Sensors and Actuators
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Lecture -18

Welcome to this module. In the last module what we discussed is interdigitated electrodes for drug screening. So, let us understand about SU 8. So, SU 8 acts as a negative photoresist.

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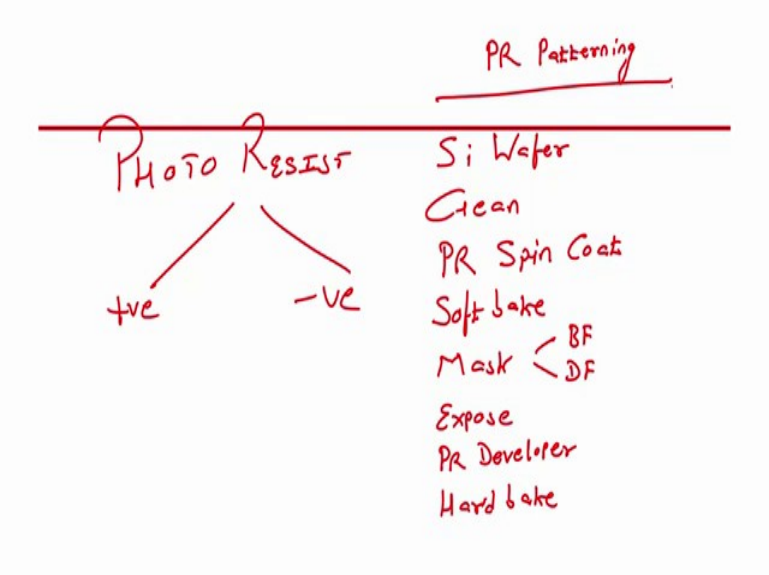

So, if we see the photo lithography technique then how we are using photoresist if you see the screen photoresist this we have already discussed, two types positive negative.

Process flow so, you take a silicon wafer, the first step silicon wafer, second step cleaning, third step photoresist spin coat, next step soft bake, next step mask loading, it can be bright field mask or that dark field mask. Next, is UV exposure, next one photoresist developer, next hard bake. So, this is the photoresist patterning for positive and negative photoresist.

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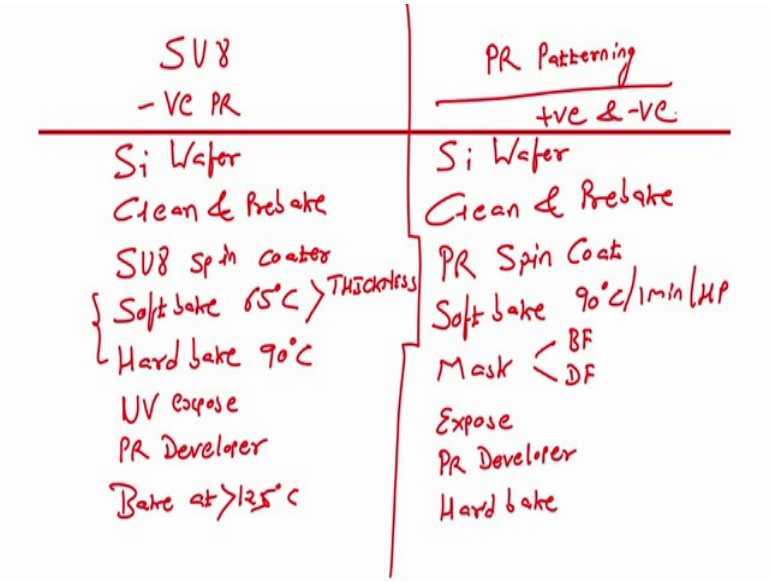

Now, let us see the steps for SU 8 which will act as a negative photoresist or which acts as negative photoresist, this we are talking about SU 8. In SU 8, we will again start with silicon wafer clean the silicon wafer. So, is a clean and pre-bake to remove any moisture content, clean and pre bake. Next step SU 8 coating using spin coater, next step is soft bake. Now, in positive and negative photoresist, soft bake is carried out at 90 degree centigrade, 1 minute on hot plate.

For SU 8 soft bake is done at 65 degree centigrade and the time depends on the thickness of SU 8, the time of baking depends on the thickness of SU 8 after that you perform hard bake, hard bake is generally done at 90 degree centigrade. Again the time depends on the thickness of SU 8 then we go for UV exposure, followed by photoresist developer.

And then to harden it, we can bake at 125 degree centigrade or above. So, what is the difference, if you see difference between positive and negative photoresist patterning and SU 8 patterning.

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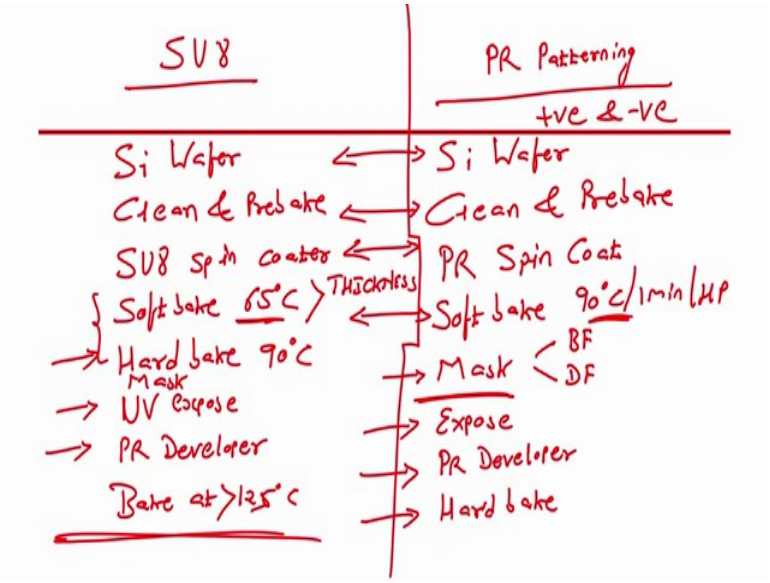

First step is same, SU silicon wafer, second step same clean and pre bake, third step same photoresist spin coating, fourth step same soft bake, but here soft bake is done at 65 degree centigrade and in positive negative photoresist at 90 centigrade, this is for 1 minute on hot plate, in this case SU 8 photoresist the thick this the soft bake temperature is 65 degree centigrade, but the time depends on the thickness of SU 8 material.

Next step in the positive and photoresist is loading of mask, but here after soft bake, the next step is hard bake. So, in SU 8 after soft bake next step is hard bake, but in positive and negative photoresist after soft bake, you have to load the mask, after mask there is an exposure. Here after soft bake hard bake there is exposure, after exposure in positive negative photoresist there is a PR developer and finally, there is a hard bake.

In this case after soft bake, hard bake, mask loading, UV exposure, there is a photoresist developer and finally, you have to bake at 125 degree centigrade.

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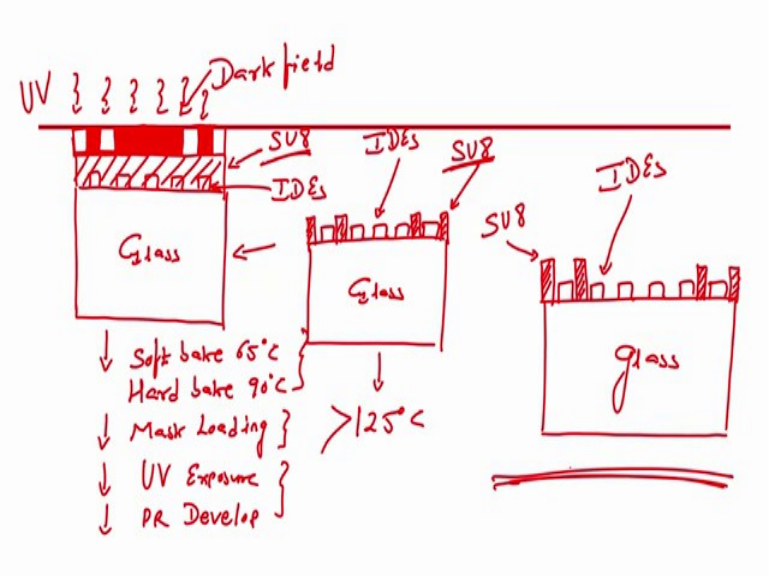

So, if you have an interdigitated electrodes inside SU 8 well so, this one is my SU 8 well the one with pattern interdigitated electors and let us say this is glass substrate. So, in the last module we have seen how to fabricate interdigitated electrodes. In this module let us see how to fabricate SU 8 well. So, these are interdigitated electrodes glass on this we will spin coat SU 8.

So, now, this is SU 8, these are interdigitated electrodes. Next step is soft bake 65 degree centigrade, followed by hard bake 90 centigrade, followed by mask loading, followed by UV exposure.

So, soft bake, hard bake, mask, UV exposure. When I expose this if there is a mask here let me draw it correctly so, soft bake and hard bake is done so, we will load a mask. So, SU 8 is negative photoresist, it will act as a negative photoresist. So, unexposed region would be weaker right unexposed region would be weaker.

So, what we want, we want unexposed region in this particular fashion. So, unexposed region will be in the mask, this is my dark field mask; unexposed region so, if I expose this with UV light then the unexposed region right would be weaker because SU 8 acts as negative photoresist. So, after exposure, I will I feel I will dip this wafer in photoresist developer.

If I dip the wafer in photoresist developer, what will I have, I will have glass, interdigitated electrodes, SU 8, is it correct? No SU 8 pattern in this particular format right because the unexposed region would be weaker see this is this was unexposed region and the contact pads were unexposed region, it got it is weaker then that is why, it is developed in SU 8 developer. After this, I will bake this wafer at 125 degree centigrade or above to harden SU 8 material.

Now, you have SU 8 well integrated with interdigitated electrodes right. So, this is a sensor that you have and you can use this sensor for several applications.

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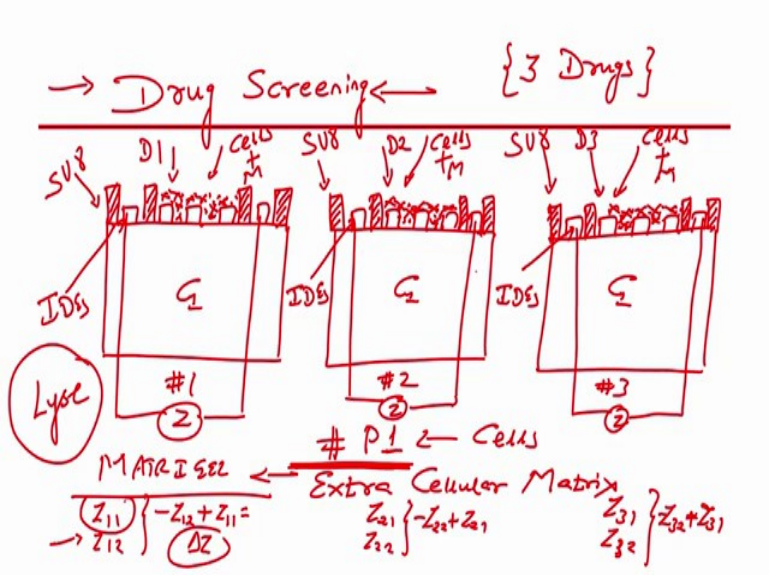

First application that we discussed is drug screening, drug screening. For drug screening, what I will do, I will take let us say there are three drugs, three drugs I will take three sensors. Glass is a substrate, inter digitated electrodes, SU 8 , interdigitated electrodes.

Now, we have three drugs, drugs is antibiotics three drugs, what we will do is if we have sample from patient 1. Let us say we have cells from patient 1, we will load these cells inside this well like this. We will load the cells on all three wells 1, 2, 3 and we will load with matrigel; matrigel acts as an extracellular matrix, matrigel acts as Extra Cellular Matrix ECM.

So, we have cells plus matrigel, here also cells plus matrigel, cells plus matrigel, all three chips we have cells plus matrigel. Now, we will measure the impedance with this what

we will measure; Z impedance, we have contact pads. So, measure impedance, we will have some value of impedance let us say for this one first chip, we have Z 1; Z 11.

Here we have Z 21, here we have Z 31, this is impedance of the chip when there is a when there are cells with matrigel. Now, what do you want to do, we want to test different drugs. So, we will add the drug 1 drug 1 here, we will have drug 2 in second chip, drug 3 in third chip.

So, when we load the drug, we will have a different impedance depending on drug is effective or not. If the drug is effective, cells would die, it is breaking up. Cells would lyse and will have different impedance Z 12, Z 22, Z 32; you can say Z or Z depending on how you pronounce it.

Now, we have to see which impedance, how what is the change from Z 12 to Z 11, here we have to see what is the change in impedance value from Z 22 to Z 21, here we have to see Z 32 Z 31. The chip which shows a maximum change in delta Z, the impedance would decrease. The maximum change in delta Z or we can say Z 11 minus Z 12 depending on it, this will be negative value, but the point is there is a maximum change in delta Z, the impedance will decrease this is higher impedance always Z 11 is higher, Z 12 is lower.

So, we can always write like this right, when there is a maximum change in impedance; that means, the conductivity is increasing that chip we can consider that the drug is more effective, you understand? If the drug is effective, this cells would lyse cells and it will improve or increase the conductivity of the chip.

So, the chip which shows the maximum change in the conductivity or there is a decrease in impedance, that chip the drug that we used on that chip is effective for our patient 1. Same thing if your patient second, the drug 1 may not be effective, drug 2 may be effective. For third patient drug 3 may be effective, drug 1 and 2 may not be effective or vice versa, it does not matter.

So, now we have a platform which we can study the effect of different drugs and we can screen different drugs; that means, this platform can be used to measure the efficacy of different drugs and to screen different drugs, it is a patient centric platform as for the

given cells from the patient, we can know out of three drugs which drug is effective by looking at the impedance values.

Thus, we have designed a sensor that can help us to understand the efficacy of the given drug, easy? That is how you can design the sensor using SU 8 material and interdigitated electrodes or using any metal it can be chrome gold, it can be platinum and titanium and you have you can use the silicon as a substrate or you can use a glass as a substrate and then depends only about the electronics part.

Easy? I feel that you all have understood the way of how to use this particular platform for drug screening application. So, we will stop the finish module here and in one of the module, I will also talk about antibiotic susceptibility right material resistance. So, we will see in detail what are the goal standards, what kind of sensors we can design to understand or to capture this bacteria and understand the effect of antibiotics on those bacteria. So, I will stop my lecture now and I will see you in the next module; till then you take care bye.