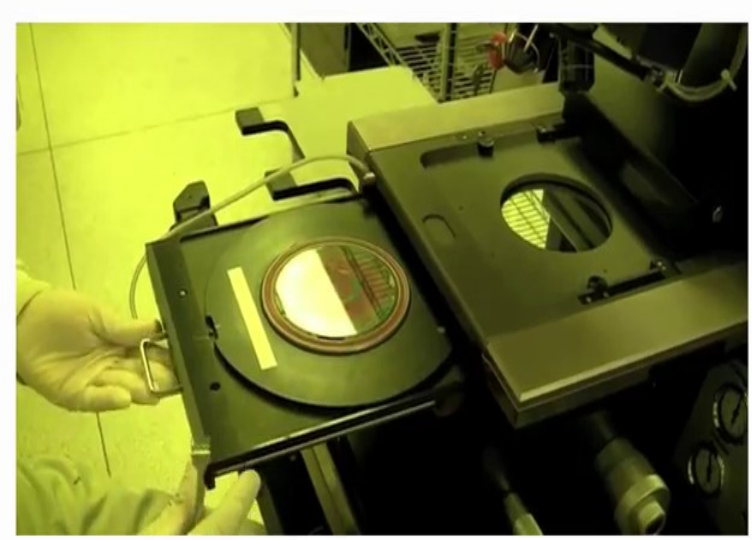
(Refer Slide Time: 14:38)



So, that is the microscope from here coming, looking up and lightening it. So, we can look for those on the screen now and pretty much what you do is, this controls the microscopes in the back. So, you can select one at a time and move around till you find your features. It looks like we found a alignment marks on the mask. So, we need to adjust the focus. So, you use this stop stick, left and right. So, the left one just the left you know I want to adjust the right focus. You can also adjust the intensity and you can also adjust the position.

So, if I want to move this one up and down, I will hit the right and then I will move it up and down. If I want to hit move the left one, it is the similar thing. So, when you find your mask and you think you are ready to do the exposure and align it, you would grab this image. So, you press the grab image button over here. When you press that, what it does is it takes a picture of the mask and now we are ready to load the wafer.

(Refer Slide Time: 16:01)



We press this button where it says load wafer. So, it says pull side and substrate onto chuck. We will just load the wafer on and when it is in, you press enter and it will bring it up.

So, now you can see you are in contact. This is the image overlay from the mask and these fishes right here seen it then the bottom substrate of your wafer.

(Refer Slide Time: 16:48)

So, how do you move the wafer? We know that these buttons move the microscope. So, how do we move the wafer? It is these buttons, right. It is these knobs right here; this is a

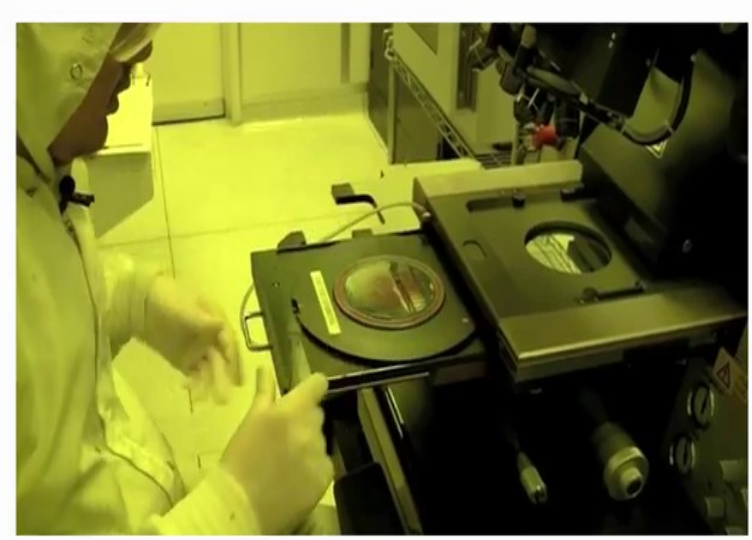
y, this is; the x is on this side and this is the tilt. So, I will give you an example. I can turn this and you can see the background these images moving and you can see this moving. So, this is the y position on the left side and the right side is the x knob. You can adjust the tilt with this too.

And, how you can adjust the focus and you can adjust the intensity or light. So, you would do that to find your alignment marks and then align them. So, once you have aligned them, you are ready for exposure and how do you expose? You pressed; first you alignment check which will bring it up to touch. You want to make sure nothing moved and then when it is in contact and you hit exposure and when you hit exposure, it is good to turn you back away from the light so, it does not damage your eye. So, hit exposure and then we just turn away.

So, after exposure you need to unload your wafer. So, what you do is you come to the screen and it will say pull slider unload expose substrate. So, you just pull it out and then this is, you press the enter button and then the vacuum will be released and you can take your wafer out and then you would put it back in. So, that is how you unload your wafer after exposure.

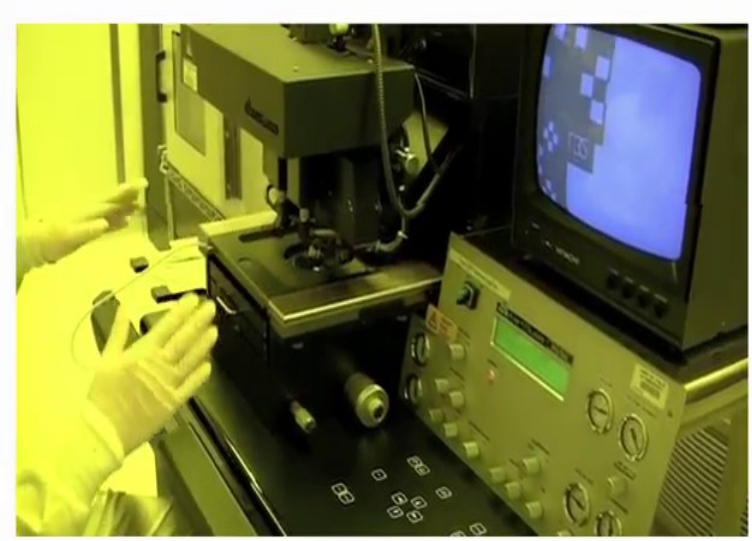
What we are going to do now is top side alignment by using the microscope on the top to align to the wafer that is underneath to the glass. So, to do top side alignment, we need to move the backside microscope. So, we press this button that turns it off. Also, we need it for the illumination to the top side and then now we can load our wafer in.

(Refer Slide Time: 19:07)



So, again you press load and it says pull slide and load substrate onto chuck.

(Refer Slide Time: 19:34)



Then you press enter when you did that, and the microscope will automatically come down because we have the BSA microscope light button off. So, now, it is down we turn the TV screen on and what this is doing is taking it, putting the image from here onto the screen.

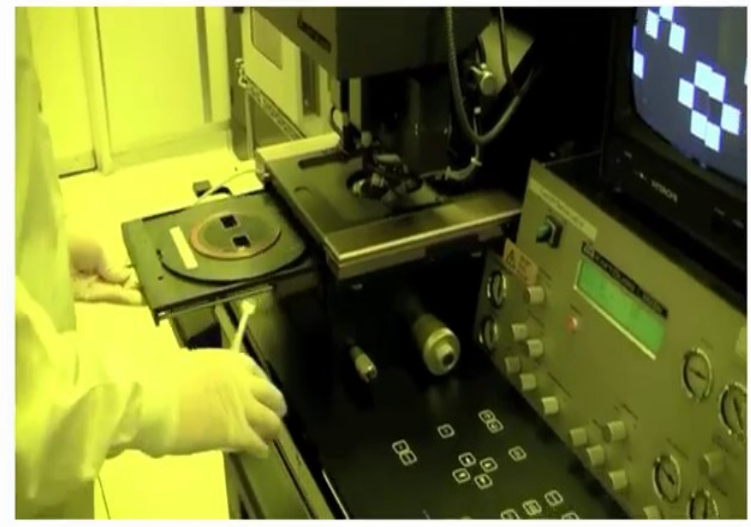
So, again, this these buttons right here control the x and y position of the microscope. So, it looks like we found something here. So, we can turn out it is pretty the power of

illumination is pretty high intensity. So, here lower the power then you can see that. So, we are going to find the mask alignment mark on this side. So, there are different functions on this; this knob right here, so, if you move it, this will put this will control the light microscope; x position in the light microscope and the left side has the same button.

So, when I move the left knob, I can turn this way, when I move the right knob I can turn it this way. We can now adjust a tilt to make these match up by turning this knob right here. So, they look like it is pretty matched up. So, what would you do is you want to the same thing as a similar to backside alignment. You align your alignment mask on your wafer. So, these right here. So, you can see that if I move this there is always these knobs always control the substrate.

So, when I move this you can see that this has been moved. So, you can tell that is the actual substrate moving not the mask. So, you try to focus it and you try to find your alignment marks and align them to the features and then once you have aligned it, you will do same thing you do a alignment check and they will bring the mask up and then you would expose it.

(Refer Slide Time: 21:57)



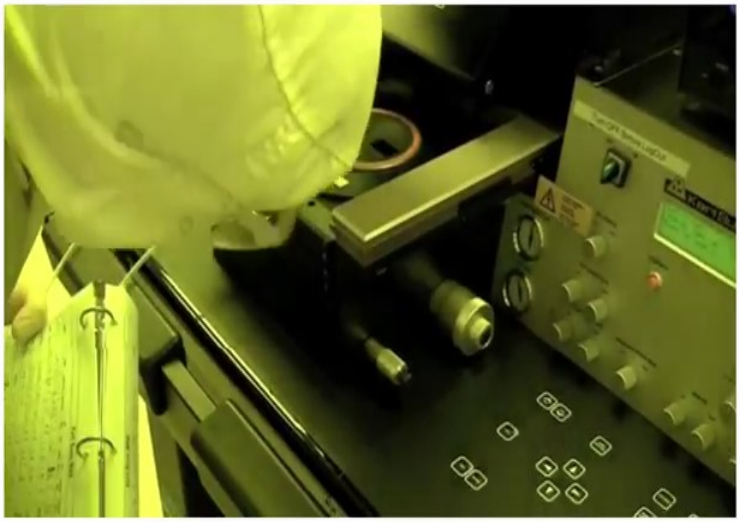
So, you press expose and when you do exposure again. So, then you turn away so the UV light does not a choice. So, after your double exposure you would unload your wafer. So, it tells you pull slide or unload substrate. So, you pull it out and then you take

it out. Now you finish your sample, we will put this back in. Now, if you are done it, you want to move this back up and you do not want to bring it back down, this is where you pressed the BSA button. So, by default this will not come down. Also, to bring this up you press F1 and then enter and it will bring the microscope up.

It is always good to leave it in the this position for the microscope up and the BSA button ON because that way the microscope does not come on and off every time you are using it. So, after that we are ready to take out our mask. If you want to unload a mask, you press the change mask; it is pretty similar to loading it. It's the reverse process you press change mask, you would take your substrate out. You hit enter the button to remove the vacuum and then you take your weight mask out. You press the change mask button again and then what says is confirm that enter as you know that mask is there.

So, now we are ready to turn the system off. So, want to make sure everything is in the standby position that you started the machine with and then before you turn it off, you want to make sure you were write in the logbook the different parameters.

(Refer Slide Time: 23:31)



So, the compressed air is about 4.9, nitrogen is about 1.65, the vacuum is about 0.86, taking the 0.86; we use the 4 inch wafer with silicon and we did 25 second exposure.

(Refer Slide Time: 23:56)

Now, I ready to turn off first thing we do is we turn off the switch; here we also the tv school and then we can log out here.

(Refer Slide Time: 24:01)

And, then some messages like do we set the x, y two position, what we did that. So, we put ok. So, since you have seen both the videos what we will be discussing in the next particular module is what is the importance of front to back alignment. Until now, we were always understanding what is the front alignment right and how the front alignment will help, how can we create different interdigitated electrodes, if you want to create a

sensing layer on it or something else, we are always exposing from the front side of the wafer, but if I want to create a diaphragm.

(Refer Slide Time: 24:38)

So, let me give an example if this is the wafer and this is the sensing area, this one right this is the sensing area. So, I want to create a diaphragm exactly on the backside of this sensing area; that means, it I should align it on this side. How would I know it is perfectly aligned with the front side? That is what called front to back alignment and to create a diaphragm exactly below this particular sensing area. This is where your front to back alignment will work.

We will take an example in the next module. Till then you just go through these slides. Again, let me reiterate that if you understand photolithography, you will be able to understand a lot of techniques, lot of sensors and actuators fabricating techniques will become easier. The heart of micro engineering or a micro processing or manufacturing at a micro scale is always a photolithography system.

So, if you have any questions feel free to ask me in the in the forum; if you have any doubts, you know, always feel free to ask do not hesitate because this is not so easy to understand and at the same time it is extremely important. So, I do not want you to miss anything out of this particular module, but at the same time it is not that difficult also if you, if you really focus right. So, let us discuss the examples of front to back in the next

module and then we will actually move to the examples of using sensors and micro fluidic systems for healthcare technologies right.

Till then you take care. I will see you in the next class. Bye.