Instability and Pattering of Thin polymer films

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Lecture Number. # 11

Photo Lithography - III

Welcome back now, to the eleventh lecture of this course. We will continue our discussion on photolithography, which we started to talk in our previous class.

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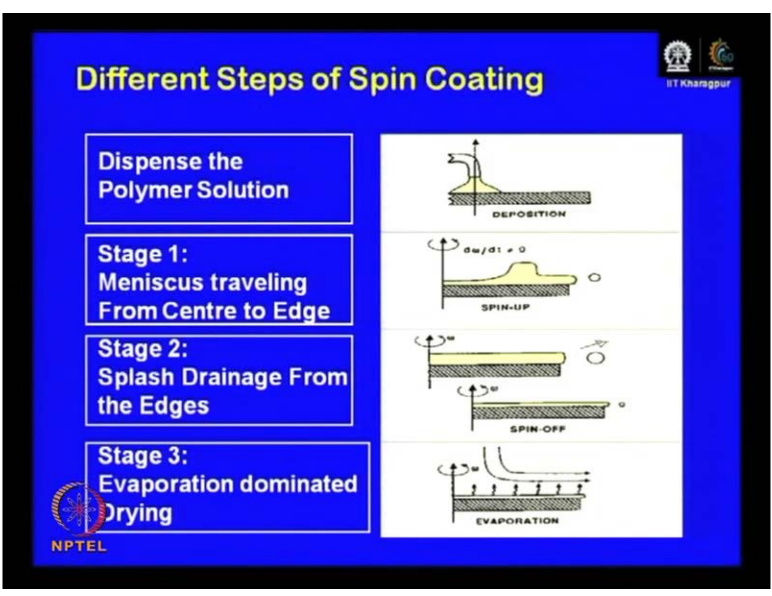

So, we looked at the different stages of photolithography. So, finally what we obtain after the evaporation of the solvent is a thin layer of the polymer or the resist film, you want to make. So, this also sort of gives you an idea about the quality of solvent, you want to use. So, if you sort of use a solvent that evaporates too rapidly, then what might happen; even before the meniscus is travelling full towards the age of the substrate and you get a continuous film of solvent rich polymer or solvent rich photo resist, the solvent might evaporate. So, that might also lead to hindrance of obtaining a continuous film.

On the other hand, if you use a solvent that evaporates too slowly or you have an environment, which is sort of pre-saturated or partially saturated with vapour pressure of solvent molecules that sort of effect the solvent evaporation rate, what might happen is that your solvent rich film or the level of the solvent residual solvent, even after spin

coating might be too high and that can be dangerous from the stand point particularly, if you are trying to coat your film on a non wettable surface.

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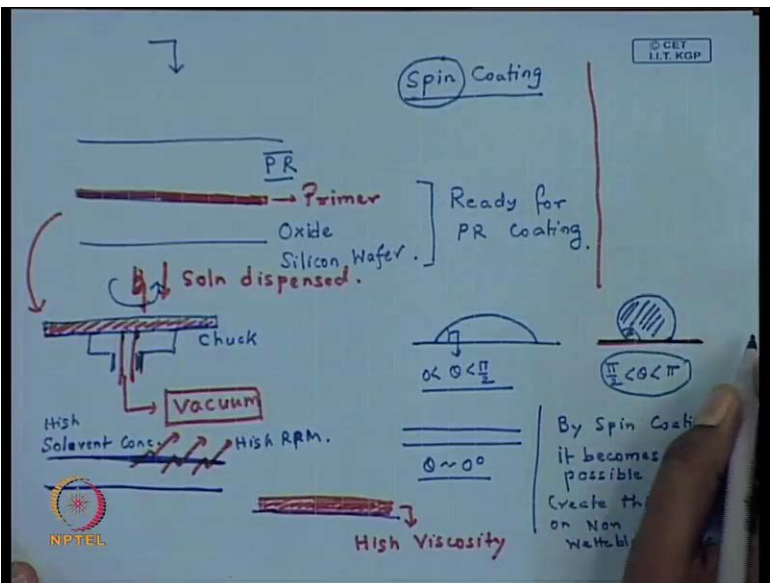

Because if after the completion of spin coating particularly on a non wettable surface, your solvent level is not low, then the molecules or the solvent containing the molecules sort of having, because of the presence of the solvent the polymer molecules of the resist molecules, will have adequate mobility and there by based on the horizontal balance of the surface tension, there can be structural reorganization or deviating. So, in order to have a continuous film with uniform smoothness, the choice of solvent also becomes very important that way.

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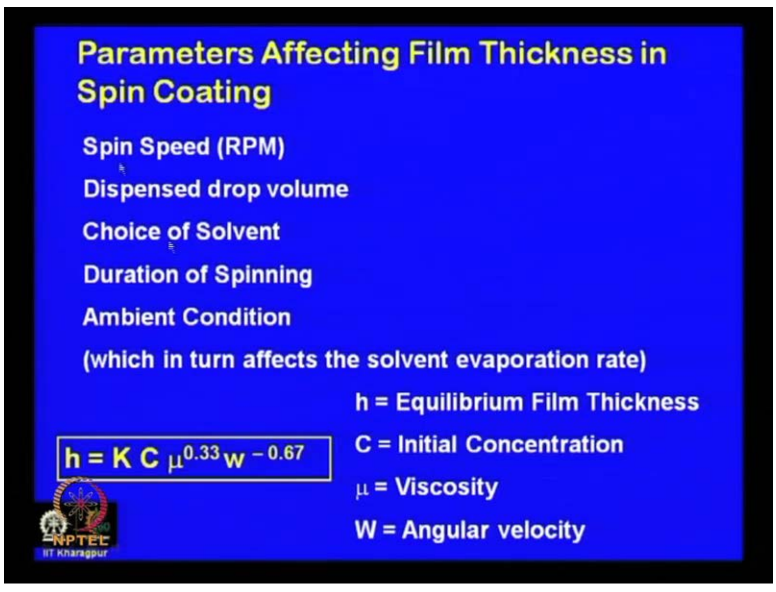

Well, So the critical parameters affecting the film thickness in spin coating are of course, the spin speed you can probably understand qualitatively that higher is the spin speed, you are adopting lower will be the film thickness.

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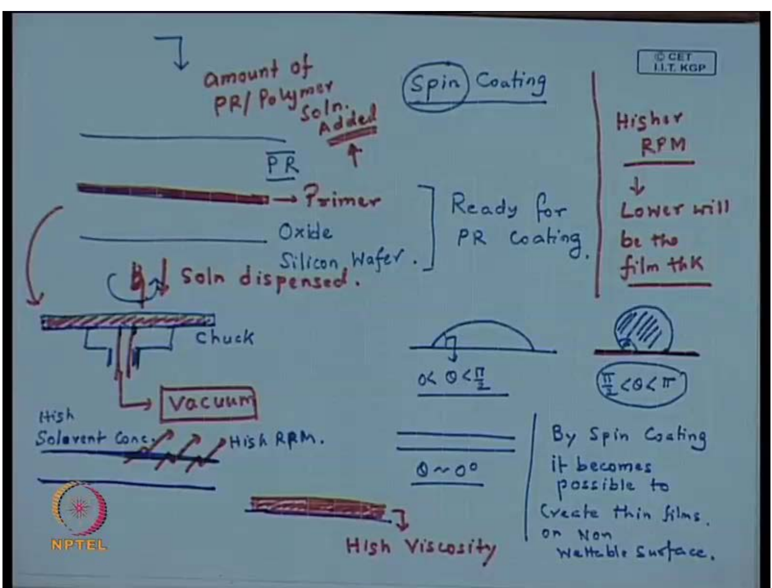

Then, essentially the dispensed drop volume or what is the amount of photo resist or polymer solution added, because this in turn affects the amount of polymer that you are adding on to the substrate. Now, this polymer that you are adding of course so, through this step you are adding two different species together, one is the polymer or the photo resist and the second thing is the solvent. Now, the polymer two things can happen either (Refer Slide Time: 00:31) the polymer sort of gets deposited on the surface or part of the polymer is lost due to splashing, meniscus travels from the centre to the edge and there is a splashing of the excess polymer.

So, if you ever see a spin coating technique, you will see that after three, four or five seconds of beginning of the rotation as the meniscus reaches the periphery of the substrate, there is significant splashing. So, significant amount of polymer as well as solvent is lost due to splashing, but what remains the polymer gets deposited on the surface and the rest of the solvent, major part of the solvent gets evaporated. So, higher is the amount of the solution added, you are actually adding higher amount of polymer. So, you may eventually land up getting thicker films, if the amount of the if or is the dispense drop volume is high or (Refer Slide Time: 02:35) you add higher amount of polymer during dispensing.

The third choice is of course, the choice of solvent we already talked about the importance of the choice of solvent. Fourth stage is duration of spinning, well duration of spinning is partially important, because if you sort of not well aware of the spin coating technique and let us say, you choose to sort of spin your sample or your substrate for let us say, ten seconds then that might be critical. Because in that case, the time window of ten seconds might be too less for major part of the solvent to evaporate, which can be sort of dangerous from the stand point again that, if the rotations stops. So, the forcible centripetal force that you are applying for enhancing the spreading of the liquid layer on the substrate is sort of switched off; turned off.

So, then you are essentially left this solvent reach polymer layer of the photo resist layer, is essentially left on the mercy of the surface tension balance. So, well if it is a preferentially weightable surface then perfectly fine the film will still be there, there will be subsequence slower evaporation of the solvent, eventually leading to the formation of an intact film. So, what is going to happen even after your spin coating stops, there is going to be gradual reduction of the film thickness for some time, but in contrast if you are using as a repeatedly telling, as I told couple of times that if you are using a non weightable surface and then you stop your spin coating at a stage, where the remnant layers still has adequate amount of solvent present, then it is going to be other devastating scenario.

Because based on the surface energy balanced or based on the surface energy of the system, the film might actually retract or rupture at different locations. However, if you are sort of allowing the spin coating process to continue significantly where you reach (Refer Slide Time: 00:31) the evaporation dominated resign. And once, you reach the evaporation dominated resign then whether you spin it for one minute or five minute, really does not make much of a difference. So, what you need to realize that, you want your process to definitely reach up to you want to choose a time of rotation, which will definitely allow your process to reach up to significantly reach will in to the evaporation dominated resign.

So, you not to like to take a chance of picking up a very low duration for spinning, which might actually result that, you stop the rotation at any one of this two stages, which can be sort of pretty dangerous from the stand point of obtaining a uniform film. However, typically for many applications at least in the lab scale, it will goes for roughly one minute spinning, which is more than enough because experiments or observations shows

that this stage lasts for roughly for the first, three to four seconds then this stage last for about twenty seconds or something like that splashing and subsequent evaporation and evaporation dominated resign than dominates beyond.

So, think to understand would be whether you spin your substrate for one minute or three minute is probably, not going to lead to much variation in the morphology or thickness of the film. But however, if you whether you spin your substrate for ten seconds or thirty seconds or one minute it is going to be critical. Because may be in ten seconds, you have not even reach the evaporation dominated ragin, if it is let us a very low probably you have just began you have just reach the evaporation dominated ragin. So, there is still significant amount of the evaporation that you need to take place, before you turn off your rotation. So, these are some of the critical aspects.

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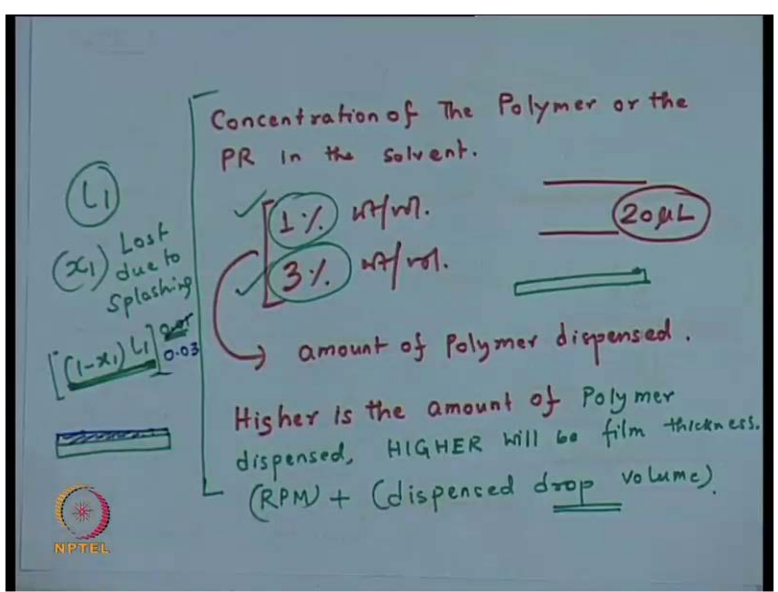

(Refer Slide Time: 02:35) Of course, along with dispensed drop volume the other important thing is concentration of the polymer or the photo resist in the solvent. So, that is another important parameter, somehow it is not there in the ppt, it is the concentration of the polymer or the photo resist in the solvent. This is actually one of the most important parameters, because suppose you decide to dispense a twenty micro liter of the solvent now, whether you have a one percent weight by volume concentration or a three percent weight by volume concentration, this is going to be critical.

Because this in turn, is going to again affect or dictate the amount of polymer dispensed and you can understand that that higher is the amount of polymer dispensed, higher will

be the film thickness. This is actually, one of the most important parameters alongside the RPM as well as the dispensed drop volume. Dispensed drop volume also it has almost is important also from the same standard point, because this in a circuited way dictates how much amount of polymer you are dispensing on the film surface or the substrate on the substrate surface not on the film surface, on the substrate surface and this again sort of tells you about, what is the amount of the relative percentage of polymer of the photo resist that is present, that is going to be eventually deposited on your substrate.

Because, if you regard if you are using the same RPM, if you are using the same solvent and the same dispensed drop volume and then if you sort of in this irrespective of the cases or irrespective of the polymer concentration, which any way is pretty low. What you are going to have that the relative percentage of the solvent or the polymer laws, due to splashing will be roughly the same. So, once that goes away whatever remains so, if you say let us say you have dispensed L 1 is the volume of the dispensed drop and let us say x 1 fraction of that L 1 is lost due to splashing. So, it is essentially one minus x 1 into L 1 is the volume of the polymer, that is of the solution that is going to be available on the substrate surface here on the substrate surface.

And from here, the solvent is going to sort of evaporate the solvent is going to evaporate away and leaving behind the polymer. So, now you can understand that if you have a one percent polymer, we say three percent polymer concentration. So, in the first case this much amount of polymer is going to be uniformly distributed 0.01times of this fraction amount of polymer is going to, we have to multiply with density and all this things to have the consistency of the units, which I am not showing this is just a backup the envelope. Example, this much amount of polymer is going to be evenly or uniformly distributed away on the film on the substrate surface.

In contrast, if you have a higher concentration instead of this, lets this much amount of polymer is going to be distributed on the film surface. So, immediately you can realize that there are more polymers in the later case. So, therefore the film thickness is going to be higher. So, this is very very important. Actually, I would regard that apart from RPM or even considering RPM the polymer the dispensed drop concentration or the concentration of the photo resist or the polymer in the dispensed drop is extremely important in determining the final film thickness. Couple of more things you may want to note about spin coating.

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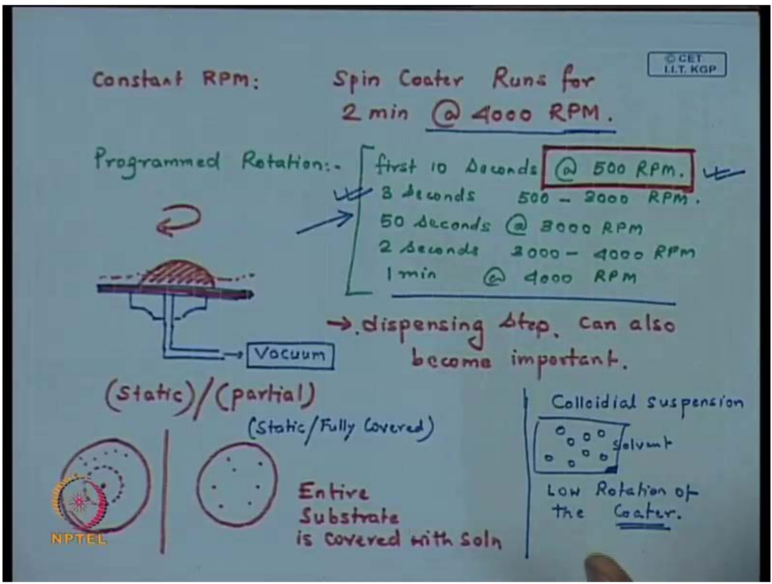

Firstly, that what we talked is that it is a constant RPM. So, let us say you decide that your spin coater say runs for let us say two minutes at 4000 RPM, but you can also have a programmed rotation of the spin coater. Some people, favor it some argue that this does not really help. So, you may sort of program it that first ten seconds it will run it say 500 RPM, then in next three seconds it sort of accelerates from 500 to let us say 3000 RPM. Then, you want to spin there for 50 seconds at 3000 RPM, then in the next 2 seconds you say go up from 3000 to 4000 RPM and let us say further one minute at 4000 RPM.

So, in some of the high end coating instruments, it becomes possible to program your rotation like this. So, this is what is known as a programmable spin coater, one might actually sort of look to the different phases. And, based on the choice of the solvent substrates, surface energy the weight ability of the substrate, one can pick up something like this. So, suppose we just give you an example, if you have a very rapidly evaporating solvent or a rather sluggish solvent.

So, you might actually if you sort of pick up a program like this, what you are doing; you are sort of slowing down the pace at reach the meniscus is travelling to the edge. (Refer Slide Time: 00:31) So, your initial propagation if you now compare that you have a program, at which in which you for the first ten seconds, you have an RPM of five hundred RPM. In contrast to let us say this, one were right after spinning you want to jack it up to 4000 RPM. So, what is the key difference you are doing? What you are doing is you (Refer Slide Time: 00:31) in the stage one, when we talk about the meniscus travelling from the center to edge.

Since, in the second case or in the programmed case you have a slower RPM. (Refer Slide Time: 00:31) So, what you are actually doing that you want to reduce the phase of the travel of the meniscus. So, this is the direct consequence it is not that just you have an instrument and you just pick out some numbers, you must understand what a physical change it is going to bringing to your entire process. So, this might be favored depending on the choice of solvent or depending on the choice of polymer, what you are going to pick up, but well these are detail things and scientist has to based on his or her own decision or the understanding the science of the system, can sort of propose to pick up the desired RPM or desired program or desired which way he wants to handle his instrument.

The other important thing, I would like to just point out here again something from the operational stand point is that once you place your way for or the substrate on the chalk. So, this is the vacuum line which is holding on to the chalk, this is your substrate as I told you the dispensing step and this I can tell you from my own experience also, the dispensing step can also become very important.

What are the possible dispensing mechanisms you can adopt, you can place the substrate on the chalk, and turns on the back home dispense the drop here. So, here you are dispensing on a static substrate and then turn on the rotation. So, as you turn on the rotation this drop will eventually flatten out, they this will eventually travel to the, the meniscus will travel to the edge, there will be splashing and it will flatten out. So, here the dispense disposition or dispensing was static and partial; why partial? Because this is the shape of my initial dispense drop. So, I just took my dispensing siring to the roughly to the centre of the way for or the substrate which is the substrate from the top, I took my place my siring somewhere over here at the centre and dispensary.

And this was the initial shape of the draw and also why I was dispensing the chalk was static, the spin quota was not rotating. This can be one possible mechanism and this is very widely adopted, very widely adopted the other possible mechanism can be you already have a stat, you do have a static coater this quoted is in a static condition, but during the dispensing step itself you try to spread or you sort of rusted your siring in such a fashion, that the entire way for is covered with the solution. So, instead of dispensing simply at the centre, you sort of dispense first drop here, second drop here and the drops relatively spread.

So, before even you start this whole way for the entire substrate is covered with solution. So, we can turn this as static fully covered. These are some, I mean these are non nonstandard classifications, but I am just trying to give you what are the possible mechanisms. The third one, where actually a programmed coating becomes very useful is and this is particularly important not for a polymer solution. But if you are let us say disposing a colloidal suspension, where you have some small particles dispensed in a solvent, where again the particles will remain after spin coating on the surface and the solvent will evaporate.

Many times it is seen that, if we the colloidal suspension you go for a static dispense, dispensing what happens is the areas over which you initially dispense the drop, the concentration of the collide particle remains high over those areas even after spinning, they just do not sort of evenly get distributed on the surface. So, if you are working or trying to spin coat, a colloidal suspension in many case what one does is just before you start the dispensing, you go for a very low rotation of the coater. And then as it is rotating at a very low RPM, you go on dispensing and as soon as you dispensing is complete, you jack up or enhance the speed.

So, that is exactly something a program like this, what I have shown here. So, you may just want to remember even this is you can find it in some journal papers, but I tell it from my own experience that if you trying to sort of coat with a substrate with a colloidal solution, it is always preferred or it is always favored that you dispense the initial drop on a substrate, that is undergoing a rotation at a very low RPM.

This sort of significantly helps in sort of preventing the agglomeration of the particles at some preferred location, at some location particularly at locations, where the initial drop or the drops where dispensed. So, these are some of the areas in which a programmable spin coater might be useful, but other than that spin coating is a very simple technique, very versatile technique and one can create films which are up to few micron thick.

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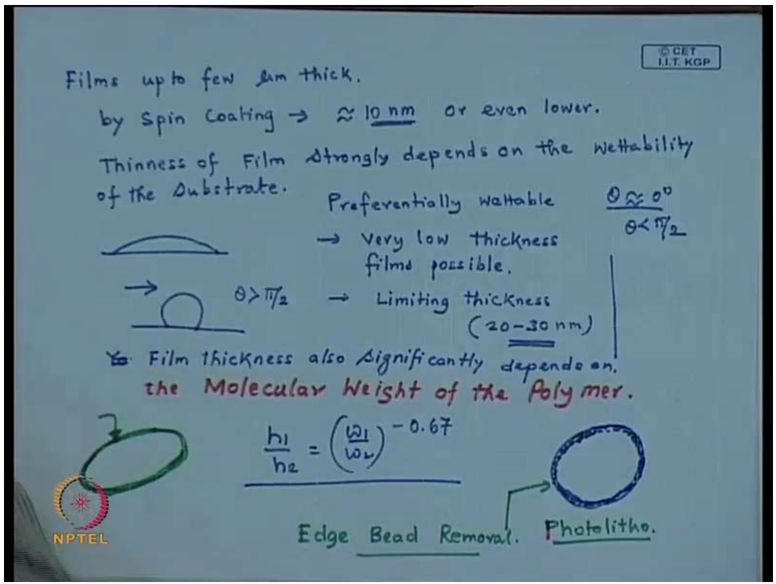

Let us say up to few micron thick which is good, but the most interesting thing is by spin coating you can create films which are which have thickness as low as 10 nm meter or even lower. Of course, how thin you can cost your film; the thinness strongly depends on the wettability of the substrate also. So, in case you have a preferentially wettable substrate that is theta is closer to zero degree or atleast, theta is less than pi by two and is pretty low, well you can achieve very low thicknesses.

In case, it is not preferentially wettable that is a theta is greater than pi by two, probably there is a limiting thickness which can depending on the choice of the polymer, choice of the molecular rate etc, it can be let us say twenty to thirty you cannot probably get a film which is thinner, than this thickness. Also, another parameter not that much in the context of photo resist, but since we are talking about spin quoting.

So, I will take the liberty of talking about it in a general setting, because as we talk about sub lithography and many other subsequent instability steps, we will see that spin coating is rather versatile or it has really expanded much beyond the domain of photolithography, that your film thickness also significantly depends on the molecular weight of the polymer. (Refer Slide Time: 02:35) So, these are the some of the critical things we wanted to talk about spin coating, there is a working formula that is available about the equilibrium film thickness that can be obtained, which goes as h equal to some constant K, C is the initial concentration, mu is the viscosity of the dispense drop and w is the angular velocity or omega.

Now, what you can see here of course, if you know the constant and then you know all the properties, you can probably find out the effective thickness that you are going to get after spin coating. But, what is very important or what is very significant here, that if you know the film thickness at that you have obtained for a particular concentration for a particular polymer, let say or a for a particular concentration of a solvent volume, then immediately you can probably predict very easily what is going to be the film thickness, if you change the RPM.

Because, in that case h 1 by h 2 nearly reduces to omega one by omega two rise to the power minus 0.67, showing in only near dependence, but you can see that higher is the RPM, lower is going to be the film thickness. (Refer Slide Time: 02:35) I repeat this sort of and working formula and some people does use it industrially well, it gives you a back of envelope idea as you what you want to do. In the context, now let us come back I mean we had some discussion on the technique of spin quoting, now let us come back to photolithography.

(Refer Slide Time: 00:31) So, other aspect of spin quoting is the it is associated to this stage actually, where you have a splashing from the ages and this splashing from the ages, often results in some sort of and inhomogeneity or higher thickness or formation of globules or isolated patches or something like that along the periphery of the edge. So, these are again these will be hindrances for subsequent processing, particularly in the context of photolithography. So, what is done at times is, so these will be hindrances for photolithography. So, these are preferentially removed by again a sort of a mild solvent wash only along the periphery, this process not very important of course, but you may need to know is known as the Edge bead removal process.

So, you can have a disk like this and the same spin coater which some attachment can be use that you have a solvent flow only along the periphery. So, you rotate at very low RPM and so, the film sort of gets washed away this unevenness sort of along the periphery gets washed away. To result in a film which is smooth and which do not does not have undulations or unevenness at the ages, which will subsequently affect your subsequent stages. (Refer Slide Time: 02:35) So, this is what is the this is the small step or a minus step, which is there right after spin coating before the subsequent photo resist processing step of soft baking is started is which is known as the Edge bead removal stage.

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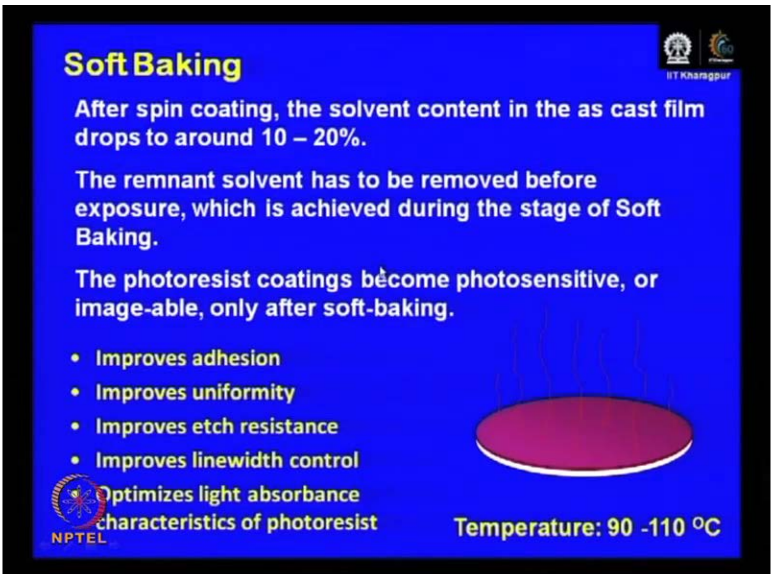

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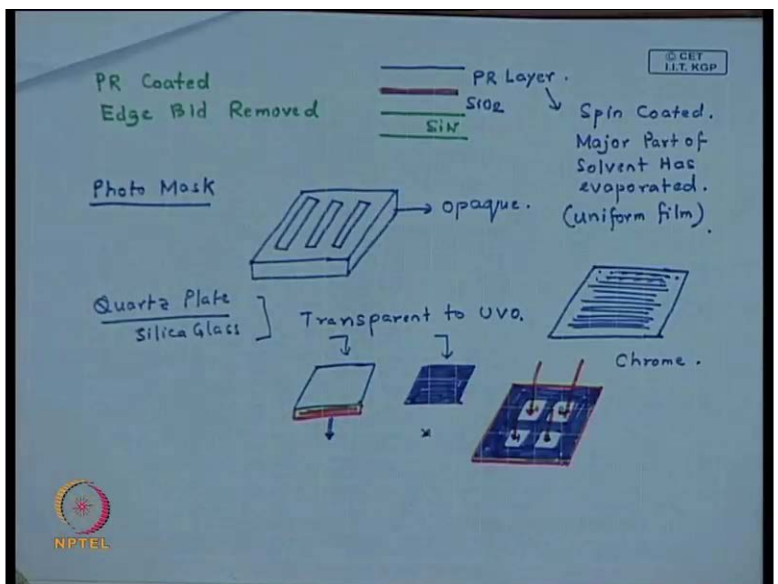

Now, once the coating is over and edge bead removal has taken place. So, you now have a refer which is photo resist coated and edge bid removed. So, we started off with this then we groove the bearer layer, then we had the priming layer and then we now have the photo resist layer. So, this photo resist layer we know that this has been spin coated. So, at the later stage of spin coating, major part of solvent has evaporated and you have a pretty uniform film, but reality is that after spin coating even though we feel the major part of solvent has sort of evaporated the as cast film, still contains around 10 to 20 percent of the solvent.

Now, this remnant solvent has to be removed before exposure because after the photo resist layer is ready, what is the subsequent step you will place the mask and then subsequently will go for exposure, (Refer Slide Time: 29:54) but if during exposure you have significant amount of solvent present in the system, that is going to effect the photo sensitivity of the layer or subsequent stages. So, that is not desirable at all and so essentially the remnant solvent has to be removed or is it is desired that the remnant solvent is removed and this is what is achieved in the stage of soft baking or in other words, the photo after soft baking.

So, soft baking is essentially you just place your coated photo resist coated or photo resist coated wafer at a temperature between let us say, 90-110 degrees centigrade and so, this sort of ensures that pretty much the entire amount of solvent is gone now and your photo resist coating becomes photo sensitive. And So, essentially the features of the critical property enhancement that is achieved in the step of soft baking involves improves addition, improves uniformity, improves edge resistance, improves line width control, optimizes the light absorption characteristics of photo resist or in other words its essentially at this stage, that the photo resist coating becomes photo sensible, photo sensitive and ready for exposure.

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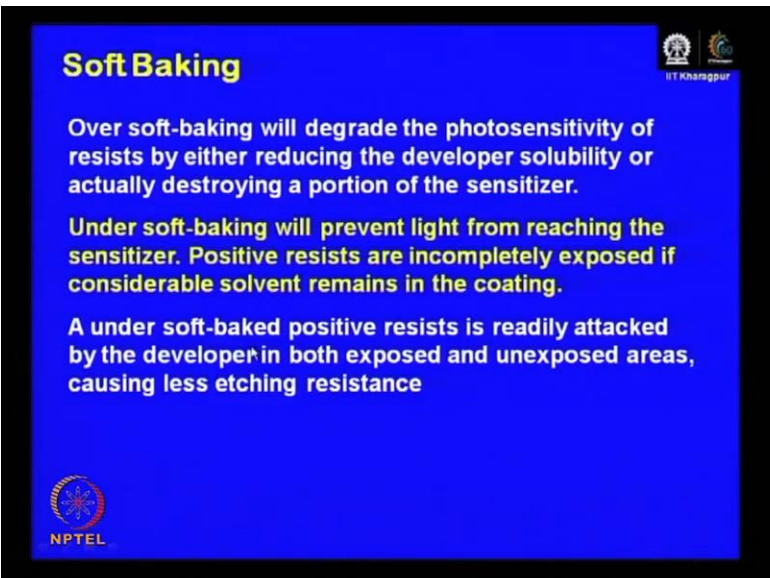

Now, couple of things that over soft baking will degrade the photo sensitivity of the resist, by either reducing the developer solubility or actually destroying a portion of the sensitizer. We already know that a photo resist has sensitizer, which is essentially responsible for the photo active properties and if you over bake it due to the prolonged

exposure to heat; what will happen is that the photo sensitizer will get sort of damaged. In contrast, if you sort of under soft bake this will prevent light from reaching the sensitizer and photo resist incompletely exposed, if considerable and the photo resist eventually if considerable amount of solvent remains in the coating, the photo resists layer will be incompletely exposed. An under, soft baked positive resists particularly is readily attacked by the developer in both exposed and under exposed areas. So therefore, the etching resistance will be less and eventually you would not get the desired pattern you want. So, soft baking is not only an important step, but also controlling the time of the extent of soft baking is extremely important, as you can see for subsequent processing.

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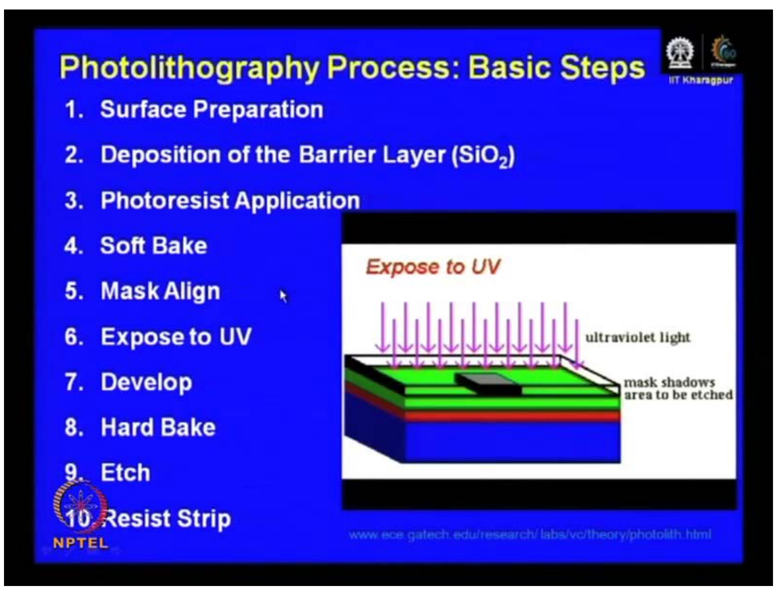

So, now if we relook back at this particular animation let us see what are the things, we now understand at this stage. So, you start up with p type silicon wafer or a doped silicon wafer, you do the burial layer you (()) the photo resist. So, now we understand what it means. So, on a barrier coated oxide coated silicon wafer, you coat the photo resist layer and then of course, what is not shown here that before coating, you do the dehydration and priming of the barrier layer after coating, you do the soft baking and then the subsequent next step is that a mask is brought in. So, the mask is brought in the mask is now placed on the photo resist layer and its ready for UV exposure, what we have discussed in the context of describing or discussing photo resist tones.

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So, now it brings us back to a slightly detailed discussion or if the stage is now, right for a slightly detailed discussion of what a mask is or a photo mask as it is ideally called is, so essentially a photo mask is an opaque plate with holes or transparencies that allow light to shine through in a defined pattern.

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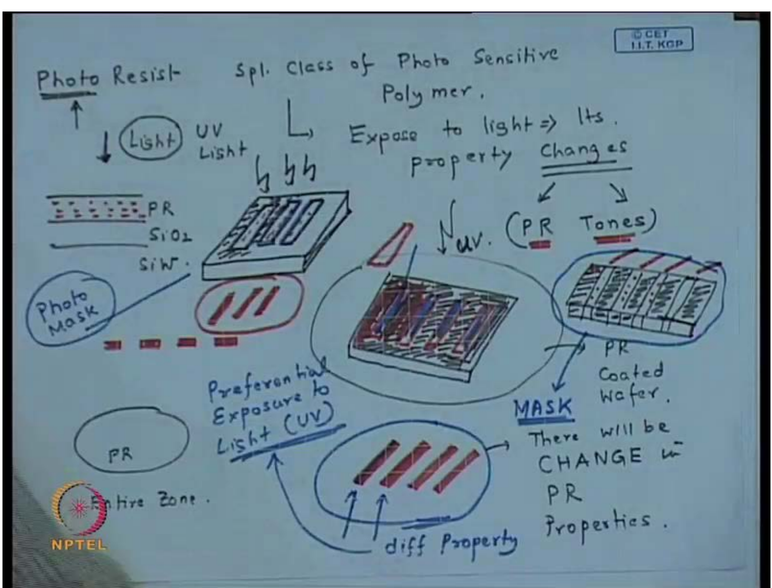

So, very loosely in our some of our earlier discussion we had considered a photo mask of something like this. So, what we are good is that it is a piece of material something we did not specify at that point of time, whether its glass or polymer or metal or whatever, but it has some areas where we told at that point of time you have a slit. So, that light can pass now we refine our definition a little bit, a photo mask is an opaque plate. (Refer

Slide Time: 35:18) So, it is a plate. So, the overall the plate is opaque with holes of transparencies, not holes having some domains of transparencies. So, let us say you have a domain or these domains which are let us say transparent.

So, through which so these domains are domain sort of replicate the pattern you want to create and through which the light will pass. So, let us say like here if this is the final pattern you want to create this is going to be the design of your mask. So, that is obvious now you probably understand it or in other words, so typically now what is the material of construction typically we take a quartz plate; quartz is a pure silica glass which is transparent to UVO. So, you have a piece of glass which is transparent to UVO you may keep it in mind that normal glass slides, the microscopic slides you use or normal glass windows or whatever normal glass we use it is not a pure silica glass and they are not transparent to UVO.

So, you need to use a quartz glass which is transparent to UVO. Now, essentially if you take a material which is entirely transparent to UVO, it would not be of any use. So, this quartz is generally coated with a layer of chromium, chrome metal coated. This chrome metal is opaque to UVO so, if UV light falls on chromium of this chrome metal coating, it will absorb the UVO. So, you had a quartz plate you shine UVO it is hundred percent transparent, if you now have the same quartz plate coated with chromium or chrome metal and you shine UVO nothing is going to pass, because it absorbs.

So, now the stage is absolutely right if you now create your design, whatever design you want to sort of replicate on your photo resist layer on this chromium coated metal layers. So, suppose this is the design you want to create, let us say you want your light to pass through these rectangular domains and in other areas you do not want your light to pass. So, what you will do you will by some technique strip off the chromium coating preferentially over these zones.

So, you had a uniform chromium coated quartz piece or a quartz blank it is, let us say this blue color in this sketch refer to a chromium coating and then by some method, what that method is I am coming to you, you remove the chromium coating preferentially at these zones. So, what does it mean, but now if you shine your UV light on this mask, light will be able to pass over these four zones and over other zones it will sort of get preferentially adsorbs.

So, probably this particular figure now makes sense to you that this is the chromium layer we are talking about. So, there is a uniform exposure to UV light, but only in the areas where there is no chromium coating, the light will penetrate the mask and these areas where you have a chromium coating, those coatings will act as absorber and it would not allow the UV light to pass. So, whatever pattern you have on your mask, the exposure on the photo resist layer will now be controlled. So, you will have the special variation in the exposure on the photo resist layer depending on the pattern geometry created on the photo mask.

Typically, the way we showed in the schematic over here from a fully so, these are the typical step. (Refer Slide Time: 35:18) So, we start off with a UV blank coated fully with chromium and then use a technique called electron beam or laser or X ray to strip off chromium at the locations of your choice. For you may want to note down that for integrated circuits, multiple masks with multiple patterns are necessary. So, you might want to have built this something we also talked in some of our earlier lectures, that it is not exactly making just one pattern. So, what is important that you go on making different layers of patterns? So, you make one set of pattern and then with respect to those one another set of pattern has to be made etc.

So, that makes it more complicated. So, one mask apparently sort of sounds pretty simple that somehow, if you have a piece of mask you have a proper photo resist and you have a UV light source, you can sort of implement your photo lithography, but as you will see that it is industrially much more complicated and since you might have to use multiple masks with multiple pattern, now these patterns it is not like random patterns you want to create. So, these patterns will be coherent to the earlier pattern you have created.

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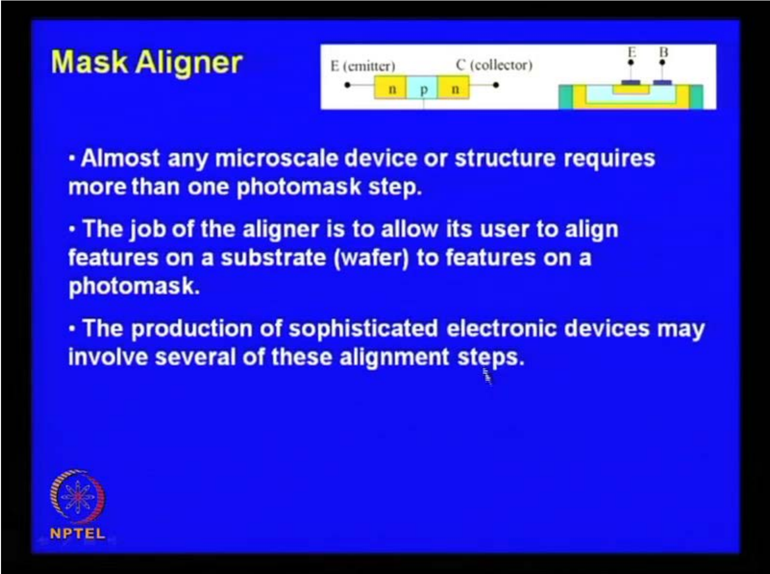

So, something likes this so you have sound layer created here and on top of that you want to create a thing like this. So, your subsequent masks has to be sort of positioned with respect to the earlier positioning of the masks or the structures you have already created of the variation in the exposure, you have already created on the photo resist layer. So, this is what is achieved by an instrument called mask aligner. Almost any micro scale device or structure requires more than one photo mask step and the job of the aligner is to allow its user to align the features on a substrate to features on a photo mask.

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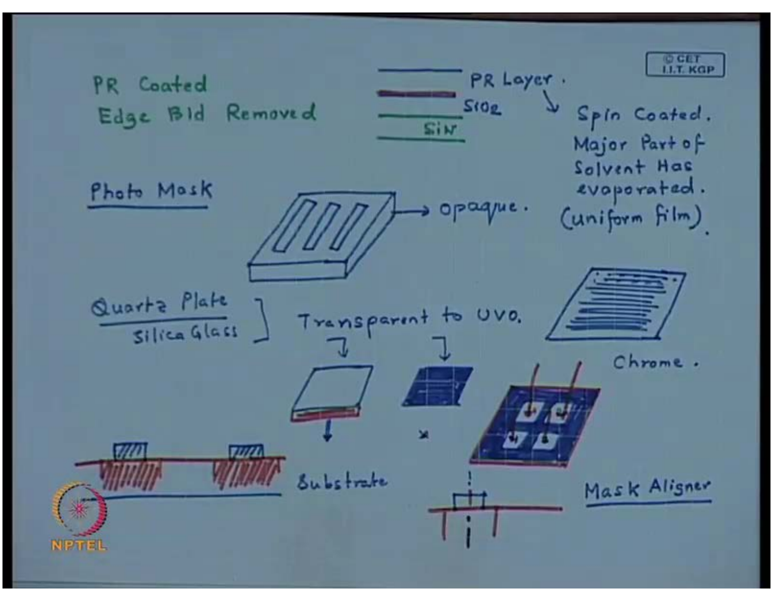

So, you have you so now, you should now changes too. So, you have these features on let us say substrate and you now want to bring in a second mask, which will create a

structure like this exactly at the middle of these domains. So, what is important I mean this is something I would not really go into the detail, because it is too much of automation and things like that what is important that you now position. So, this is your first structure, this is the central line you position the mask which you want to use for creating the second structure, where the central line of the features matches with the central line of the first structure and remember we are talking of dimensions which are let us say few micron or may be even lower than that.

So, this cannot be achieved manually and this is what is achieved or done by the instrument or equipment called mask aligner. Again for any commercial or even a reasonable photo lithography setup this is something that is a very important hardware element or an instrument production of sophisticated electronic devices may involve several stages of this alignment.

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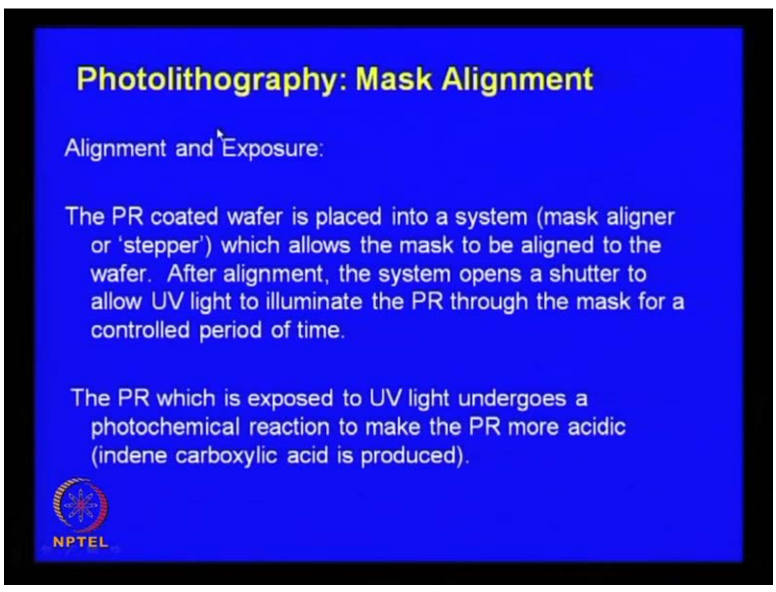

Well now, so you now understand that we are now ready. So, since I have briefly introduced to you the concept of mask aligner.

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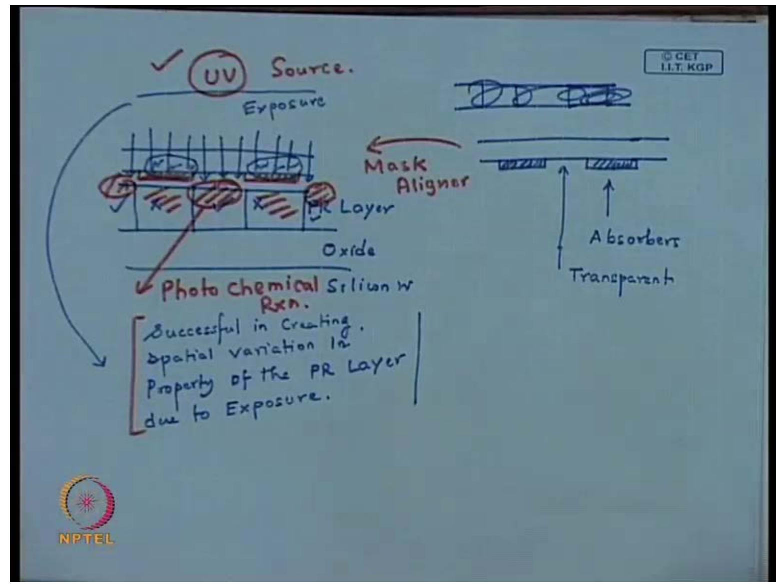

So, you now have the photo resist layer, you on the oxide coated wafer you have a silicon wafer. So, now you have your mask aligner in place. So, you have your mask let us say these are the; now we understand that since we have a chromium layer which has been preferentially strict of at some locations. So, this might be a more appropriate image of your mask. So, these are the absorbing zones and these are the transparent areas.

So, now your mask aligner takes care of this particular mask and brings in it on top of the photo resist layer. So, this is placed on the photo resist coated film by the mask aligner and then you have the UV light source, which is now ready to shine light on this photo resist layer. So, the photo resist coated wafer is placed into a system, which we already have mentioned is known as the mask aligner or it is also known referred many times as a stepper, which allows the mask to be allowed aligned to the wafer. After alignment the system opens a shutter to allow the UV light, to illuminate the photo resist layer through the mask for a controlled period of time.

So, you have the UV light source it is exactly like a camera, you can say that once the mask aligner has been placed has been aligned with respect to the photo resist layer or the photo resist film then, you sort of opens the shutter. So, you allow the UV light source or UV light for a specific duration to fall on your essential on your mask, which then controls that over these areas the light passes penetrates the mask and goes all the way up to the photo resist layer over these areas, because of the presence of the absorber layer light falls, but it gets absorbed within the chromium layer or within the absorber.

So, these areas get preferentially exposed these areas that is no exposure and well now we are again back to what we talked initially discussing the photo resist stone. So, you have now based on this particular stage of exposure have been able or successful in creating spatial variation in property of the photo resist layer due to exposure.

Now, what type of variation you have caused whether the exposed areas have sort of preferentially got become weaker or they have become preferentially become stronger of course, you understand depends on the choice of the photo resist stone what you are using. So, here it is the photo resist which is exposed to UV light undergoes a photochemical reaction. So, these areas of the photo resist layer sort of there is a photo chemical reaction, over these areas there is no reaction. So, this leads to the variation of the chemical properties along the photo resist layer.

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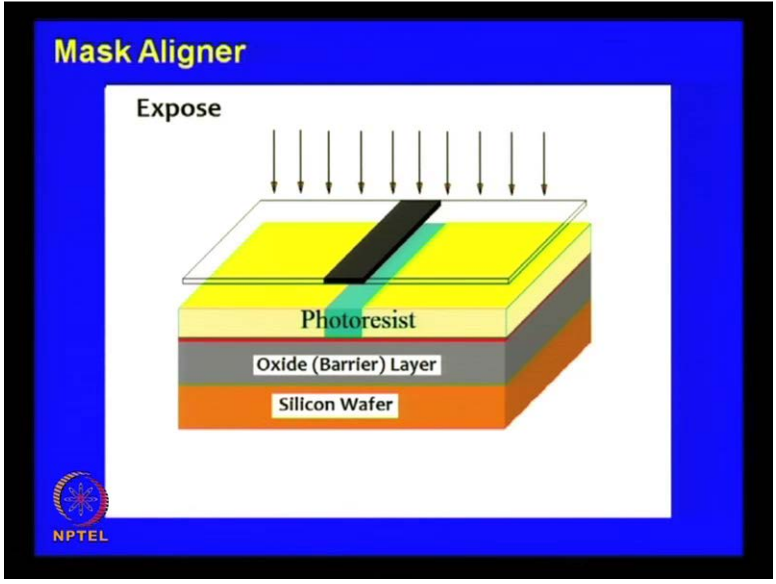

So, this is this cartoon will now give you a reasonably good idea. So, this is what we have been talking about silicon wafer, then you have the oxide layer, then this is the priming layer, and then you have a photo resist also. So, this is the photo mask; so, this is the transparent areas, and this is the absorber, and alignment has been achieved by the stepper or the mask aligner. And then you expose; so you allow your UV light to fall on it, and since these areas is transparent. So, the light penetrates, and there is a photo chemical reaction that takes place over these areas. However, this particular strip now weakens its color, if you see to initially we represented photo resisted blue, and after exposure we have turned it to change some color. So, this color scheme is just to give you an idea, that over these areas there is a photochemical reaction that has occurred and

consequent to that there is a structural change in the photo resist layer. However, since this particular zone was below the absorber layer. So, therefore, there is no change in the photochemical property and therefore, it returns its original property.

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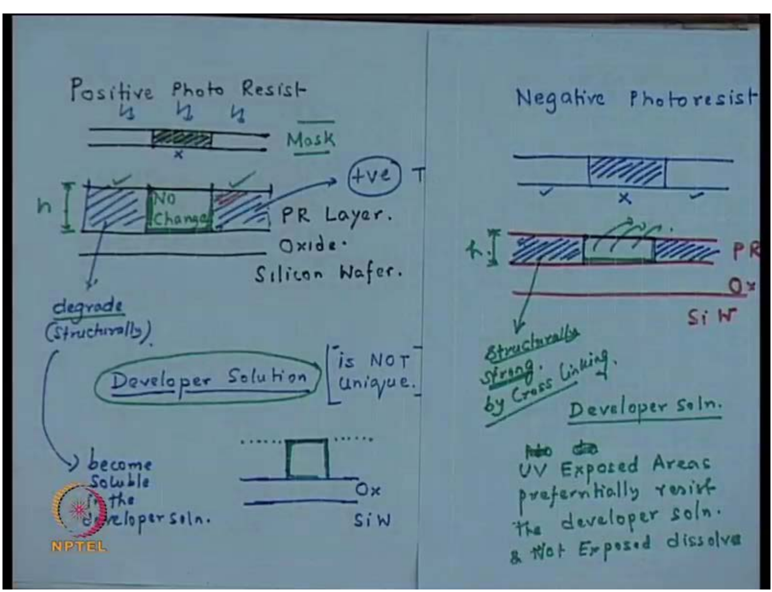

And now, if we look back to some of what we discussed initially we depending on whether, we have a positive photo resist or a negative photo resist, this particular strip, this particular blue strip over here will… If it is a positive photo resist, this area will actually be stronger or sort of remain intact during the development stage, and if it is a negative photo resist well, actually this part of the area will get washed away during the development stage. So, this is what exactly the role of a mask aligner or the exposure does, we will pick up our discussion from this particular point in the next class, where we talk a little bit in detail about mask aligner and the subsequent processes of photo lithography.