**Integrated Circuits, MOSFETs, OP-Amps and their Applications**

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**Lecture - 10**
**Introduction to fabrication technology Contd.**

Welcome to this module and in this module. We will understand what exactly the photoresists. In last module we have seen how we can use a wafer; and what are the steps to form to perform the photolithography right. We have seen that we can take a wafer and then you have to clean the wafer, after cleaning the wafer you have to perform several steps to finally, obtain the pattern of the photoresist.

What are those steps? If you recall first step is after wafer cleaning you have to dehydrate the wafer; that means, you have to prebake the wafer and then you have to do primer coating primer was HMDS, HMDS right. Then next step is you have to spin code the photoresist, after spin coating photoresist. What is the next step? Soft bake, soft bake is ninety degree one minute on hot play next step is take a mask do the alignment do the exposure, next step is you have to develop the wafer. Next step is develop the wafer with photoresist develop; that means, you are developing the photoresist right next step is you have to do hard bake at 90 degree 1 minute finally, you have to inspect the wafer then inspect the pattern of photoresist on the wafer that, that much we have seen.

Let us see in this class what are the photoresists, what are the photoresist. So, if you come on the screen you can see what are photoresist.

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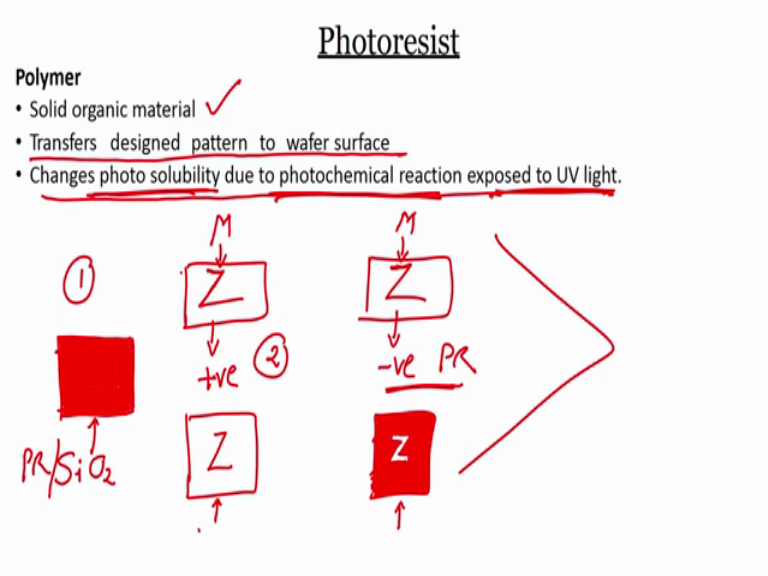


So, photoresist is nothing, but a polymer and it is a solid organic material it is nothing, but a solid organic material. The advantage of this is it can be used to transfer the design pattern to the wafer surface. We will see an example. So, you understand how it is used.

Finally it changes photo solubility due to photochemical reaction exposed to UV light it changes the photo solubility; that means, we have seen that if I have pattern which is Z right I use positive photoresist then on the wafer this area will be protected; that means, the area of which is not exposed, the area of which is not exposed is protected in case of photoresist right. If I use Z and if I use negative photoresist then I will not up then I will have everything except to this area which is Z. So, let me draw like, it is easier for us to understand. Everything except this area, everything except this area which is exposed will be strong and the area which is not exposed will be weak, the area which is not exposed will get weak. You can see here, you can very clearly see what we are getting is absolutely opposite of the positive photoresist right you see here what we are getting right

So, in this case we got this, we got this you see. In this case the area which was exposed right which was exposed photoresist got etched; that means, that if I have this as a mask, this is a mask, this is a mask and I have a wafer and I have a square wafer let us say like this coated with coated with photoresist; I have a square wafer coated with coated with photoresist then if I use positive photoresist and if I use bright field mask if use positive

photoresist and if I use bright field mask then what I will obtain I will obtain the pattern which is on the mask, which is on the mask. So, what I run here I have coated my I have coated my wafer with a positive photoresist this is my wafer silicon wafer or oxidise silicon wafer right on which there is a photoresist correct.

Now, this is my substrate. If I use positive photoresist then if I have mask which looks like this which is Z right then I will retain I will retain the similar pattern. If I use a mask with a negative photoresist then the opposite of that of the mask we will get it; that means, here if in another terms the area which is not exposed you see the area on the Z is not exposed that on exposed area gets stronger. In this case negative photoresist the area which is not exposed this area under Z the area which is not exposed gets weaker that is why you can see that photoresist from the area which was not exposed is etched is removed.

Here you can see that the photoresist under the area which was not exposed is become stronger, photoresist under the area which is not exposed gets stronger in this case photoresist which is the negative photoresist case the photoresist which was not exposed that area gets, it becomes weaker, it becomes weaker right. So, this is the example this is the example of your positive and negative photoresist. This example of your positive and negative photoresist

Now, how this happens how this happens because it changes the photo solubility due to photochemical reaction under the expose of exposure of UV light because this is photosensitive that is why it is called photoresist, photoresist. Now, I shown you by showing an example how you can use a photoresist and if I have a bright field mask what will happen if I have a bright field mask what will happen correct good. Let us go to the next step.

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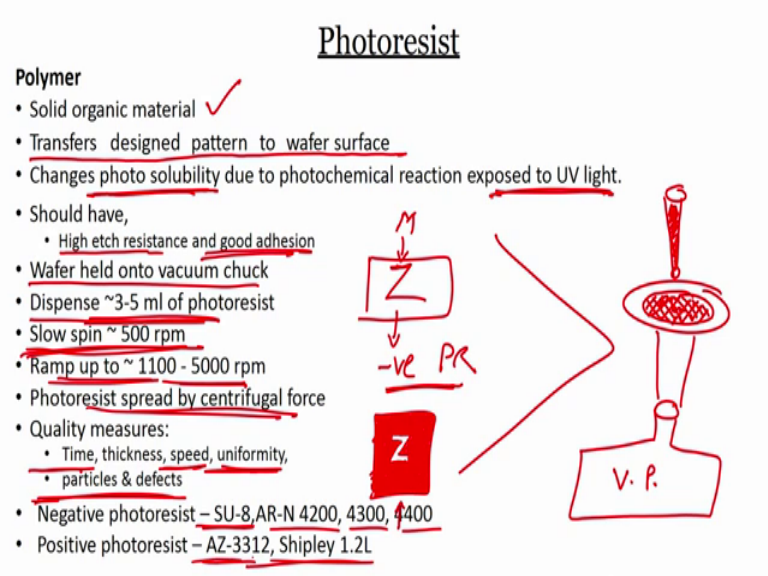


So, next step is after this after this we can what we should do we should. So, how we can coat this photoresistor is a question, how we can coat the photoresist. So, you guys are understand this particular thing right. So, I am removing it. So, that you can see what is written I am removing this schematic. Now you can see.

So, now the photoresist should have high etch resistance and good addition that is the property of photoresist. So, wafer is held on to the vacuum chuck, so that means, there is a vacuum chuck which is connected right to the vacuum pump and here the wafer is hold on this vacuum chuck, this is our wafer, this is our wafer all right. It is hold on the vacuum chuck this vacuum is created by connecting these two a vacuum pump, by connecting it to a vacuum pump all right.

So, then we have to dispense the photoresist we have to coat the photoresist we have to dispense it all right using a dropper, using a dropper we can dispense it right. Dropper is something like this like a fennel and you can you can take the photoresist and you can dispense the photoresist onto this wafer on to this wafer.

So, how much about 3 to 5 ml, then initially to have a uniform coating we will start with the slow spin of 500 at rpm, rpm is rotation per minute. Then we ramp ramp it up to 1000 to 5000 rpm 1100 to 5000 rpm right photoresist is spin coated by a centrifugal force and the quality measure is time. If I increase the time my thickness will decrease if I increase the speed my thickness will decrease how uniform the photoresist is that is another thing,

whether there are particles or defects that is another thing. So, I had to see lot of things when I am coating photoresist. What is the thickness desire? If a thickness is the higher right then I have to spin coated at lower rpm, if a thickness is lower, then I can spin coated at higher rpm. Then if I have a uniform rpm if I increase the time my thickness will decrease if I decrease the time my thickness will increase whether the PR is uniformly coated or not, whether there are particles and defects or not everything we have to take care when we use the photoresist, when we use the photoresist.

So, it is very important step extremely important step and we will see how we can use it. Now, there are several kind of negative photoresist and we heard about SU 8 and then there is a AR-N 4200, 4300, 4400. Positive photoresist from a company Shipley also there is AZ-3312. So, there are several kind of photoresist right.

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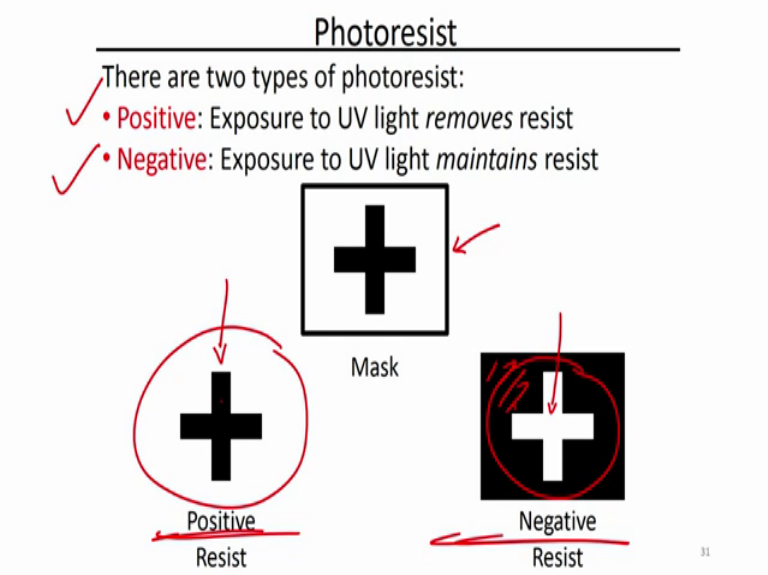


Now, this is the same thing that we have discussed. So, there are two types of photoresist one is positive one is negative. If this is the mask if this is the mask here which is shown for the positive photoresist we will retain the pattern. In negative photoresist opposite of whatever this thing is there will happen; that means, if you consider that this is a mask and the whole wafer was coated with photoresist then only this area was protected; that means, only this area has photoresist. In this case everywhere there is photoresist except this area, except this area. You see absolutely opposite of each other that is why it is

positive that is why this is negative positive and negative all right excellent, easy, super easy.

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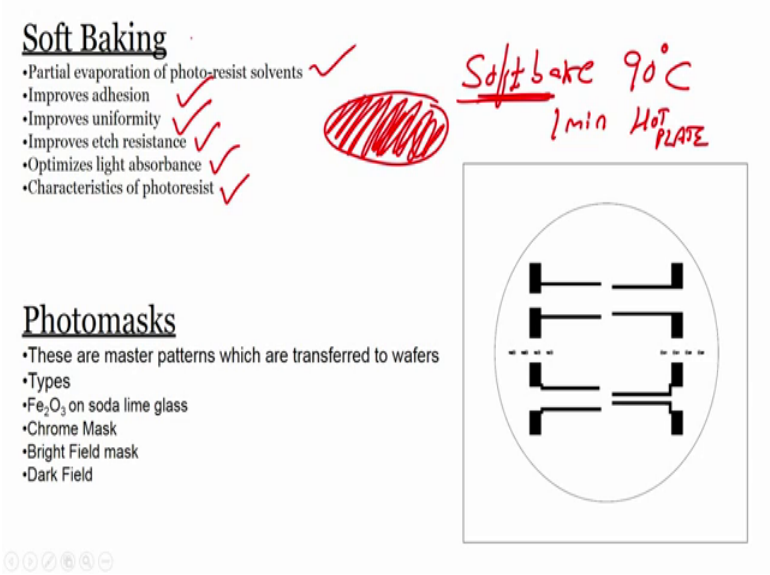


So, let us see what is the advantage of doing soft baking all right. Soft baking soft baking helps for partial evaporation partial evaporation of what photoresist solvents partial evaporation of photoresist solvents. Then second thing is it will improve the adhesion, improve the adhesion that means that once you coat once you coat on the wafer the photoresist right, you have to perform soft baking right, you have to perform soft baking. This is done at 90 degree centigrade for 1 minute on a hot plate right. So, that you can do, that you can do and then this advantage of soft baking is, so that the photoresist or there is a partial evaporation of solvent photoresist solvent will gets evaporated.

Second things it will improve the adhesion, third it will improve the uniformity, fourth this will improve the etch resistance, fifth it will improve optimize light absorbance finally, characteristics of photoresist we can be well defined when we do the soft baking right. 6 points we have to remember.

Let us see once again, let us see once again. First is partial evaporation of photoresist solvents, second is improvement of adhesion, third is improving uniformity, fourth is improve etch resistance, fifth is optimize light absorbance, sixth is characteristics of photoresist is retained right. That is why we use soft baking all right guys.

Now, comes another topic which is mask and we have seen already mask. There are two types of mask right we have seen. One is called bright field mask another one is called dark field mask right.

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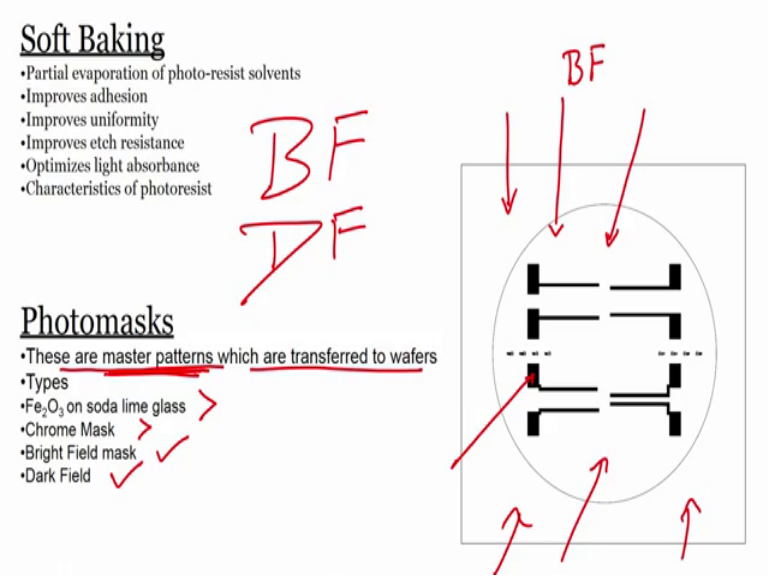


So, these are master patterns which are transferred to the wafers right, whatever there is of the mask we can transfer it onto the wafer that is why these are called master patterns, master patterns right.

Types. How many types of mask? There are two types basically one is Fe 2 O 3 on soda lime, second one is chrome mask, chrome mask. Now, based on the field there is a bright field mask, there is a bright field mask and there is a dark field mask. So, the pattern here the mask here that you are looking at is a bright field mask, is a bright field right you see here the field is bright, here the field is bright, field is bright, everywhere the field is bright except the pattern except the pattern area right except the pattern area that is why it is bright field mask.

So, for now let us understand what we have seen we have seen that, we can perform the photolithography using photoresist and then we have seen the type of photoresist, then we have seen how can we see the or inspect the wafer then we have seen why soft baking can be helpful a and how it is helpful and finally, we have seen what are the photo mask. Now, I have shown you the photo mask bright field mask how it looks like dark field mask how it looks like. So, I am not going to repeat the same thing again and again

because it will get boring right. So, many things if you have already discussed if you go on repeating it becomes boring. So, I will not discuss this thing, but we have seen already what are the bright field mask, what are the dark field mask.

So, now until here it should be clear to you that whenever you have a wafer you have to have photoresist if you want to do, if you want to do a photolithography. If you want to pattern any schematic any design right you need to have a photoresist right. So, if you have oxidise silicon substrate coated with some material if you want to pattern it you need a photoresist, you need a mask, you need a UV exposure 3 things are clear right. How can we use a photoresist? I have shown it to you. What kind of mask are there? I have shown it to you right.

And now we will take an example one more time different example and we will see how can you do a complete process of photolithography all right using a metal. Then we will move to our favourite thing which is our MOSFET. Let us see whether you guys can understand the fabrication of the MOSFET all right.

So, till then you guys again read whatever I have taught in this particular class. You understand how we can use photoresist, what are the types of photoresist, what are the types of mask and how we can use it, what if I use positive photoresist with bright field what will happen, if I use positive photoresist with dark field what will happen, if I use negative photoresist with bright field what will happen, I use negative photoresist with dark field what will happen. So, and what is prebaking, what is soft baking what is hard baking right we have seen this.

So, let us continue our discussion in the next class. Till then you take care, have fun. Bye.