Fabrication Techniques for MEMs-based Sensors: Clinical Perspective
Prof. Hardik J Pandya
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 08
Photolithography

Welcome. This is very important module for this particular session of lectures. The reason is because we are today understanding a very important aspect and that is photolithography. So, what is the purpose of photolithography and why we want to perform photolithography or why we want to understand photolithography.

So, let us take few examples. Let us take few examples, so that you understand how we can use photolithography for fabricating different devices or different structures on the devices.

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Now, you I am holding one wafer in my hand right; and it has few patterns it has few patterns. There is another wafer in my hand; again it has few patterns right. There are two wafers in my hand with few patterns as you can see right. Now, how can you design this patterns, how can you design this patterns? The answer is photolithography. So, we are learning how to perform photolithography. I will show you few more device just to make sure that we clearly understand what we are learning today.

You see there is a heater on this. If you can zoom in little bit, yeah. So, you can clearly see or hopefully you can clearly see there is a heater right heater which is right over here in this area all right. And these are two contact pads of the heater two contact pads of the heater; heater is right here; two contact pads of the heater. How can you fabricate this heater that is a question all right. How can you fabricate this heater? And we will learn this thing today all right.

And then you will see them in subsequent classes when we talk about micro engineering devices for clinical perspective right, how you can fabricate those devices using photolithography.

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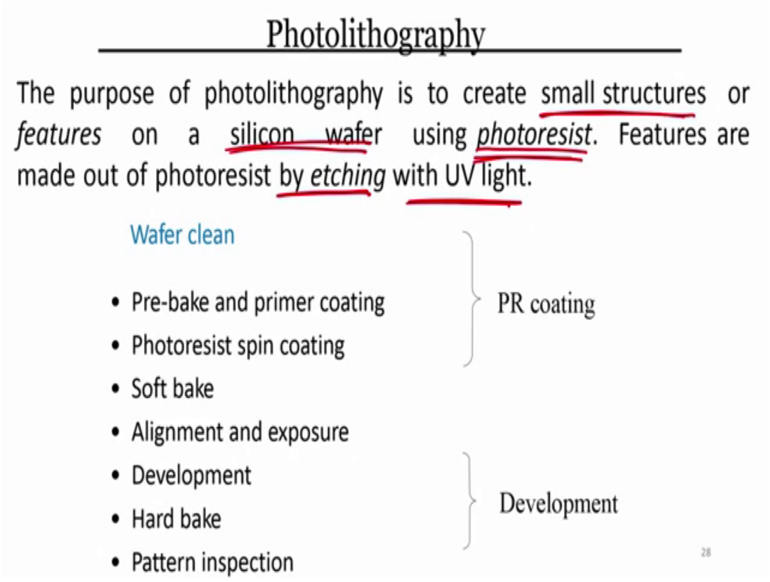

Photolithography

The purpose of photolithography is to create small structures or *features* on a silicon wafer using *photoresist*. Features are made out of photoresist by *etching* with UV light.

Wafer clean

- Pre-bake and primer coating
- Photoresist spin coating
- Soft bake
- Alignment and exposure
- Development
- Hard bake
- Pattern inspection

PR coating

Development

So, let us see on the screen photolithography. Photolithography comes from word photo and then lithos. So, lithos and graphy is a Greek word used which means carving from a single stone carving from a single stone. The purpose of photolithography is to create and of course photo means nothing but photons light right light to carve a single stone; here in our case is a single crystal which is silicon.

So, anyway the purpose of photolithography is to create small structures or features on a silicon wafer using photoresist. We will see what is a photoresist and features are made out of photoresist by etching with UV light. So, what we understand, we can create small features one, we can use silicon wafer, but it is not just limited to silicon wafer; we can also use glass as we have just seen; we can also use an insulator like alumina. There is a polymer involved and that polymer is called photoresist; this polymer is photosensitive polymer. And we will be using this polymer to create several features by etching the polymer with the help of UV light.

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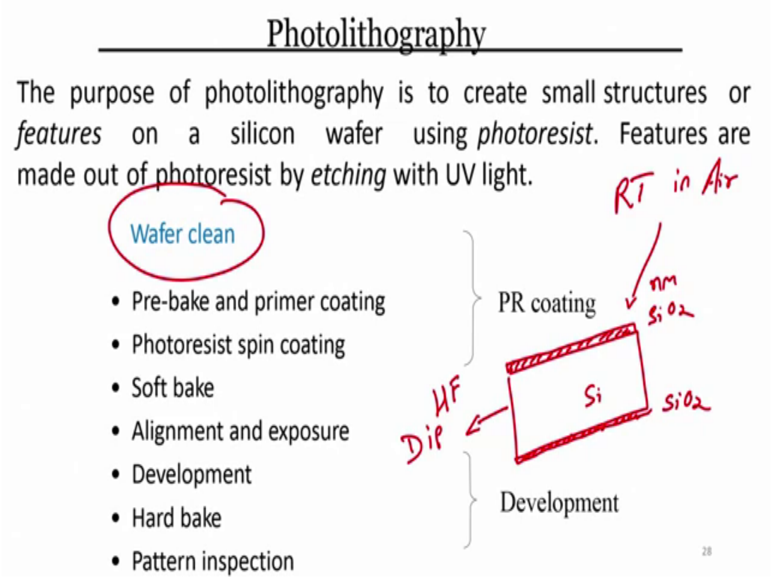

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Development

So, now, when you talk about photolithography, there are several steps involved. And the first among several steps is wafer cleaning. You cannot or you should not start any process in micro engineering without cleaning the wafer. Now, cleaning the wafer does not just mean to clean by clean ah with the a Di water or to drive it nitrogen or to just pre bake it.

Cleaning of wafer means like we have discussed in earlier classes right, we have a wafer, we have a thin layer of oxide. Even we do not do anything in air at room temperature in in air, there will be thin layer of oxide few nanometers right few nanometers of oxide grown on silicon wafer. So, first thing that you have to do is dip this wafer in HF, H F dip. This is very important. When you perform HF dip what you will see is the silicon dioxide the silicon dioxide can be etched from silicon wafer.

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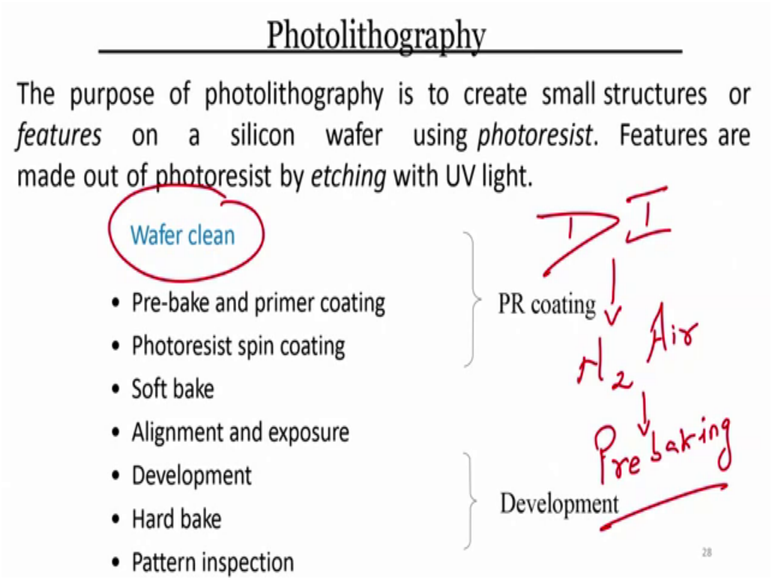

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Development

DI ↓ H_2 Air ↓ Pre baking

After silicon dioxide is etched, then you have to perform the rest of the step which is cleaning with Di water de ionized water followed by drying with N 2 hydrogen air right; followed by pre-baking all right to remove any moisture on this surface.

So, what are the process first you have to perform HF dip, then you have to clean the wafer or rinse the wafer with the help of DI. After rinsing the wafer with DI, you have to dry the wafer with help of nitrogen. After drying the wafer with nitrogen, you have to pre-bake the wafer to remove any moisture. After this your wafer is ready for photolithography. So, to perform photography, the first step would be, if you see the screen first step would be pre-bake; we perform pre-baking already and primer coating.

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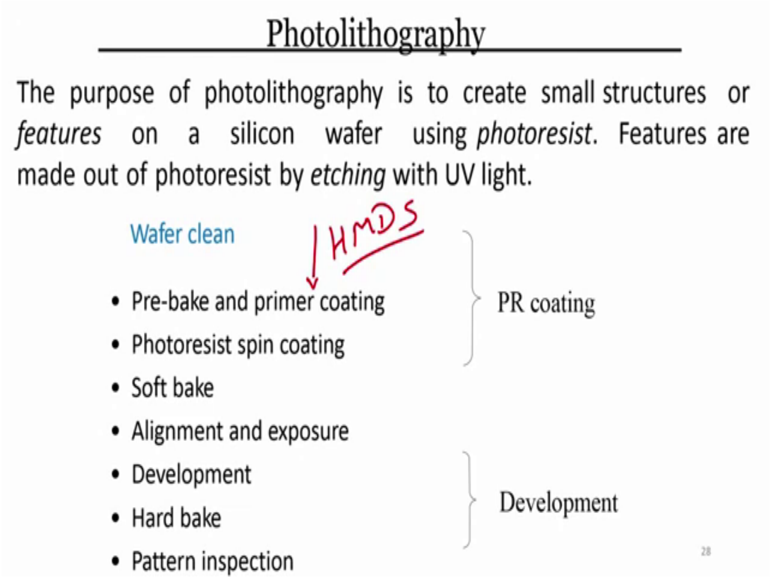

Photolithography

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Wafer clean

HMDS

- Pre-bake and primer coating
- Photoresist spin coating
- Soft bake
- Alignment and exposure
- Development
- Hard bake
- Pattern inspection

PR coating

Development

HMDS is one of the primer that we can coat and this will improve the adhesion of photoresist on to a surface of the substrate. After coating HMDS or primer, the next step is photoresist spin coating, we have to spin coat photoresist.

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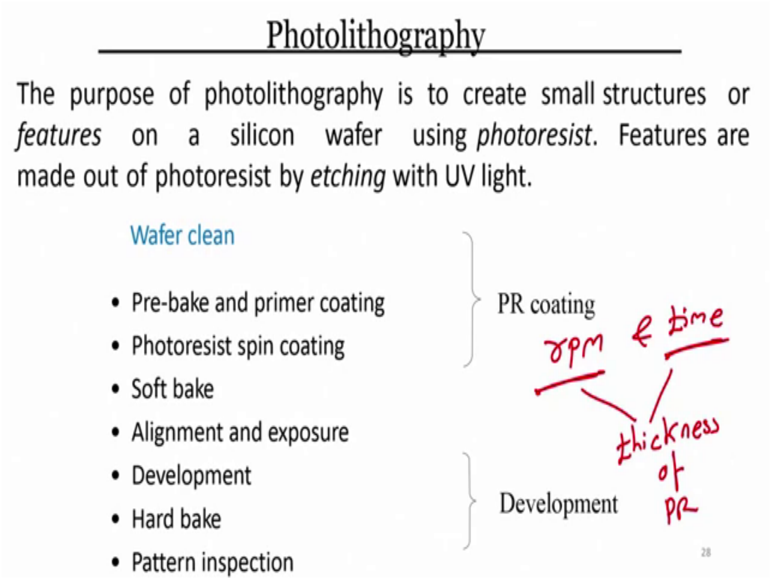

Photolithography

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Wafer clean

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PR coating

rpm & time

thickness of PR

Development

And the thickness of photoresist depends on the rpm and depends on a time right. How many rotations per minute we have programmed; for how much time we are spin coating the photoresist based on or depending on rpm and time, we can know or we can determine thickness of the photoresist. So, once we perform spin coating with photoresist, we go for soft bake.

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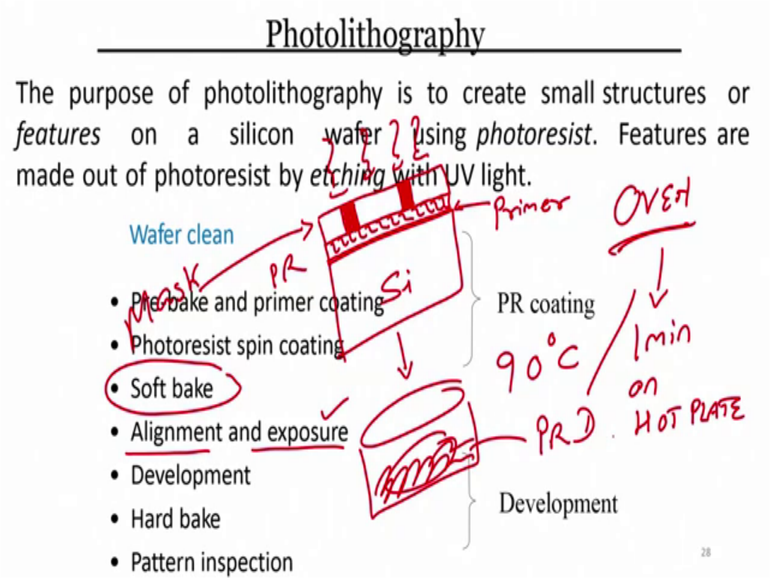

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PR coating

Development

Now, in a conventional situation soft bake is done at 90 degree centigrade for 1 minute on hot plate. This time would vary if I use oven. After soft baking, I had to perform alignment and exposure. So, I have a wafer; I clean the wafer and then on this wafer I coat a primer on the primer right. I of course, pre bake it and then coat the primer on that I will spin coat my photoresist spin coat my photoresist. This is my silicon. This is my primer.

After photoresist, I have to get a mask let us say this is a mask. We will talk about the mask and photoresist how it will work depending on its type. Mask has mask are also classified depending on its pattern that is we will discuss it later. So, this is your mask. You have to align the mask and then perform UV exposure right.

After UV exposure, you have to unload the mask and dip the wafer and dip the wafer in a beaker in a beaker which contains photoresist developer photoresist developer. After developing photoresist, you have to take out the wafer and perform hard baking; hard baking in a conventional way.

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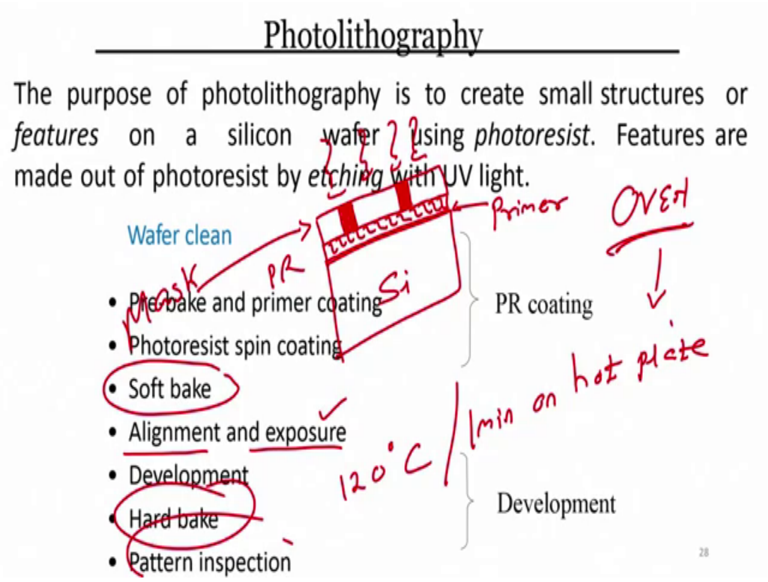

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PR coating

Development

Conventional photoresist that is positive negative photoresist is performed at 120 degree centigrade 1 minute on hot plate. Let us write it down on hot plate. After performing hard bake, you can inspect the pattern. After performing hard bake next step is inspecting the pattern.

So, we will take an example we will take an example to see what we have discussed right now ok, so that we understand clearly how photoresist or how photolithography can be used.

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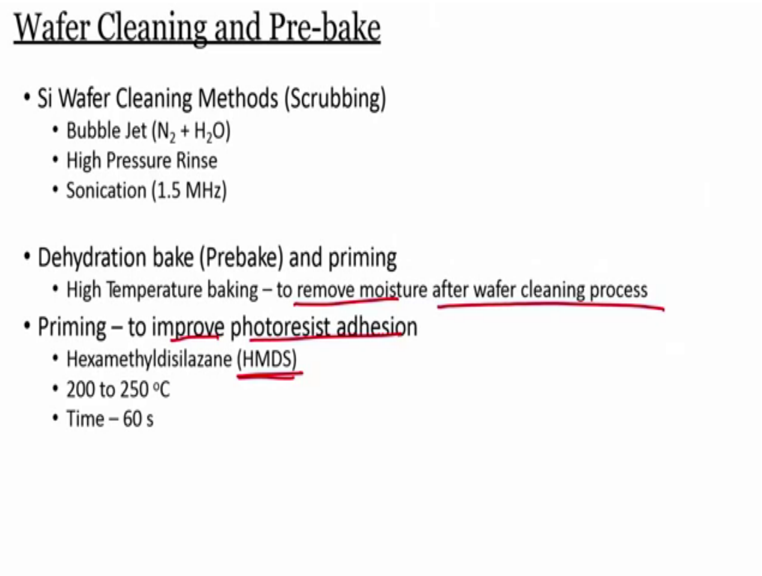

Wafer Cleaning and Pre-bake

- Si Wafer Cleaning Methods (Scrubbing)
  - Bubble Jet ($N_2 + H_2O$)
  - High Pressure Rinse
  - Sonication (1.5 MHz)
- Dehydration bake (Prebake) and priming
  - High Temperature baking – to remove moisture after wafer cleaning process
- Priming – to improve photoresist adhesion
  - Hexamethyldisilazane (HMDS)
  - 200 to 250 °C
  - Time – 60 s

So, like I said wafer cleaning and pre bake can be done by bubble jet, high pressure rinse by sonication. Dehydration or pre-baking can be done at high temperature baking to remove moisture right to remove moisture. After wafer cleaning, process priming or primer is used to improve photoresist adhesion HMDS is used. HMDS is your hexa methyl disilazane and that is used to improve the adhesion of a photoresist onto the substrate.

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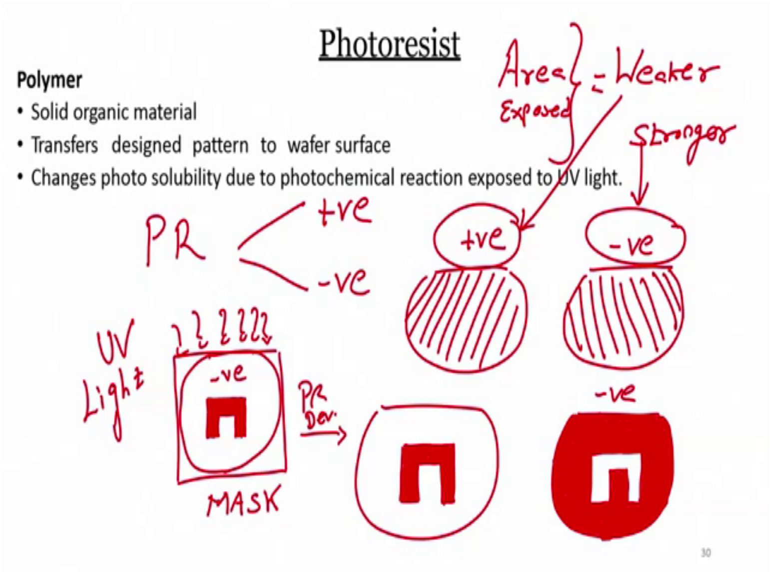

Photoresist

Polymer

- Solid organic material
- Transfers designed pattern to wafer surface
- Changes photo solubility due to photochemical reaction exposed to UV light.

So, what is photoresist? Photoresist is solid organic material, it is used for transferring the design pattern to this wafer surface changes photo solubility due to photochemical reaction exposed to UV light. So, let us first understand the role of photoresist. So, if I say I have photoresist; photoresist are two types, one is positive photoresist, second is negative photoresist.

Now, let us take an example of this particular pattern; this pattern. Now, there are two wafers or let us draw the top view of the wafer rather than cross sectional view. There are two wafers one wafer is coated with positive photoresist, second wafer is coated with negative photoresist. This is your mask.

So, if I use this mask on the photoresist, so I will I have to, so what does that mean if I keep this mask on this wafer like this and the wafer is coated with positive photoresist. What will happen that when I expose this, I will have when I expose it to UV light and I develop the wafer right in which I use this kind of mask, then I will have my photoresist protected in this area.

So, what do you understand here, what we understand is that the area which is exposed becomes weaker. And the area which is not exposed becomes stronger right. Why, because our mask was this right and we had positive photoresist coated on the wafer. And this wafer if I place under this mask and if I expose it and I develop it, then I obtain this pattern for positive photoresist.

In case of negative photoresist, in case of that sensor of positive photoresist, we have used wafer which was coated with negative photoresist negative photoresist. Then when I expose with UV light, when I exposed with UV light, what I obtain, I obtain pattern which I am drawing right now. I will obtain a pattern which looks like this [noise.]

Take one more minute, because it is very important I do not want to rush it through, yeah you see. So, that is if I use negative photo photoresist sorry and I used this mask, then I obtain this kind of pattern. And this pattern means that the area which was exposed gets stronger and the area which was not exposed gets weaker. So, in case of positive photoresist and negative photoresist, we have to remember in positive photoresist, they exposed.

Let us see here let us write down exposed. Can you see? No exposed, let us say area exposed becomes weaker. In case of negative photoresist, it becomes stronger which one area exposed. In case of positive photoresist, it becomes weaker. In case of negative photoresist, it becomes stronger; you can see here right. This is the area right. I just move remove the mask remove the wafer sorry, then you can see this is the area, which is not exposed the area here which is not exposed; remaining area is exposed.

So, in case of positive photoresist, what I obtained is the area which was not exposed get stronger, the area which was exposed gets weaker here, correct. In case of negative photoresist, the area which was exposed this area this one this area is exposed right; it is transparent is exposed. Exposed under what, UV light; area which was exposed became stronger.

An area which was not exposed this is area, which is not exposed, correct becomes area which is not expose becomes weaker, in case of negative photoresist, you can see here, it becomes weaker. So, photoresist is developed photoresist is developed in this area. So, it is very important to understand photoresist, because we will be using positive and negative photoresist; extensively when we understand photolithography.

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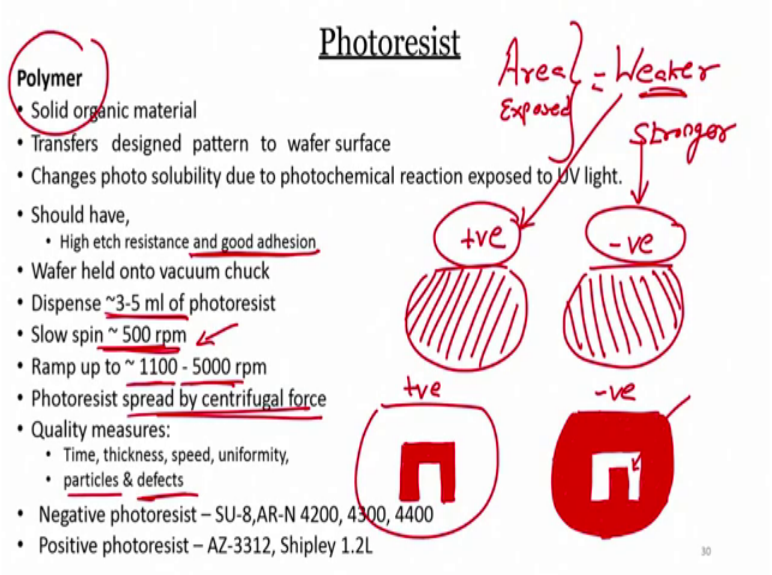

Photoresist

Polymer

- Solid organic material
- Transfers designed pattern to wafer surface
- Changes photo solubility due to photochemical reaction exposed to UV light.
- Should have,
  - High etch resistance and good adhesion
- Wafer held onto vacuum chuck
- Dispense ~3-5 ml of photoresist
- Slow spin ~ 500 rpm
- Ramp up to ~ 1100 - 5000 rpm
- Photoresist spread by centrifugal force
- Quality measures:
  - Time, thickness, speed, uniformity,
  - particles & defects
- Negative photoresist – SU-8,AR-N 4200, 4300, 4400
- Positive photoresist – AZ-3312, Shipley 1.2L

So, let me show you few more points. Now, what should the photoresist consist of what this is a polymer should have, polymer should have high etch resistance, and good adhesion that is a requirement right.

And how it is performed this, how the polymer is coated onto the wafer, these are the steps; first dispense 3 to 5 ml of photoresist, second slow spin at 500 rpm, followed by high a ramp up to 1100 to 5000 rpm, depending on the thickness that you want, photoresists is spread through centrifugal force. And the quality measures for this photoresist can be time, thickness, speed, uniformity, also we can see particle particles and defects, if any on the photoresist. When we coat the photoresist, we have to take care of this many parameters

Now, if you see here, there is a requirement of slow spin. This low spin is to uniformly distributed photoresist onto the wafer, and then we ramp it up to 1100 to 5000 degree 5000 rpm, so that we can obtain the thickness of our ah desire. Now, there are two types of photoresist like we have discussed here, positive and negative type. Negative photoresist can be SU-8, it can be N 4200, 4300, 4400. Positive photoresist can be AZ-3312, it can be from Shipley 1.2 litres or Shipley 1.2.

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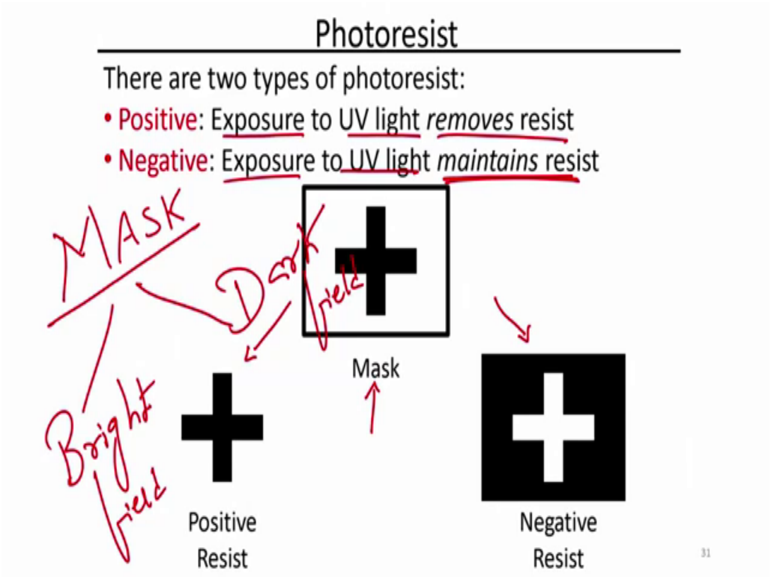

Photoresist

There are two types of photoresist:

- **Positive**: Exposure to UV light *removes* resist
- **Negative**: Exposure to UV light *maintains* resist

So, like I said, when you talk about photoresist are two types. One is positive photoresist that is exposure to UV light removes this resist, exposure to UV light removes the resist or exposed region becomes weaker correct. Negative photoresist exposure to UV light maintains resist or the exposed region becomes stronger. So, this is a case that if you have a mask, then if I use positive photoresist, I will obtain this pattern. If I use negative photoresist, I will obtain this particular fashion; if I use the mask which is shown in schematic here.

So, since we were talking about mask. Let us see how the mask looks like, how the mask in reality looks like ok. So, when we talk about masks, mask can be bright field mask, it can be dark field mask; bright field, dark field, two types of mask bright field and dark field mask. So, let us see how bright field mask looks like, let us see how dark field mask looks like.

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So, I will show it to you, mask holder mask is in my hand. So, you do not have to worry about zooming in this time, you just see that I am holding a glass plate I am holding a glass plate right, this is a 5-inch mask.

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Why we are using 5-inch mask, because we were interested in using a 4-inch wafer like this, correct. We were interested in using 4-inch wafer, 4-inch wafer 5-inch mask. So, whenever you are using wafer depending on the diameter of the wafer, you have to change the size of the mask.

Now, what you see in mask, can you see my finger, can you see my face, you can right, but there is some pattern through which you cannot see through which you cannot see. So, most of the area in this mask is empty is transparent. So, this mask is nothing but bright field mask, field is bright you see, this field is bright; bright field mask. And there is some pattern on the mask there is some pattern on the mask with some alignment mark right over here which you cannot see from there, it is impossible,. But, the point is there is a glass, it can be chrome mask, it can be a chrome mask.

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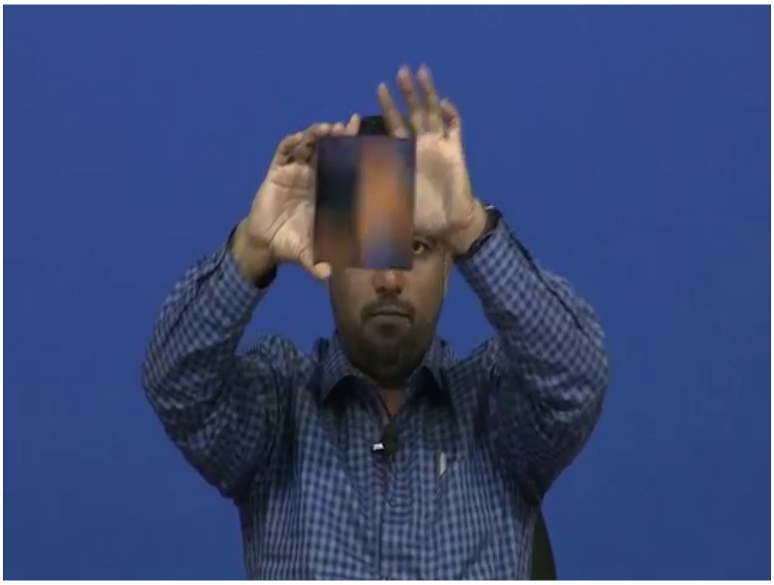

Now, let us see one more mask. So, we can clearly distinguish what I mean by bright field, and dark field mask. This is another mask here right, what you can see? You can see there are two patterns on the bottom, which are transparent; remaining field is dark remaining field is dark right, but here on the two bottom you can see some patterns are there. So, this is your dark field mask this is your dark field mask, it can be used as a mirror just kidding.

So, we have bright field mask, and we have a dark filed mask. You know guys in fab lab, you are wearing a gown, and everything. You can see your face in this, I am just kidding do not do that. So, this is your bright filed mask, this is your dark filed mask very easy to identify you know it is very easy. So, both are 4 both are 5-inch mask.

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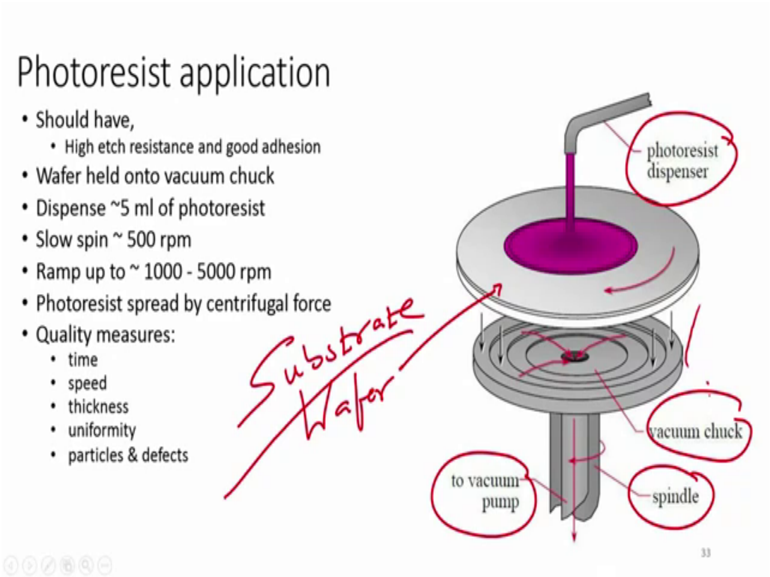

Photoresist application

- Should have,
  - High etch resistance and good adhesion
- Wafer held onto vacuum chuck
- Dispense ~5 ml of photoresist
- Slow spin ~ 500 rpm
- Ramp up to ~ 1000 - 5000 rpm
- Photoresist spread by centrifugal force
- Quality measures:
  - time
  - speed
  - thickness
  - uniformity
  - particles & defects

So, coming back to the screen of photoresist positive, negative; mask, bright field, dark field.. So, how can we spin coat photoresist onto a silicon wafer right? So, we need a vacuum chuck, which you can see here there is a vacuum chuck right. There is a vacuum pump; this goes to the vacuum pump to vacuum pump. There is a spindle; there is a spindle which spins right.

And we said in starting, there is a vacuum chuck here. Now, here the vacuum would be created here, in this area center. This is the wafer, wafer you can also say substrate substrate right. And substrate is holded onto this vacuum chuck with the help of vacuum. And once it is attached or holded through vacuum, then we start dispensing photoresist. So, there is a photoresist dispenser.

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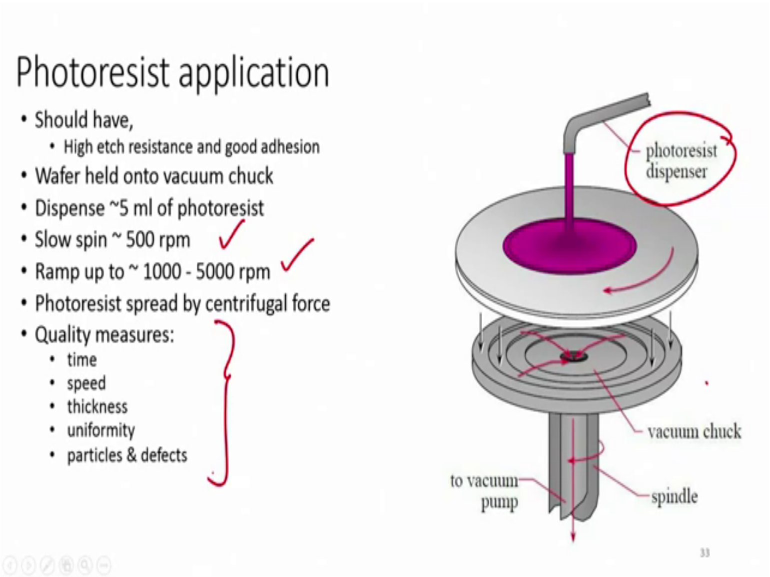

Photoresist application

- Should have,
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- Dispense ~5 ml of photoresist
- Slow spin ~ 500 rpm ✓
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- Photoresist spread by centrifugal force
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  - time
  - speed
  - thickness
  - uniformity
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So, once the photoresist is dispensed. Then, we have to follow slow spin; ramping up; and once it is spin coated. And it stops, we can see time, speed, the quality measures can be time, speed, thickness uniformity and particle size.

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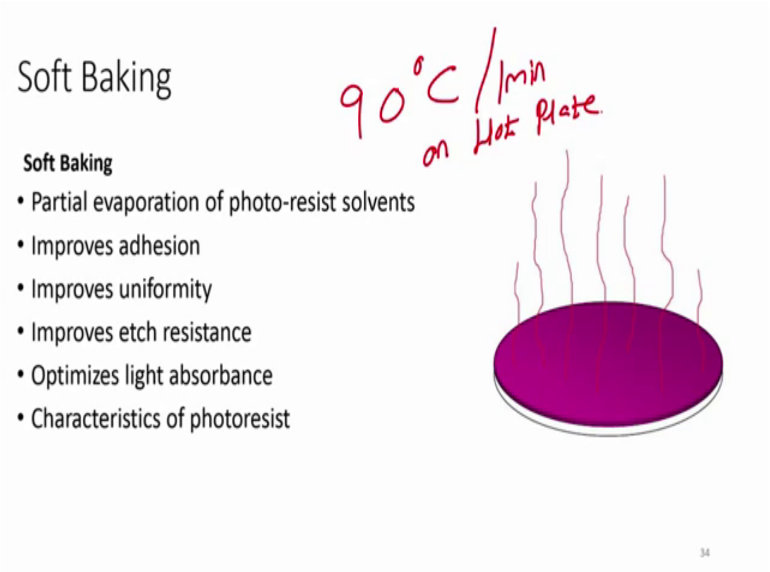

Soft Baking

90°C / 1min
on Hot Plate

Soft Baking

- Partial evaporation of photo-resist solvents
- Improves adhesion
- Improves uniformity
- Improves etch resistance
- Optimizes light absorbance
- Characteristics of photoresist

So, if you remember the steps in photoresist is first is your after spin coating, there is a soft bake. Soft bake like I said 90 degree 1 minute depending on type of photoresist, 1 minute on what on hot plate.

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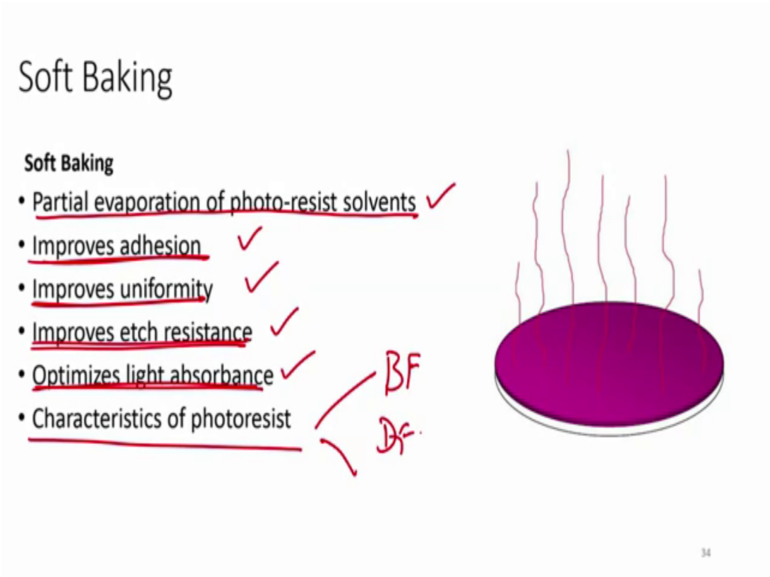

Soft Baking

Soft Baking

- Partial evaporation of photo-resist solvents ✓
- Improves adhesion ✓
- Improves uniformity ✓
- Improves etch resistance ✓
- Optimizes light absorbance ✓
- Characteristics of photoresist

BF

Df.

So, soft baking when we perform, what is the advantage of soft baking, what is the advantage of soft baking? First is partial evaporation of photoresist solvents; second is it improves adhesion; third is improves uniformity; 4th is improves etch resistance; then optimize light absorbance; finally characteristics of a photoresist, of course there is a characteristics of photoresist.

So, optimize light absorbance; improves etch resistance; uniformity; improves adhesion; and partial operation of photoresist solvents. So, characteristics of photoresist can be defined, if depending on is it bright field photoresist, is it dark field photoresist.

And also also what kind of mask, you use so now, we know what is the advantage of performing soft baking.

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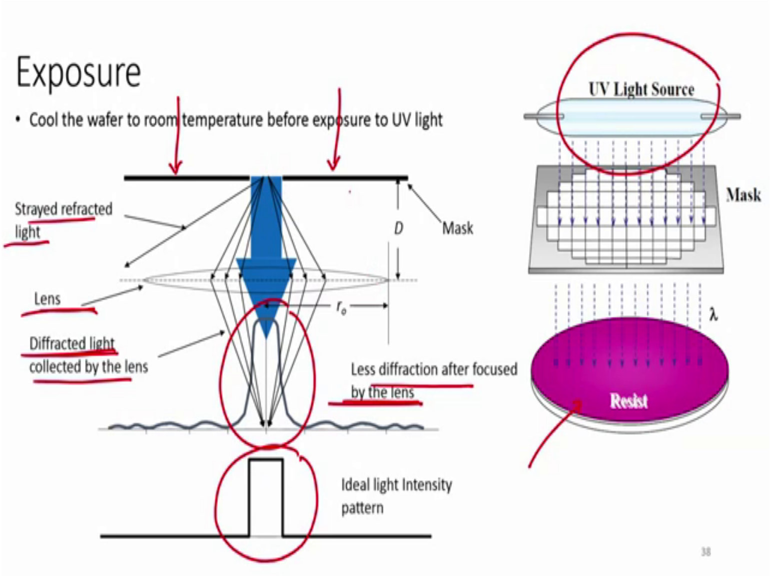

Exposure

- Cool the wafer to room temperature before exposure to UV light

After soft baking, we have to align the mask. First is load the mask, and then align it with the spin coated wafer right. So, when you align the mask after then, what you perform UV exposure. So, you should have a UV light source, you should have a UV light source.

The ideal intensity pattern should be like this. However, the intensity on the wafer the UV intensity on the wafer is somewhere like this. So, how it is how it happens that there are few, this is a mask through the mask, when the UV light passes through there is a straight refracted light. Of course, there is a lens here, and through the lens the life is diffracted and collected by the lens right which falls on the UV. So, lens diffraction after focused by the lens right, and falls on the photoresist coated wafer. And it cannot pass through the dark area; it can only pass through the bright area; it cannot pass through carrier; can only pass through bright area; what cannot pass UV light; cannot pass UV light cannot pass.

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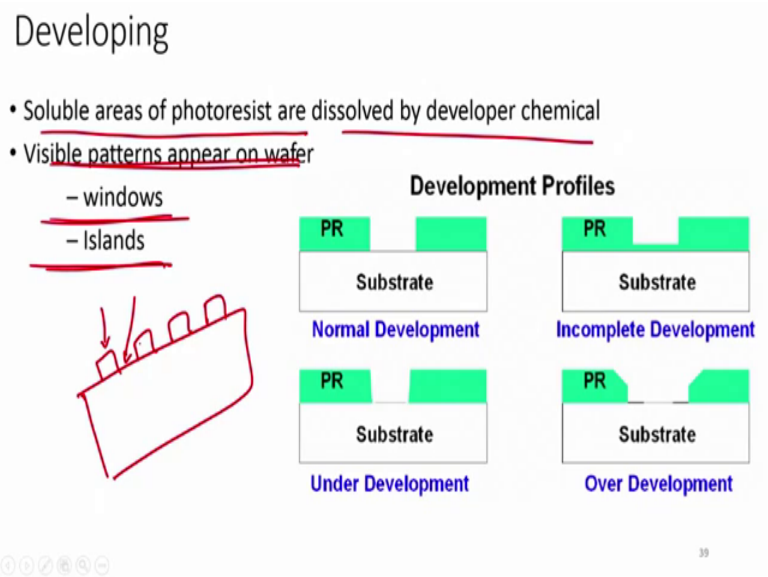

Developing

- Soluble areas of photoresist are dissolved by developer chemical
- Visible patterns appear on wafer
  - windows
  - Islands

Development Profiles

So, after the photoresist is exposed in UV light like I said, depending on the so after that depending on the mask, n type of photoresist will obtain different pattern right. So, how can we obtain by developing photoresist in photoresist developer? So, the soluble areas of photoresist are dissolved by developer chemical, visible patterns appears on the wafer right, either windows or islands whatever we have designed, whatever we have designed right.

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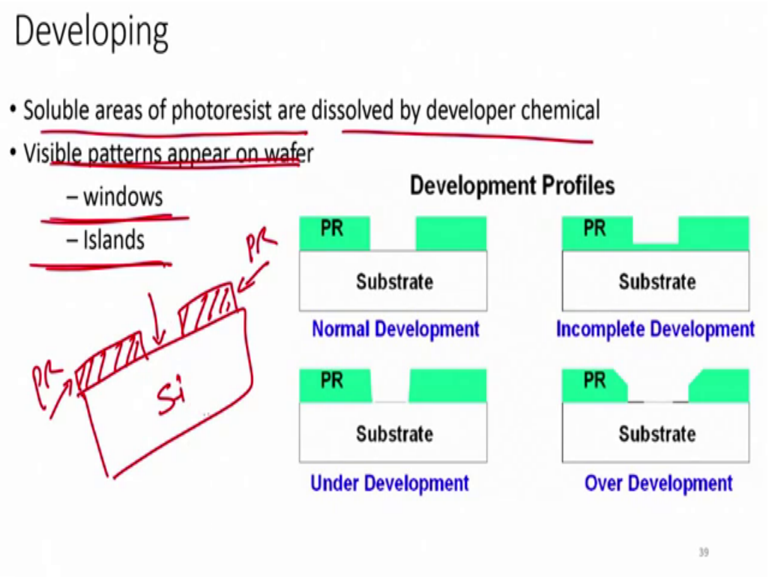

Developing

- Soluble areas of photoresist are dissolved by developer chemical
- Visible patterns appear on wafer
  - windows
  - Islands

Development Profiles

Suppose, we are designing on the wafer some electrodes, then these are some islands, these are some valleys right, or we are creating a pattern like this, which is your photoresist. Then this area, we want to etch, this is your photoresist, this is your silicon, we want to etch silicon right. So, this is a window that you have created, a window that you have created. We will take an example in later class.

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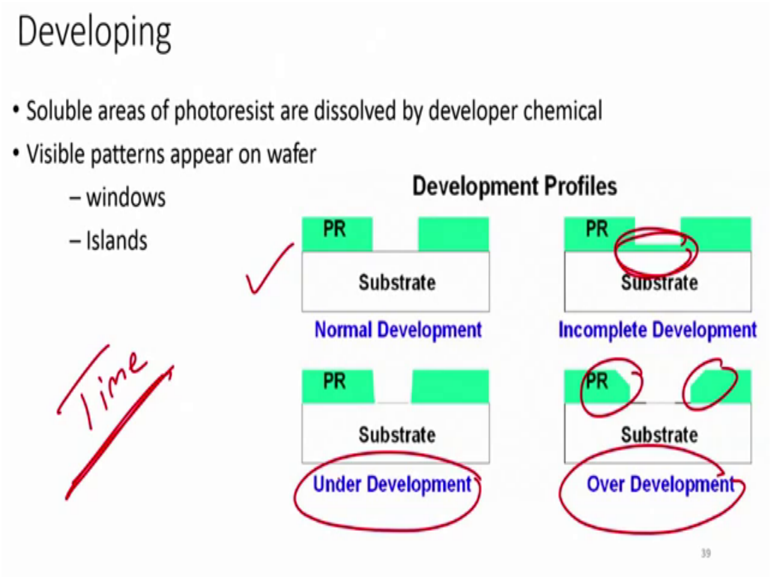

Developing

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- Visible patterns appear on wafer
  - windows
  - Islands

Development Profiles

So, when you develop the photoresist? If it is a normal development, you will get pattern which is shown here. However, there is a under development, then you will get this kind of pattern. If it is incomplete development, you can see here. If it is over development then, you will see this structure ok.

So, the time is very crucial. The time to develop the wafer in the photoresist or develop the photoresist in the photoresist developer is very important is crucial. And if you exceed the time, then there is a over development; sometimes there is a incomplete development. If you ah take out the wafer before time and that can be under development.

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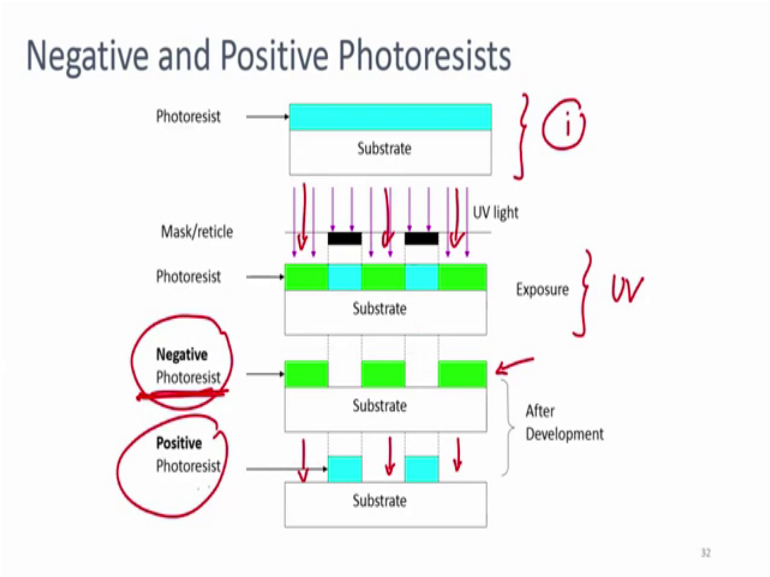

Negative and Positive Photoresists

Having, said that let us see negative and positive photoresist example right which we have just seen, but in form of schematic. So, if I have a substrate and if I coat the substrate with a photoresist, I have a mask here a mask here. You can see the there are two dark areas. Remaining there are bright fields it is a bright field mask or let us assume it is a bright field mask.

Now, if I expose this wafer, if I expose wafer number 1 with UV light right, then if it is a negative photoresist; if it is a negative photoresist, the area which is exposed, you see the area which is this one, this one this one exposed will be stronger, you can see here right. The area which is exposed is stronger in case of negative photoresist.

While in case of positive photoresist, the area which is exposed becomes weaker; you see the area which is exposed becomes weaker. Area which is exposed by UV light right, that area photoresist will get developed if it is a positive photoresist you got it, easy, right very easy right. It is a negative photoresist and positive photoresist is very easy to understand, ah what will happen, if I use a particular photoresist.

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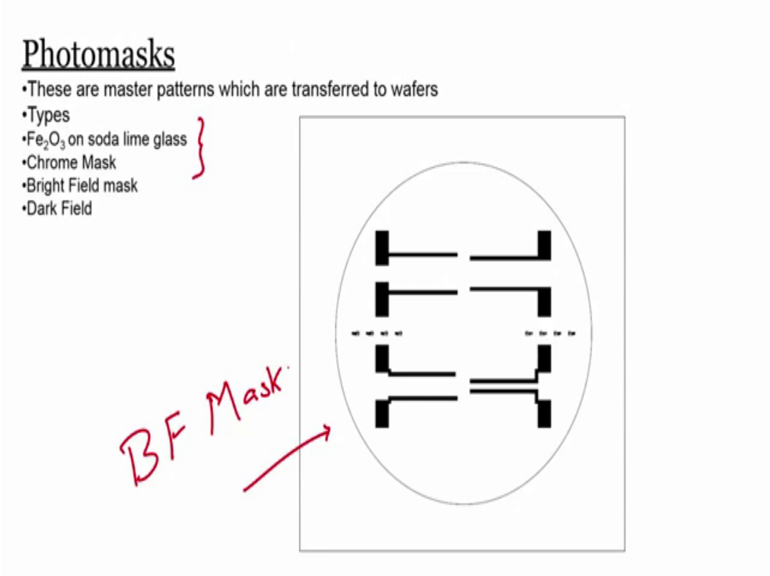

Photomasks

- These are master patterns which are transferred to wafers
- Types
- Fe_2O_3 on soda lime glass
- Chrome Mask
- Bright Field mask
- Dark Field

BF Mask

[voice] We have just seen mask, we have just seen few masks. And these are master patterns which are transferred to the wafers. So, when you talk about types of mask, we have F e 2 O 3 on soda lime glass; we have chrome mask; these are 2 different materials; while the masks can be classified as bright field mask or dark field mask. This is an example of this is an example of bright filed mask ok.

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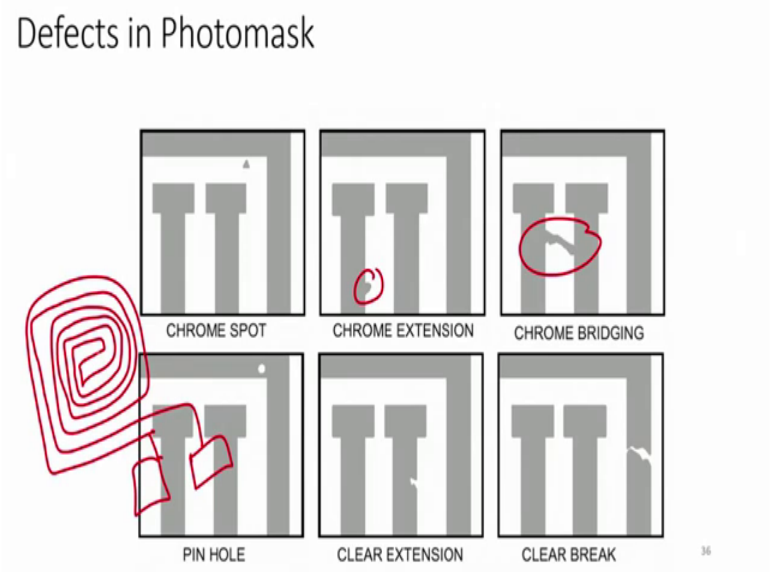

Defects in Photomask

Now, when we talk about mask there can be defects in photo mask, defects in photo mask. What are those defects? The first defect that you will see is a chrome spot. Now, for us we do not care, when we are going to make a bigger structure; we are when we are going to fabricate a bigger structure, but when we talk about MOSFETs. Then within this area there can be 1000 of MOSFETs right. So, we are losing those MOSFETs, if we have the chrome spots.

If we have chrome extension, we will not have correct results. If we have a bridging and if I am going to make a heater, it will be short right. If we if I make a heater let us say, and if there is a bridging there is a short. So, resistance would be different or let us say, you have heater like this right. And if I have short here, then it is gone correct. So, chrome bridging is not acceptable.

Next pinhole; chrome is not there at all not allowed. Then the clear extension, you see clear extension not allowed right. Because, the value that we you calculate and value when you use this mask would be totally different.

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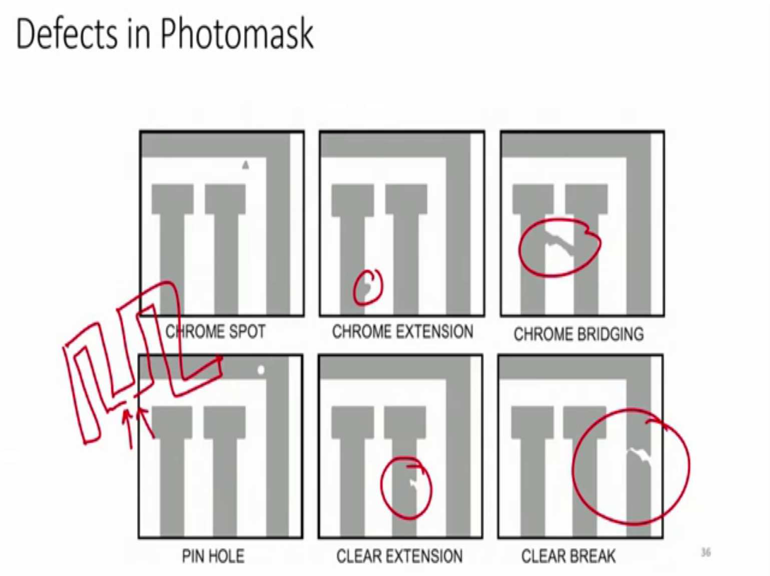

Defects in Photomask

Next is clear break, breakage is at all not allowed right. If there is a break let us say, if I make a this pattern right. And if there is this is a break, then it is not to correct right. The design itself will give us a different value, if there is a break in the mask. So, these are few defects that you need to understand, and need to observe whenever you start working with a photo mask.

So, this is a video interesting video, where you will be able to see the mask aligner and it is a automatic mask aligner. So, I will play the video look at it. It is a front to back alignment, and it is a very interesting to see this mask aligner. Then let us let us talk after the videos that are here to follow, and then we will discuss for another 5 minutes to see, what we have learned.

Hello my name is Bernhard from Research Microtech Development Team. Today I would like to present our new generation of production aligner.

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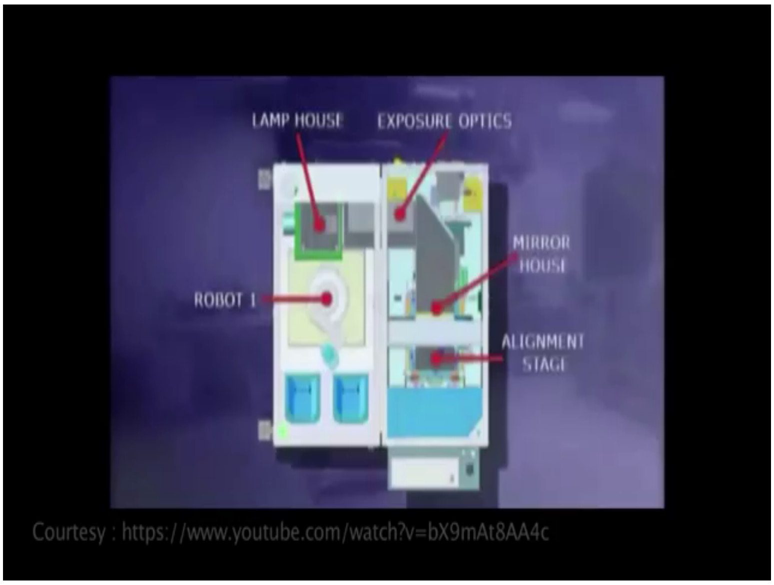

Courtesy : https://www.youtube.com/watch?v=bX9mAt8AA4c

The m a 200 compact which offers an advanced technology design,; unmatched precision and a high degree of flexibility. Say 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; equally, easy to insert or the mask holder and the mask. Now I load the carrier; that is all there is to it. And the m a 200 compact is ready for operation.

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Courtesy : https://www.youtube.com/watch?v=bX9mAt8AA4c

The processes of the m a 200 compact can be controlled via touch screen. For some processes, you can select between fully automatic and manual operation. A robot scans the wafers, and determines their quantity, position and size.

And the processing begins, the m a 200 compact processes wafers and substrates up to 200 millimetres, regardless of their material size, shape, and thickness. The machine runs and adjusts fully automatically. And is optimized for the processing of fit resists; such as with thick resists, left chip bumping, wafer level packaging, memes, nanotechnology or telecommunication devices.

The big advantage over steppers is the exposure of the entire wafer in one step. Thus a throughput of more than 100 wafers per hour can be achieved with overlay accuracy in the sub-micron range.

Now, let us slow the process down, and take the closer look. First the wafer is pre adjusted on to the pre aligner in preparation for the ensuing alignment. A linear transport system loads the wafer onto the exposure chuck which together with the robot arm guarantees the optimal and flexible handling of the substrate.

No other mask aligner on the market offers a higher degree of alignment accuracy than the m a 200 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, and 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 levelling system from suss compensates for topographic variations and wedge errors. Thus guaranteeing perfect alignment and exposure results and the entire process is easy to monitor, here on the touch screen.

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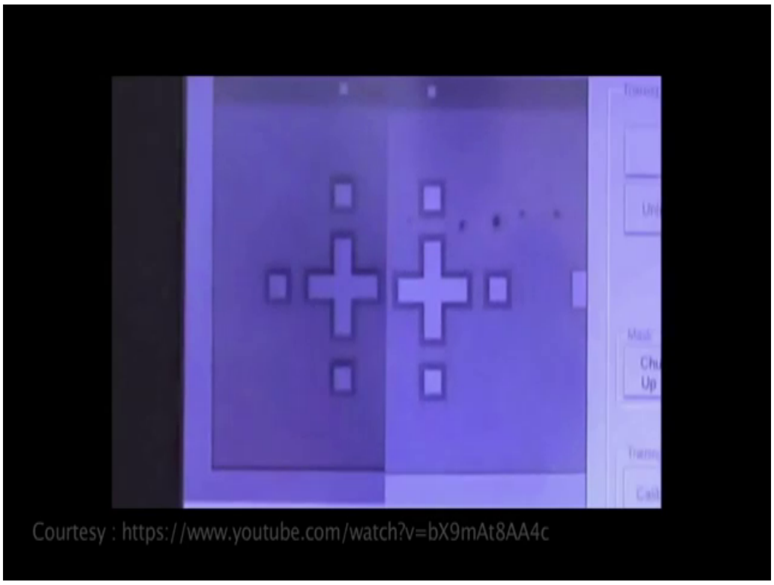

Courtesy : https://www.youtube.com/watch?v=bX9mAt8AA4c

Because, of the m a 200 compacts newly designed microscope. During exposure the mirror housing does not move forward, the microscopes only move sideways. Thus, reducing the vibrations of the alignment stage to a minimum resulting in far greater accuracy.

The optics of the m a 200 compact are optimized for thick resist processing and bend resists. It achieves a resolution of 3 microns in proximity mode and a sub micron resolution in contact printing.

A microscope for bottom side alignment is optionally available. It can process substrates with thicknesses of up to 4 millimetres. The m a 200 compact is a master, when it comes to detail 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.

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Courtesy : https://www.youtube.com/watch?v=bX9mAt8AA4c

Because of it is compact size, it also saves valuable space in the clean room. The m a 200 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 Microtech.

Let us see another video and again this is on the Karl Suss MA6 Mask Aligner S O P. How to use a mask aligner this is a video on this, so let us see this video, and then let us discuss. This is the M A 6, it is used to expose our UV light to a substrate that has or in the photoresist on. So, before we on the machine the first thing, we got to do is make sure the light bulb is turned on or even enough.

So, we come out to the back. And you can see the lights turned on by the recession here or you can see the right polling. So, you know that the light bob 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. Hold this button, it says 3 2 2 6 (Refer time: 51:20) hours the bulb is 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 to use, and there is nothing wrong with the bulb, and the power supply, what a login to the system. So, before we log in, we check the logbook. And the logbook would say that the last person, who used him is Monica on on 221, and then you would check the notes. She had her anything was wrong, so you can see there is nothing wrong.

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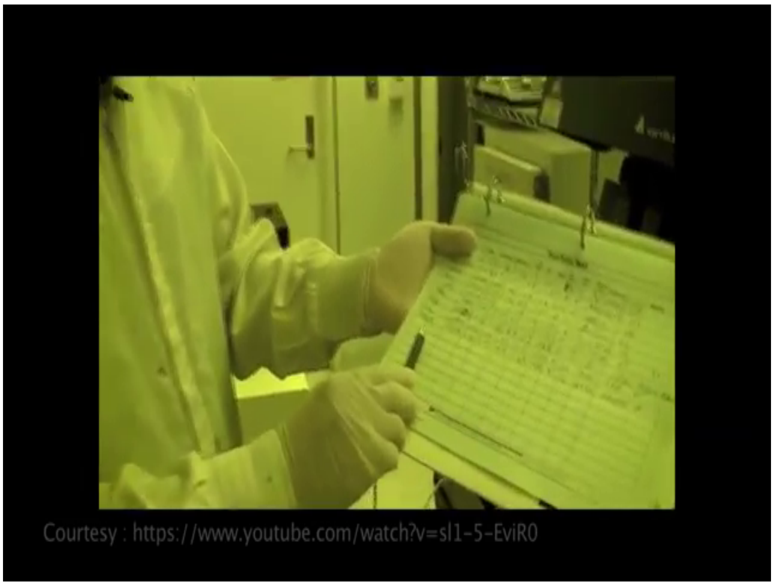

Courtesy : https://www.youtube.com/watch?v=sl1-5-EviR0

So, we will turn the machine on and login. So, the log in computer say, you have to login to use the machine that, otherwise you would not turn on. And the login has several functions.

The first thing is the login, where you type in username and password. Your scheduler to use a machine at different hours also, you should check this to make sure nobody else is using. So, today is a 24th and its 10 a year nobody using it. So, definitely use it.

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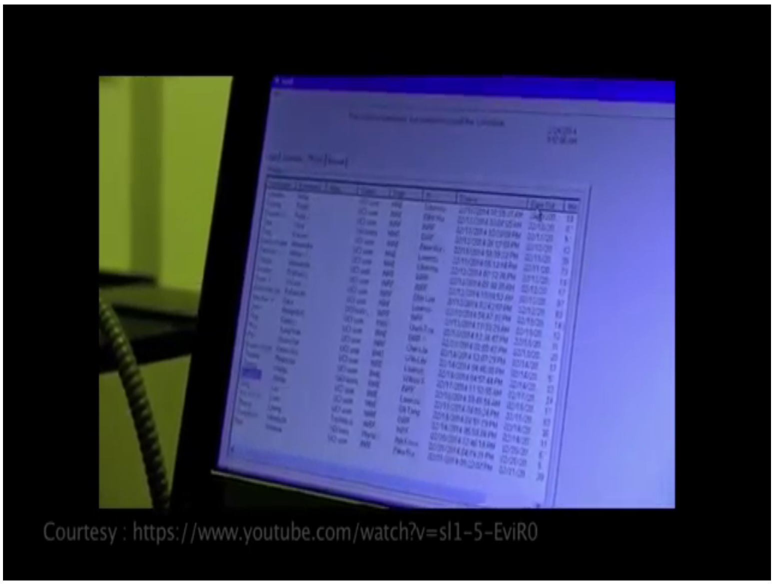

Courtesy : https://www.youtube.com/watch?v=sl1-5-EviR0

The user has a history tab, where we can see the last star user. And you can see that Monica is last user. And she is the last one to whiten log. So, let us me know the machine is already and something to 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.

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Courtesy : https://www.youtube.com/watch?v=sl1-5-EviR0

So, we just going to the on switch. Now, you can see a machine starting up. There is a front to read the screen, it tells you a lot of information. So, it says ready for start, last load button. So, the load button is right here, I will press that, and now it says watch out machine is starting up.

You know, where the machine is ready for loading. And started up, when if the (Refer Time: 53:20) says ready for load. So, before we are going to on machine. The only thing, we can do is change the parameters. So, hit this button called edit parameter. So, now you can, you can just a parameter such as time, and distance, and type of exposure.

So, how do we edit the parameters or change the difference from this p is the x or left and right. So, we made this way, we change the gap; change the type of contact; and then change exposure type.

So, let us change the exposure time first. So, it is 5 seconds now, we can change it to 25 seconds. If you hold fast and up, you can change it faster. So, it is 25 let us make it 26. Now, one of those slower; so, we do not hit fast, you just. So, now weight a just an exposure time. Let us change the alignment gap, let us make that 40, and let us change the to make a soft contact, many problems have changed.

There is different type of exposure types. Some soft, vacuum, hard or if you look at a supplemental to, get more information right. Now, we will send a soft, so what is the timer is a set.

We vary parameter, what can a do, now is the load the mask. So, how do we load the mask, we better, we press the button for the change mask on the screen. So, we have changed mask, ready to load the mask.

So, you get a look over here, so, you load your mask in here my lifting this up here. And putting it in (Refer time: 55:10) you hit this button called enter. We were talking about vacuum, so right, now the vacuum is off, when you press enter. Now, the vacuum is on, when you come back, you can see that it is it is vacuum stuck by lock.

So, now let us put this in here, so we carefully carry it. And face it all the way in and when it is in the press change a mask. And that is how, you load your mask. We are going to be doing a backside aliment. Now, so what this does is and aligns features on the back of your wafer see your mask, and how it do it means you got the microscope from the bottom.

So, first thing, they do is and we have to have our mask loaded. And then we turn the screen on. And we make sure this thing says backside, why my microscope is on. So, it is on but also, we need to change this to backside alignments.

So, if you need your topside alignment or it can be a backside alignment. So, this is a elimination. So, now the light is coming from the backside. So, if you look here, you can see the light hitting the features. So, that is the microscope from here coming looking up to lighten yet. So, you can look for those on the screen, now. And a pretty much, what you do is.

This controls the microscopes on the back. So, you can select one at a time to move, around to you find your features. It looks like a, we found a aligning marks on the mask. So, we now just the focus. So, we use is a stop straight left and right.

So, left one adjust a left no white, just the right focus, you can also adjust intensity, 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 with the left one; it is a similar thing, so did you find your mask, and you think, you are ready to do next exposure, and align it. You will grab this image same press grab image button right here.

And then your first hour later does it. It takes a picture of the mask, then now we are ready to load the wafer. You press this button, versus load wafer. So, it says first I file and substrate on to chuck. We just load our on, when it is in if the centre, and you bring it up.

So, now you can see, you are in contact. This is the image overlay from the mask. And these features right, here see the bottom substrate on your wafer. So, how do you move the wafer? We know that these buttons move the microscope the wafer. It is these runners right; it is these knobs right. Here this is the Y, this is X is on this side, and this is (Refer time: 58:51)

So, I will give you an example. I can turn this, and you can see the background. This image is moving, and you can see this moving. So, this is the right position on the left side. And the right side is the X knob, we can adjust the tilt with this too, and how you can adjust the focus. Now, you can adjust the intensity of light.

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Courtesy : https://www.youtube.com/watch?v=sl1-5-EviR0

So, you ever do that to find the alignment mask, and then align them. So, once you have aligned them, we are ready for exposure. Then how do you expose, we press first your alignment check, which will bring it up to touch. You want make sure nothing moved, and then with some contact you hit exposure. And when you hit exposure, it is good to turn your back away from the light. So, does not damage your eye. So, hit exposure, and then we just turn away.

So, after exposure, you need a unload your wafer. So, what you do is you come to the screen. They you say (Refer time: 60:01) unload, it is no substrate. So, let us pull it out. Then this is (Refer time: 61:07) you press the enter button. And then vacuum would be released then you can take your wafer out. Then, when you put back in, so that is how unload your wafer after exposure.

What we are going to do? Now is topside alignment by using the microscope on the top to align to the wafer that is underneath to the glass. So, to do topside alignment, we need to move the backside microscope. So, we press this button that turns it off.

Also, we need to put the elimination to the top side. And then we can load our wafer in. So, again, you press load. Now, it says pull slide, and load substrate onto chuck. When you press enter into that, then the microscope will ultimately come down. Because, we have the BSI microscope power button on and off.

So, now it is down. We will turn the TV screen on. And look this is doing is taking it in in the image from here onto the screen. So, here this buttons right. Here, controlled the X and Y position of the microscope. So, this thing, we found something here.

So, we can turn up, it is pretty the power of the elimination is pretty high intensity. So, we lower their 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 knob right here.

So, if you move it, just for control the light microscope the X position of the microscope. And the left side has the same button. So, I knew the left knob, I can turn this way; but I move the right knob, I can turn it. This way, we can adjust the tilt to make these match up by turning this knob right here.

So, they look like it is pretty messed up. So, what you do is you do the same thing as a quarterback side alignment, align on your wafer. So, these here so you can see that, if I move this. So, these knobs always control the substrate. So, I move this, you can see that, this has been moved. So, you can tell that is the national substrate moving not the mask.

So, you try to focus it. And you are trying to find your alignment mask and align them to the features. And then once you are in aligned; that you do the same thing. You do a alignment check, and I will bring the mask up. And then you expose it. So, you press expose, then you need to exposure again. So, then you turn away. So, the UV light does not choice.

So, after double exposure wafer, so it told you first either unknown substrate. So, you pull out. And then you take it out. Now, you finish your simple you put this back in. Now, if you are done, you want to move this back up.

And you do not want to bring it back down. This is where, you pressed A P S A button. So, by default this will not come down. Also to bring this up, you press F 1 and enter, and you bring the microscope up. It is always good to leave it. In the fix position for the microscope up, and the BSA button on, because that way the microscope does not come on and off, every time you using it.

So, after that, we are reached take out our mask the way to unload the mask. Let us press the change mask. It is pretty similar to loading it. It is a reverse process, you press change mask. It would take their substrate out. We hit the enter button to remove it back in. In a new ticket mask out, you press the change mask button again. And there will ask formal enter. Now, here the mask is there.

So, now everybody would turn the system off. So, we will make sure everything is in the standby position. Then you started the machine with, and then before you turn it off. You want to make sure you write on the log book to different parameters. So, to compress air is about 7.9; nitrogen is about 1.65; the vacuum is about 0.86 taking 0.86. We use a 4 inch wafer with silicon though we did 25 seconds exposure.

Now, we are going to turn off first thing. We do is we turn off the switch here, press on the TV screen. And then, we can logout here, and it is a message is like did you reset the X Y at 2 position. Now, we did that. So you put ok.

So, if you now see, what we have learned, what we have learned. If you can see, I will show it to you on the screen. Here, I have in something in my hand. What we have learned today is a step called photolithography, a step called photolithography. In the last two videos, what you guys have seen one is a automatic mask aligner. You have to load the wafer, it will perform everything a robotic arm will take the wafer, and then it will perform the photolithography.

In the second one, you have seen how can you perform front to back alignment, how can you align the wafer, how we have to align the mask, what is the procedure. The idea is to fabricate simple things simple devices like the one that I am holding in my hand or complex devices such as MOSFET or devices that can be used for clinical application, like our drug screening device that, we will be talking about in a in the lectures to follow right.

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A drug screening device will look similar to what I am holding right now in my hand. This device can be used for rapid drug screening that means that, if a person comes with a cancer to a doctor, where the doctor has to decide, which drug he has to or she has to give to the patient and which will work out.

But, unfortunately there is no patient centric platform that a doctor can try, the clinician can try, before giving it to the patient, that means what I am saying is if you take the cells from the patient, you load the cells on to this device. You flow the drug, you get the results, and tell which drug would be effective for this particular patient.

Can you fabricate this kind of device? The answer is yes. How? By understanding photolithography right. So, we will be looking at such kind of device such kind of interesting platforms that can be used for rapid drug screening. Why I said rapid drug scanning? Because there are multiple channels here and at either a single in a single shot, we can perform 8 different, 8 different drugs, we can screen using this platform or we can check 8 different patient samples with single drug. So, such kind of applications, we can use it using the micro engineering platform, and understanding the photolithography.

So, just go through this particular ah module and try to understand, try to focus and see what things we have been discussing in this module. And if you have any questions, feel free to ask me in forum, and either me or my TA would reply to your queries. Let us see very interesting applications of this microengineering devices in the classes to follow.

Till then you take care, have a nice day, bye.