Advanced Neural Science for Engineers
Professor Hardik J. Pandya
Department of Electronic Systems Engineering, Division of EECS
Indian Institute of Science Bangalore

Lecture 21
Soft Lithography – 2

Hello everyone, welcome to this class in this class we will be looking at CVDs which is chemical vapor deposition techniques. And we will also look at how the SU 8 can be used as a mold alternative to silicone.

So if you remember about soft lithography, how we can use PDMS and pattern the PDMS using the silicone mold, the similar PDMS can be used when the mold is fabricated using SU 8. So let us understand the advantages also and difficulty also, both things.

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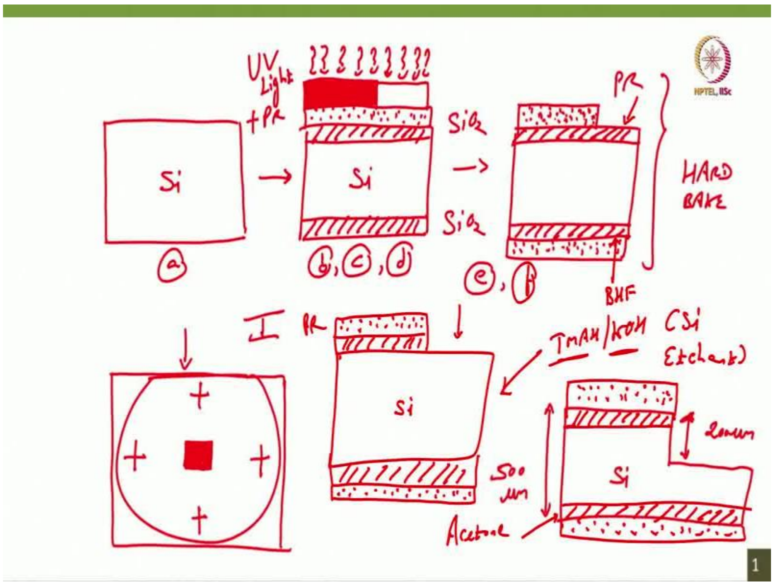
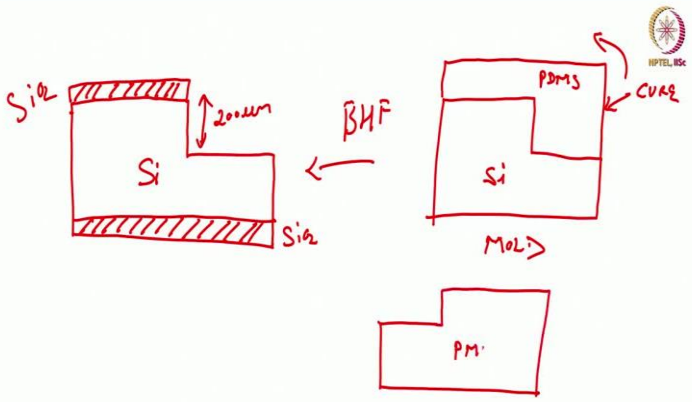
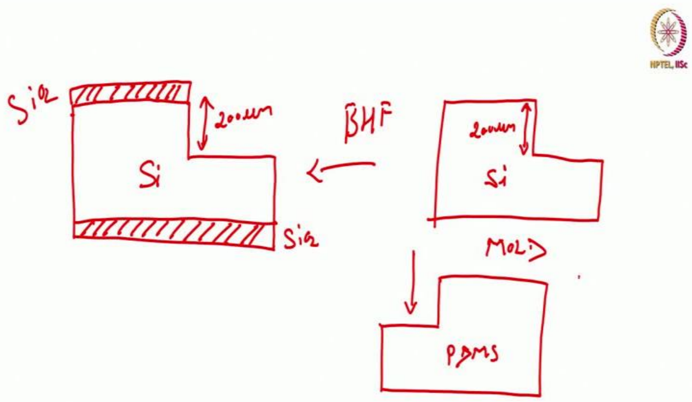



SiO2
200um
Si
SiO2
BHF
PDMS
CURE
Si
MOLD
PM


SiO2
200um
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MOLD
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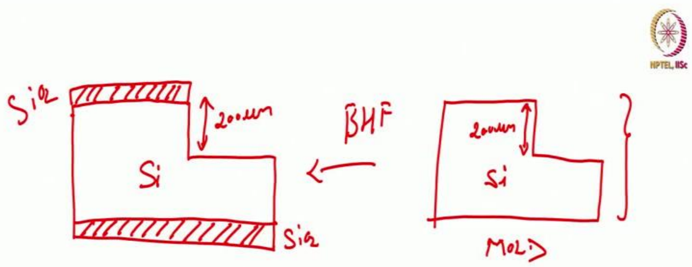
SiO2
200um
Si
SiO2
BHF
200um
Si
MOLD

SU8 = -ve PR

So if you see the screen, if I take a silicon wafer and we want to have a mold which will look like this with depth of 200 microns. This is a silicone mold the silicon wafer thickness is close to 500 microns assuming we are taking a 4 in silicon wafer.

So to create this what we need to do this is silicon wafer we need to create our oxide layer thermal oxidation followed by photolithography that means, we need to spin coat photoresist spin coat the photoresist load the mask and the mask patterns should be such that we can create this step. So we have loaded the mask align the mask you a load about alignment.

When the first time is first time wafer should be in this way it should be in the center of the mask like this and so that the alignment mark on the mask would come on the wafer. And then there can be a pattern like this which we are talking about in the cross section.

So first time we need to align the primary flat with respect to the mask like this. There are different ways also that there are 4 plus so you just making the center of this one and alignment techniques are also there. So once you align the mask next step is the UV exposure or is not it? UV light is there and once you expose the photoresist with UV of course, you do understand. Whenever we sprinkled photoresist after that was the next step.

Next step is always a soft bake and soft bake is that what temperature 95 degrees centigrade for how much minute one minute on what, hot plate. It is oven that temperature remains same that is 95 degrees centigrade, but the time would vary. So after this, if you have exposed the positive photoresist with UV light using the mask that I have shown here, what I am expecting that the unexposed area will be stronger good.

So unexposed area is stronger when I develop this particular photoresist after unloading the mask once you exposure is done. So this is what I have. Then I will perform the hard bake I will perform the hard bake and then dip this wafer. So the another thing that I can do before I dip the wafer into the.

And before performing even hard bake, he said I spin coat the photoresist on the backside of the wafer as well, after the UV exposure is done, and photoresist is developed, I will spin coat the photoresist on the backside of the wafer, and then I will put this together into the hard bake, you got it, what I am saying.

So once you perform this step a then you have oxidized silicone ‘b’ then spin coating and soft back ‘c’ then UV exposure mask alignment and new exposure ‘d’ then you perform the photoresist developing step which is ‘e’. Then after photoresist developing step ‘f’ will be the after you develop the photoresist you have to etch the silicon dioxide. So for etching silicon dioxide, before that what we will do, we will like I said we will have hard bake on both sides.

So the silicon dioxide from the backside is protected when you did the wafer in BHF. So when you do that, the different BHF then the next step that you get is oxidized silicon wafer. Now, oxide is gone only it will stay in this area and it will stay in the back side of the wafer as you can see in this particular image. So this is your silicon dioxide and then the photoresist which was hard bake stays intact photoresist hard bake stays intact.

So now what do we have? We have silicon that is exposed and because silicon dioxide is etched from the region which is not protected by the photoresist. If we did this wafer into TMAH or KOH then silicone these are the silicone etchant. So if the if we dip this different TMAH or KOH silicone will get etch and if silicone gets etch what we will have will have photoresist oxide and silicone etched for 200 microns.

This is what we will have. After this what we will do, we will dip the wafer we will dip this wafer in acetone. If we dip this wafer in acetone, what we will have, we will have photoresist stripped off from the silicon wafer. We have photoresist stripped off from the silicon wafer. Now, if I did this wafer in BHF buffer hydrofluoric acid what will I have? I will have my silicone mold I have my silicone mold.

Now if on this if I spin coat PDMS and cure it what will I have? I will have if I cure it and strip this off strip PDMS off. Then I have PDMS which is pattern says that it has a step of 200 microns because the step that we created in silicon is also 200 micrometers. Once I do this I my BDMS will be gone from here because I have created a step in PDMS as you can see in this schematic.

Now, if I again spin coat PDMS onto the silicon wafer cure it and strip it off then I will have the same image replicated onto PDMS as long as my mold is intact as long as my see silicone mold is intact. This is the way that you can create a mold in silicon wafer, but we are looking at alternative and that is SU 8 and what I said SU 8 is the it works as a negative photoresist. So for that what we need to do so let us see how we can pattern the SU 8?

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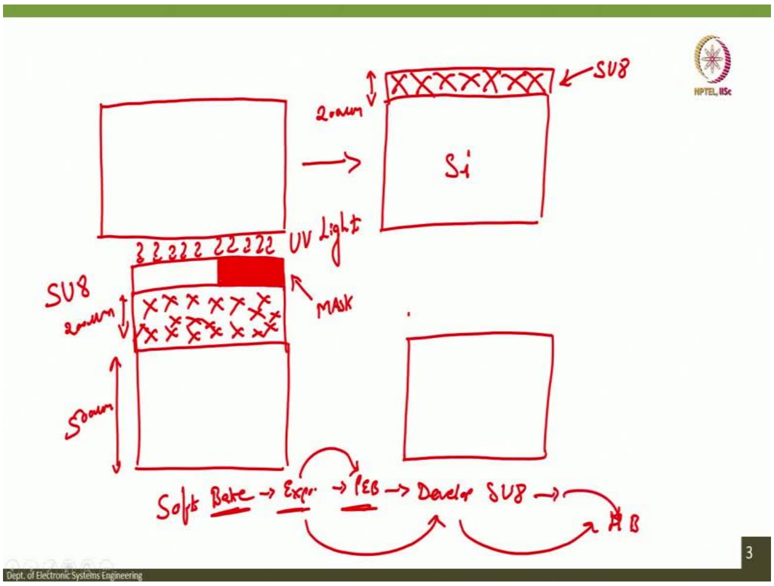
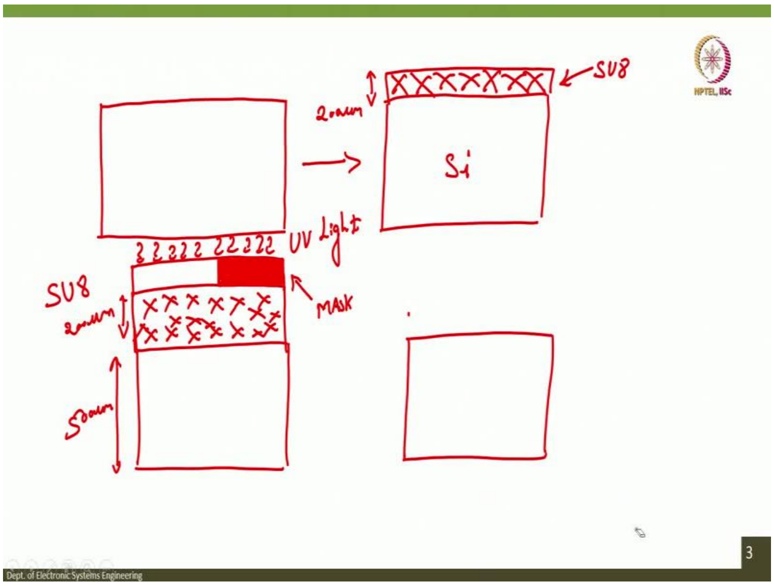

SU8
200um
Si
UV light
SU8
200um
MASK
500um
Soft Bake → Expo. → PEB → Develop SU8 → HB
NPTEL, IISc
Dept. of Electronic Systems Engineering
3


SU8
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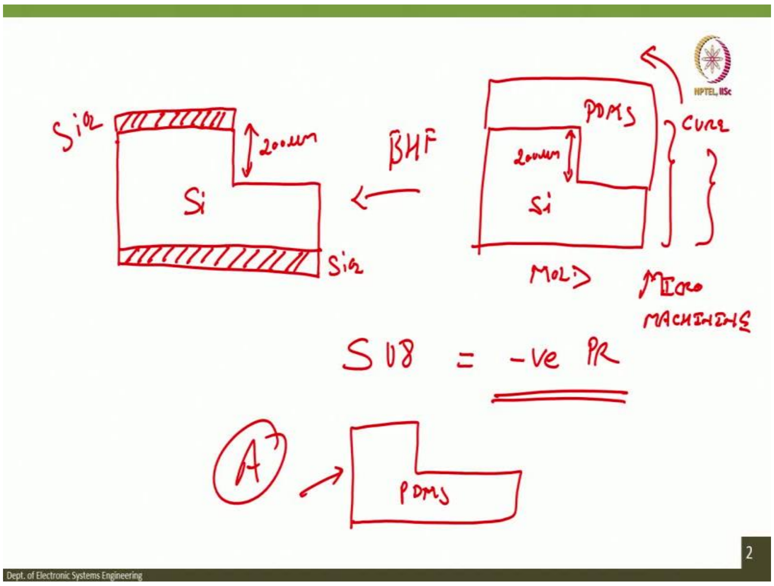
SiO2
200um
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SiO2
BHF
PDMS
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Si
CURE
MOLD
MICRO MACHINING
SU8 = -ve PR
A
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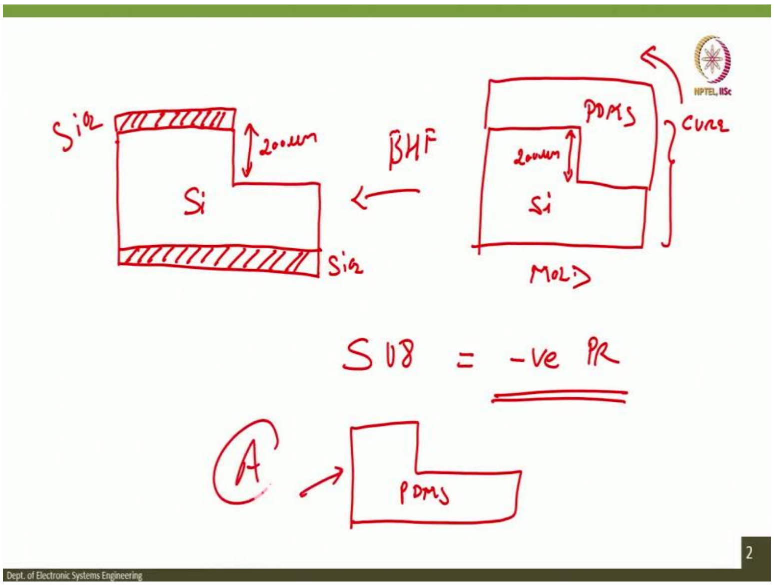

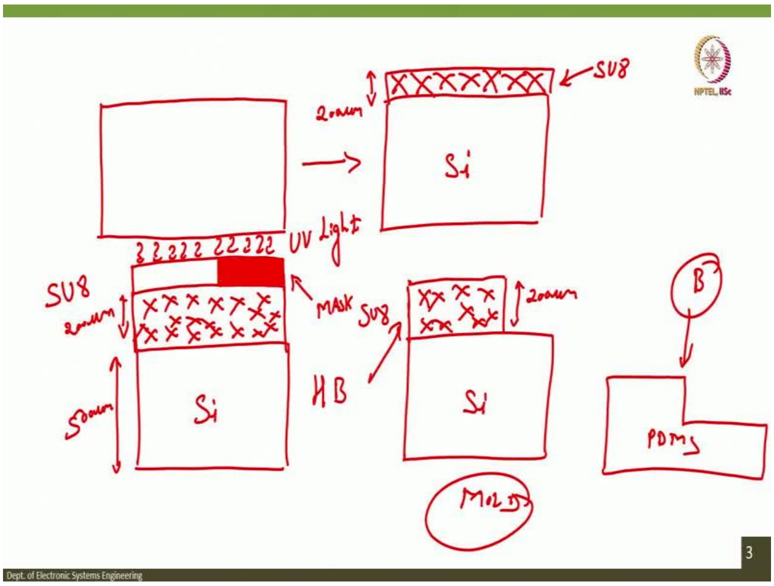

We will see here so you take silicon wafer and you can spin coat SU 8. Let us give some pattern for SU 8. Next is you take a mask you have to do soft bake after performing soft bake of SU 8 and this SU 8 is 200 microns, so let me draw it a little bit thicker because if this is 500 microns silicon is 500 microns by SU 8 200 microns it should look something like this.

Now, for SU 8 of 200 microns I will take a mask and minded SU 8 is a negative photoresist. I will take a mask and expose the area which I want to make strong and the unexposed area will become weaker why because Su 8 x is the negative photoresist so this is my mask. And now I will do the mask alignment followed by the UV light exposure mask followed by UV light exposure. If I do that, what will I have?

I will have a wafer and after this what do you need to do after this you need to first post exposure bake that means you have to do a hard bake. Post exposure make because you have to make sure that soft bake, then exposure, then post exposure bake, then developer.

After post exposure bake the next step is to develop SU 8 this is a little bit of difference between photoresist and SU 8 and after exposure and photoresist you go for developer and then you go for the hard bake. In SU 8 after exposure you go for post exposure bake develop Su 8 and then you go for the hard bake.

So after the exposure you go for post exposure bake followed by developer so followed by developing means I will have SU 8 like this and then I will perform hard bake. Once I do that, I am ready with my mold. Now, this is SU I will spin coat PDMS cure it and strip off. What will I have? I will have PDMS form like this, is not it?

This one, let us say B looks similar to so if I have PDMS here and I strip it off your and strip, strip it off I will have and this is you A. Does A and B looks similar A and B looks similar yes, but both are created one using a silicone etching we call it as micro machining because we have H 200 micron of silicone and then create a mold.

In this case we have performed photolithography and we actually created a SU 8 step same 200 microns. So both ways you can create what we call as a mold.

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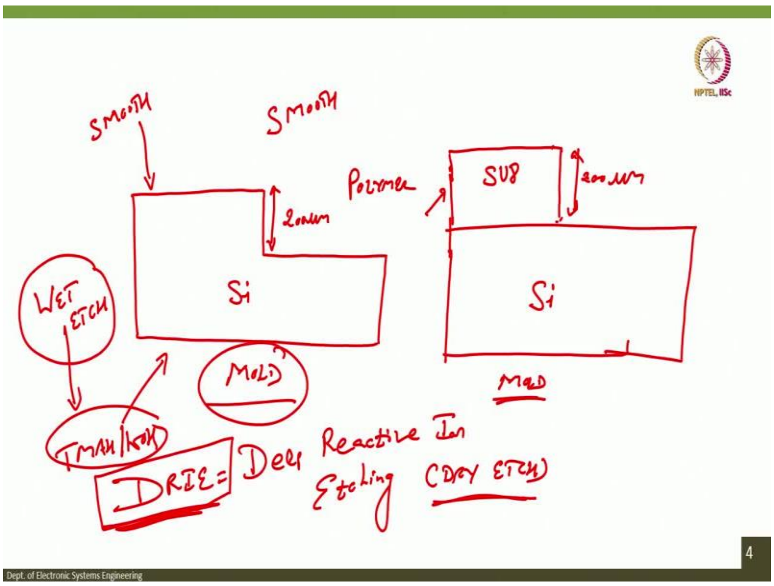

Now, what is the difference between the mold that is created with silicone and mold that is created with SU 8? What is the difference? The rough this area this is in the step is smooth, this region is also smooth. In case of SU 8 it is still a polymer. So this area when you perform SEM image find that it is slightly, slightly curve to like this.

This is a polymer it is a very smooth, but when you zoom in you will fill that the boundaries are not as smooth as what we get in the silicon. The second thing is that the way the silicone mold is created this is a standard photolithography technique where you have exposure you have bulk micromachining and you can create a mold.

This is an alternative way where you do not have so again silicone when you do that so I told you that you can use TMAH or KOH. But alternative technique is go for the DRIE which is called Deep Reactive Ion Etching. The when you do not have DRIE with you see TMAH and KOH are wet etching because there is a chemical involved. While DRIE is a dry etching because only gases are involved.

TMAH tetramethylammonium hydroxide and potassium hydroxide are chemicals that is why we call when we etch silicone wet etch. While deep reactive ion etching using gas we call is the dry etch. So if you if you do not have access to DRIE but you do have access to photolithography system then you can go for the SU 8 mold because here you do not have to etch silicone.

If you have access to the DRIE you should go for the silicone mold. So that is a different that is how the PDMS you know patterns are created. Now with this mold you can create as many patterns in PDMS as much as you want do not worry about my this what you call the exact length of the device and all these things, we can make it like this so that it looks slightly similar to what we are seeing. This is 200 microns, this also 200 microns.

So here we will stop this particular class and now in the next class, we will see the chemical vapor deposition. Chemical vapor deposition like we have seen the physical body portion and if you kind of recall in physical body the vapor deposition at the last section we compared that how what are the advantages of physical vapor deposition, what are the advantages of chemical vapor deposition and what are the limitations of both.

But one thing that we were sure that in chemical vapor deposition the step coverage is excellent. So suppose in this mold you have a step of 200 microns if you want to cover this step with let us say silicone dioxide, and it is easier and it is more uniform, not really easy, but more uniform to go for chemical evaluation, because the step coverage is excellent.

The difficulty with chemical propulsion is that the byproduct other gases so you need to really make sure that these gases are not exposed directly to the environment, but are processed through certain technique. So we will see the types of chemical vapor deposition again just to understand and not go in depth how the reaction occurs and all these things, but there are different techniques, whether it is APCVD, LPCVD PCVD, ALD.

And we will see that one particular CBD which I really like it which is PCBD, we use it exclusively when it comes to fabricating MEMS based sensors, because the insulating material we had to use it and that insulating material we cannot grow using thermal oxidation because, if there is a metal which is below this insulating material and instantly material is grown at 900 to 1100 degrees centigrade, then the metal below it will get affected will get melt in most of the cases.

So we cannot just keep the wafer whether is already a metal or there is another material below it and you want to grow silicon dioxide is not possible because silicon dioxide growth itself required silicon. And in that case, we go for PCVD can be done at very low temperature, so one of my favorite CBDs but we will see when we when we go through that particular class, and then we will take an example as well.

Followed by we will start going into comparing the different bio potentials, where it is ECG or EEG or EMG and then dive into the area of unknown brain and see how we can collect or acquire the signals which are called the neural signals. So till then take care, look into the class. I will see you in the next class. Cheers.