Fabrication Techniques for Mems-based Sensors: Clinical Perspective
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Lecture -16
Scalable Data Science

Hi, welcome to this particular class. Today, we will learn few examples, how to use photolithography to fabricate a micro heater or presser sensor actually end presser sensor, because I will be teaching you both the things today.

And using this understanding this particular process, you will be able to understand, how we can actually design a process flow for devices that can be used for clinical research such as micro fluidic chip for a pit toxaemic right. Or it can be chip for understanding immunotherapy or it can be a chip to understand antibiotic resistance or it can be a device that can measure the electrical, thermal and mechanical property of a tissue right or it can be a grossing device.

So, lot of examples, but the core lies with micro technology, and a core lies with photolithography right. Now, again in lithography there are x lithography, e-beam lithography, but we are not going into that particular aspect. The idea of this particular course is to understand, how we can use a basic knowledge of micro engineering and applied for a designing different devices, novel devices, for clinical from clinical perspective right.

So, yesterday or I think in the last lecture, what we have learned is how to use positive photoresist, negative photoresist, bright field mask, and dark field mask. And what happens, when we use positive photoresist; what happens, when we use negative photoresist right?

Just to recall, when we use positive photo resist, and we expose the expose the wafer, then expose the wafer using UV light. rhen the area, which are not exposed in positive photoresist that becomes stronger. In the case of negative photoresist, the area which is not exposed becomes weaker right. And we have seen an example.

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Today, let us see, how we can design a micro heater right a micro heater. So, I will show you a micro heater, which is right now in my hand if you can see, this is a micro heater right. And yeah so this is what we can look at the micro heater. Just to help you out if I put it next to my shirt or let us say like this it is better you see, yeah.

So, these are the coils right. Here are the coils on the micro heater, here are two contact pairs; here are two contact pairs ok. So, if you see this, so here is a coil of a micro heater. And here there are two contact pairs. So, how can we fabricate this particular micro heater? This is a glass wafer, but you can take example of oxidized silicon wafer as well. So, let us see.

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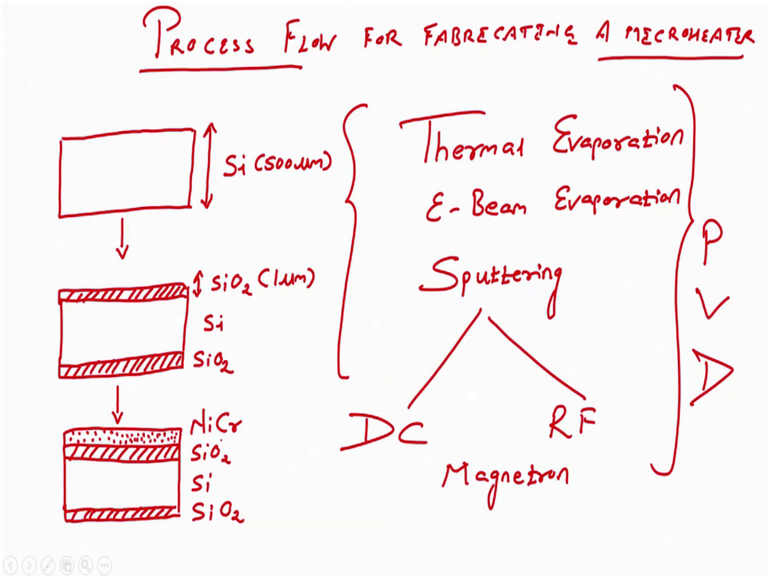

So, let us take an example of a fabricating micro heater on and oxidize silicon wafer. And then, you will also see how we can design a micro heater on a glass all right. So, what we are learning today, we are learning the process flow process flow for fabricating a micro heater process flow for fabricating a micro heater. So, what is this process flow and then a micro heater ok?

So, let us use silicon as a starting wafer or you can say silicon as a substrate, this is silicon. If you want to extremely precise, you can draw like this silicon is 4 inch diameter about 500 microns thick ok. Next step is to grow silicon dioxide. We have learn yesterday right, how to grow silicon dioxide either using wet oxidation or using dry oxidation correct, using wet oxidation or using dry oxidation.

This is Si O 2, silicon, Si O 2. Si O 2 let us say, we have grown 1 micron. And this is using thermal oxidation thermal oxidation ok. What is our next step?Next step would be to deposit material for micro heater right. So, what is that material, we can use nickel, we can use nichrome right, we can use platinum, we can use poly silicon not of materials are available for us to fabricate our micro heater all right.

How we had deposited nichrome either using thermal evaporation or using erbium evaporation right or sputtering. Yesterday or day for yesterday, whenever we have taken a last lecture, what we have learned, how what are physical vapour deposition techniques right.

And in physical vapour deposition techniques, we have learned thermal evaporation thermal evaporation, then electron beam evaporation, and sputtering right. In sputtering, there is a DC sputtering, there is a RF sputtering. Then there is a magnetron, magnetron if you use magnetron, then the heat generated would be less that we have seen that in the last class right.

So, these are all physical vapour deposition. These all techniques are physical vapour deposition PVD right. So, using one of these techniques, we will be depositing nichrome or nichrome on oxidized silicon substrate right oxidized silicon substrate good.

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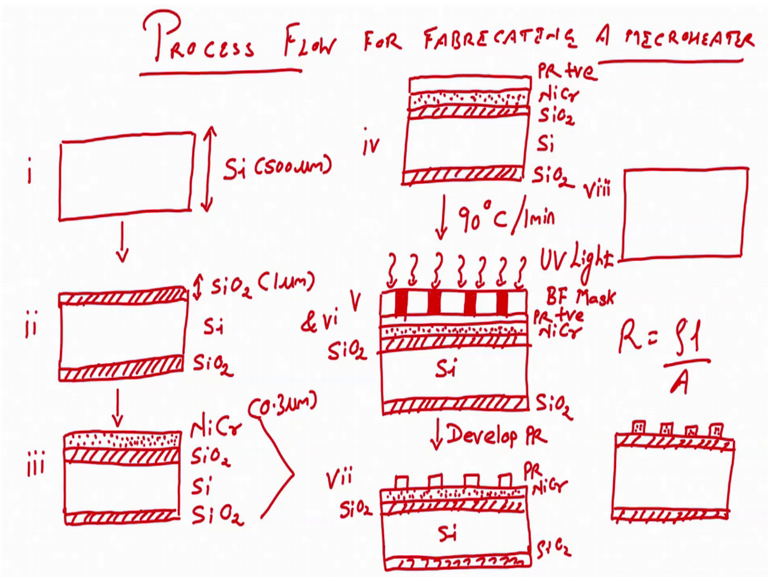

Now, what now we have to pattern we have to pattern this vapour right, this vapour we have to pattern. Why, because what we want, sorry we want to have our micro heater on our oxidized silicon substrate in this particular fashion. This is a cross section correct, this is what we want.

So, after this thing, so let say step number 1, this is step 2, step 3, step 4 would be now will be; step 4 would be to spin coat spin coat photoresist right spin coat photoresist. This is our silicon dioxide, this is silicon, the silicon dioxide, this is nichrome, and these our photoresist. What kind of photoresist, we are using positive photoresist for this particular process.

Next step, there will be step number 5th. So, after use spin coat positive photoresist right, next step would be to prebake the vapour or softbake the vapour at 90 degree centigrade for 1 minute on hot plate right. Now, we you will ask that you know in lithography, we learned that we have to coat a primer before we coat photoresist correct, so that is one way of doing it, we may not use primer, and in that case also we can use the process, that I am showing you right over here ok.

So, not always we have to use primer. Of course, we have primer h m d s you use it, and it will help to have a better sticking of a photoresist, you can see better aeration of photoresist. So, here in this process flow, if you see we have not use primer, but we have spin coated positive photoresist. And then, we have a soft bake it at 90 degree centigrade for 1 minute.

So, our next step would be what is the next step, we have to expose the wafer correct, but for exposing the wafer we have to first load the mask we have to first load mask, load and align the mask. So, this will be our mask. And we are using bright field mask.

Now, we have used positive photoresist and we have used bright field mask. What will happen in this case? This is our bright field mask, this is photoresist, this is nichrome, this is silicon dioxide, this is silicon, this is silicon dioxide. And then, we are exposing our wafer using UV light, so that will be 5th and 6th, process number 5th and process number 6th right.

So, we are using what kind of photoresist, we are using positive photo resist. So, if we are using positive photoresist and if we have expose the wafer, what we are expecting the area, which is not exposed the area which is not exposed, we will get stronger right. The area which is not exposed will get stronger. So, next step would be step number 7, we will develop the wafer. So, develop the wafer means developing photoresist developing photo resist. So, this is what we get this is what we get ok.

Now, now we have to next step step number 8. What we have to do next step? Next step would be to etch nichrome right. So, this is our photoresist. This is nichrome, SiO2, silicon, Si O 2 right. And the nichrome would be about 0.3 microns. We can change the thickness of nichrome depending on what whatever resistance of the heater we desire, because we know the area covered by the heater. We know the length of the heater. So, from that, we know the resistivity of the material.

So, from that, we can calculate the resistance right. Resistance formula is very simple R equals to rho l by A right. If you know the length, if you know the area, and if you know the resistivity of the material, you can calculate your resistance. So, and of course the area is nothing but w into t. So, it depends on thickness as well. So, thickness will change the thickness of nichrome will change the overall the distance of the heater.

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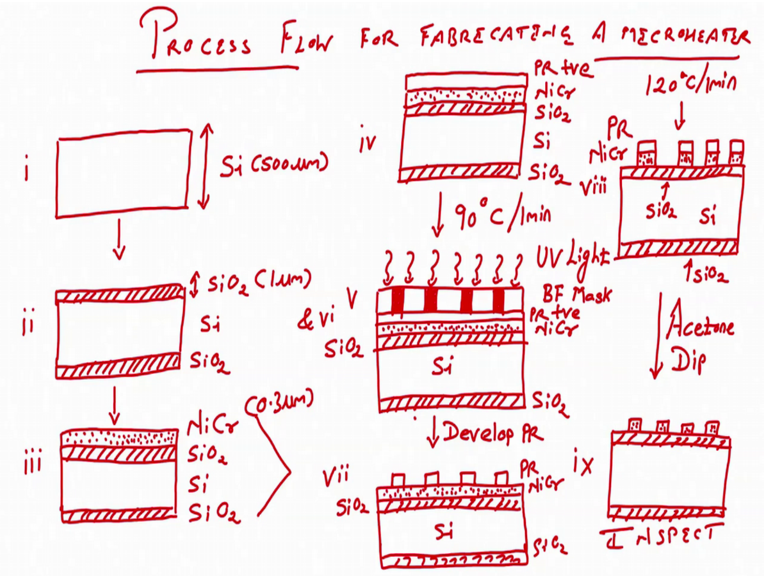

So, now after photoresist developer, developing photoresist next step would be to etch nichrome by dipping the wafer in nichrome etchant right by dipping the wafer in nichrome etchant. So, as you can see the area, which is protected by photoresist the area, which is protected by photoresist, it will not get etched right. The area, which was not protected by photoresist, which is not protected by photoresist will get etched. This is nothing but our silicon dioxide, vaporised silicon, and this is our silicon dioxide, this is photoresist, and this is nichrome right.

Next step, would be acetone dip acetone dip. So, you always have to remember, whenever we perform any chemical etching like for example, photoresist developer. You have to rinse a wafer, and then dry the wafer with nitrogen. Same way for nichrome etching, you have to rinse a wafer with d i and then dry. After nichrome etching is over, we have to rinse a wafer and dry it with nitrogen. After that, we have to perform acetone dip. So, acetone dipping is used, because acetone will be stripping of the photoresist. The photoresist, we have to remove it right, to get what we require, which is our micro heater right.

So, to obtain a micro heater, which is right now in step number 9 right. We need to dip the wafer, which is step number 8 into acetone. Since, acetone will strip up the PR, it will remove the PR ok. So, acetone is a stripping agent or stripper for positive as well as negative photoresist right. Once you get your wafer with micro heater, you have to inspect the wafer inspect inspect the wafer ok. So, this is how you can fabricate or design a process flow for fabricating a micro heater right.

Once again quickly let us see, what we have done. We have a silicon substrate, silicon since it is semiconductor. We need oxide layer, so that the material that we are depositing, which is metal will not get short with semiconductor, that is why, we are growing oxide layer about 1 micron thick using thermal oxidation. You can use wet oxidation in this case.

Since, we do not have to worry about too much worry about the quality of the oxide. After this, you can deposit material, which is nichrome that is used for fabricating micro heater. After nichrome, we have spin coated positive photoresist. And we have performed, soft baking at 90 degree centigrade. After that, we have exposed the wafer by loading the mask right with UV light.

And then, before developing of course there is a strap, which is your hardbake, which is perform at 120 degree centigrade for 1 minute right. So, after exposed sorry after after after UV light exposure, we have to develop the photoresist. After developing the photoresist, you have to perform one hardbake, which is done at 120 degree centigrade for 1 minute ok.

So, do not get confused. Here soft bake after you use spin coat photoresist hardbake, after you develop the photoresist ok. After hard baking, you have to etch the nichrome right, because this PR would be hardened a hardened. And after etching your nichrome, you have to dip the wafer in acetone. So, when you dip the wafer in acetone, you get your micro heater. This is photolithography process that, we have performed to obtain a micro heater that, we have seen at starting of this class, which was on glass.

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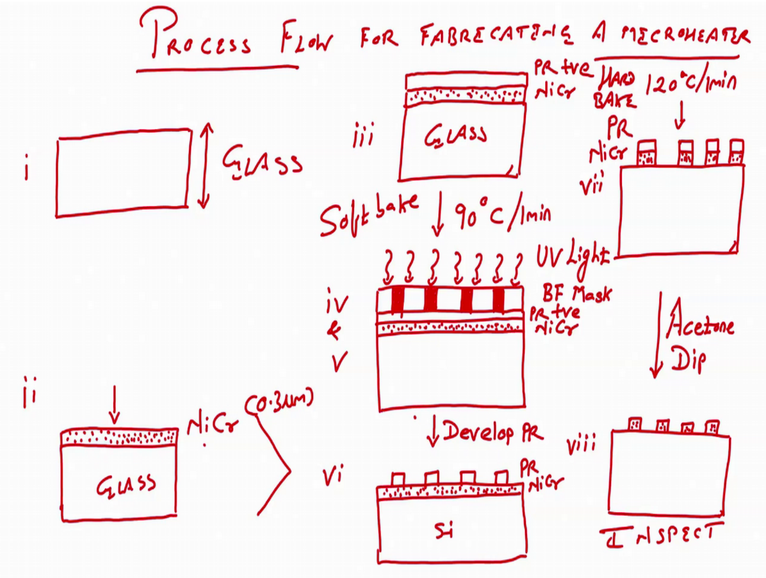

So, now if somebody asks you that instead of silicon, if I give you a glass, what is the process flow instead of silicon? If I give you a glass, what is the process flow right, so it is become so easy. Let us see here, this becomes glass right, on glass so just let me put glass like this.

So, on glass I can directly deposit nichrome correct I can directly deposit nichrome, so my process flow remains same. Just instead of silicon dioxide and silicon, I have to write glass that is it, so easy see right. Let me just write down the glass like a plain glass right, like glass g l a s s glass.

So, here just a number of process would be one step less. So, this will be the 1st step, this will be second step right glass, then you have nichrome deposited on glass using PV D. Then you coat positive photoresist on glass, then you perform softbake at 90 degree centigrade for 1 minute on hot plate. Then you load the mask load the mask and the expose wafer with UV light.

Next step would be develop photoresist. Next step would be you hardbake at one 120 degree right hardbake 120 degree 1 minute. Next step would be to etch nichrome. Next step would be acetone dip to obtain a micro heater on glass correct. What is the difference? What is the difference between silicon dioxide and glass? What is the difference between silicon dioxide and glass? glass is silicon dioxide right.

So, whenever we have to use glass, we do not have to grow silicon dioxide and glass, because glass itself is silicon dioxide right. So, glass is an insulator. So, when we are using glass, we can directly deposit a material on to the glass. So, when you perform this experiment, when you perform this process flow, then you get the device that we have seen in the in the starting of this body like this is a micro heater that you get right. So, this is an example of a micro heater.

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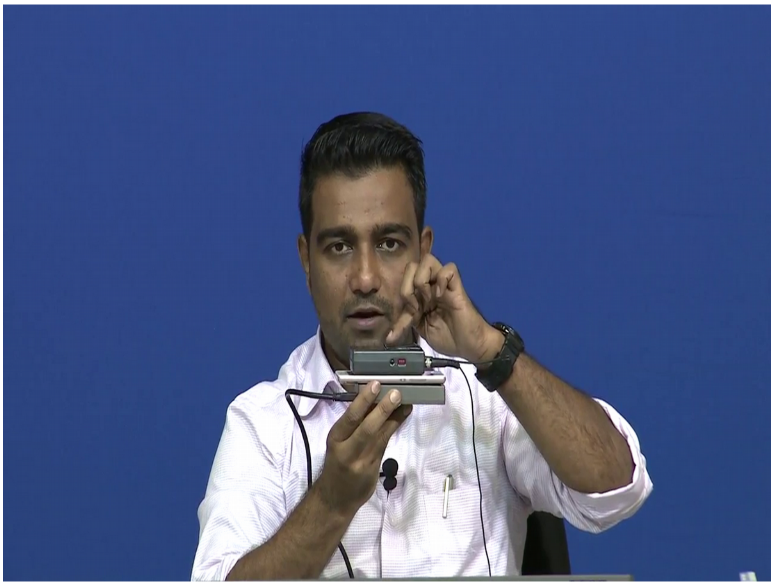

Now, the interesting thing would be what if I have to design an interdigitated electrode on micro heater, what I mean by this right. So, I have my substrate, which is my glass right. And let us say, this is a glass; on this class, I have a heater ok. So, I will take an example of the mobile. Heater on this heater, I want to have another material, which are my interdigitated electrodes right. So, let say this is interdigitated electrode.

Now, can I deposit or can I fabricate interdigitated electrodes over the glass in this fashion, no right, because interdigitated electrodes will get shorted with my heater with my heater. So, what I need a insulating material on the heater on which I can deposit my interdigitated electrodes. So, there will be three mask processes.

Now, you say hardbake, how it is three mask process. We started with the micro heater, and we need a insulator, and we need a interdigitated electrodes, why this three mask process, so we will see, why this three mask process. And how we can use another dark field mask in that that particular case. So, let us see if we want, to have interdigitated electrodes over the micro heater with insulating layer in between.

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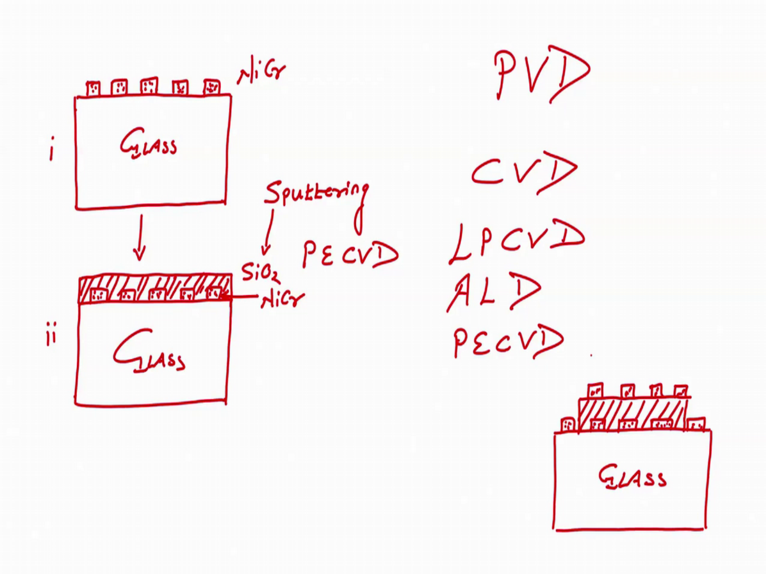

So, let us see on the screen. If that is the case, what we require, I will draw it here, what we require; this is what we require as a final device. We take example, like we have a glass as a substrate right, on the glass, we have micro heater ok. And on the micro heater, let us draw like this. On the micro heater, we want to have an insulating material. On insulating material, we want to have interdigitated electrodes.

So, glass this is our micro heater. This is our insulating layer on; that we have interdigitated electrodes, this is what we want. How can we get this? So, we know how to fabricate a micro heater. So, I am not going to discuss the process flow once again for micro heater. We already have glass with micro heater right, there is our 1st step.

Next step would be to grow insulating material right, to grow insulator on this micro heater. So, we can grow or deposit insulating material on this micro heater ok. So, nichrome and then insulating material on nichrome, how can you deposit insulating material, you can use you can use sputtering ok. There is another process also called PECVD.

We will see, will seen one of the glass plasma enhance chemical vapour deposition until now what we were looking at, we were looking at physical vapour deposition techniques right. There are chemical vapour deposition techniques. And in chemical vapour deposition techniques, chemical vapour deposition techniques there is LPCVD, ALD, PECVD.

LPCVD stands for Low Pressure Chemical Vapour Deposition low pressure chemical vapour deposition. ALD stands for Atomic Layer Deposition, atoms where atoms there are form. Next would be Plasma Enhanced Chemical Vapour Deposition-PECVD right; three different techniques that we will be looking in this particular course right.

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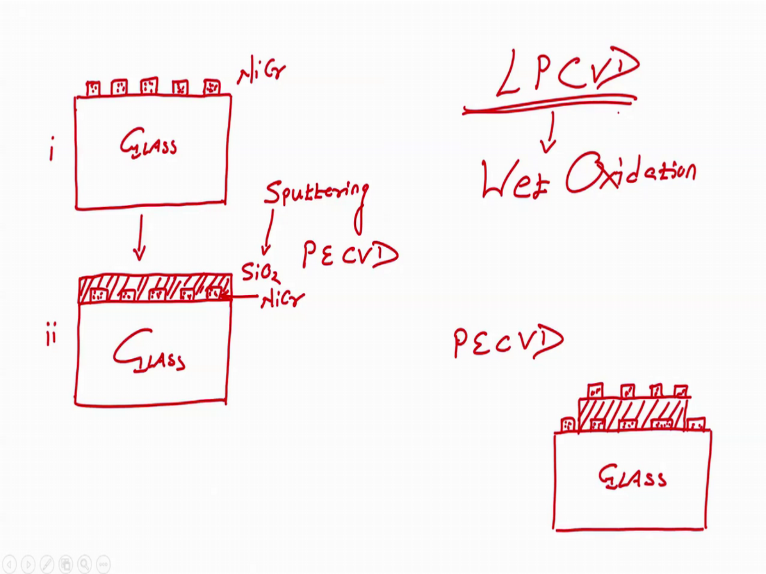

So, to give a one quick example of LPCVD, ee learned, this wet oxidation right.Yesterday or in the last class wet oxidation wet oxidation wet oxidation is one of the technique, that we are using LPCVD form, wet oxidation using wet oxidation uses LPCVD ok.

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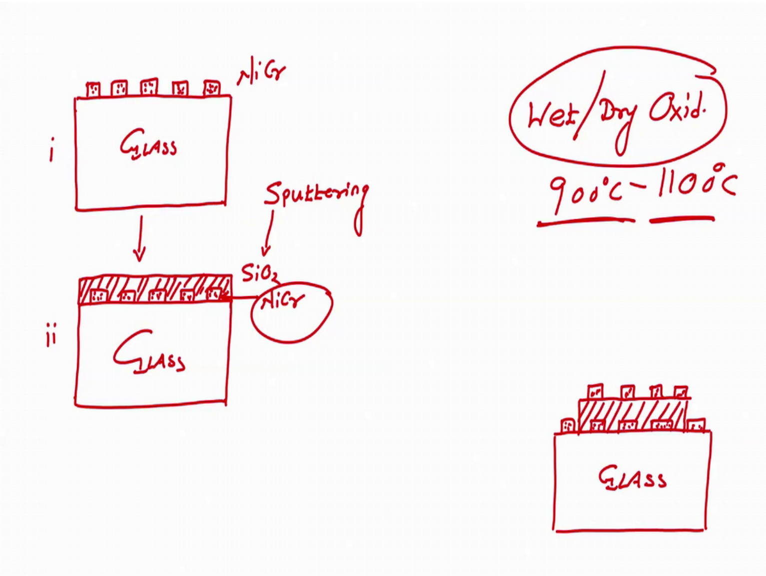

In PECVD so in LPCVD, what was the case LPCVD if you remember, the oxide that is grown like wet oxidation wet or dry oxidation the temperature was 900 degree centigrade to 110 degree centigrade correct 900 degree centigrade to 110 degree centigrade. So, if I use if I use this technique, then my nichrome will get melt nichrome will melt right, because this is extremely high temperature, or so that is why, we cannot use wet or dry oxidation technique to grow silicon dioxide on nichrome.

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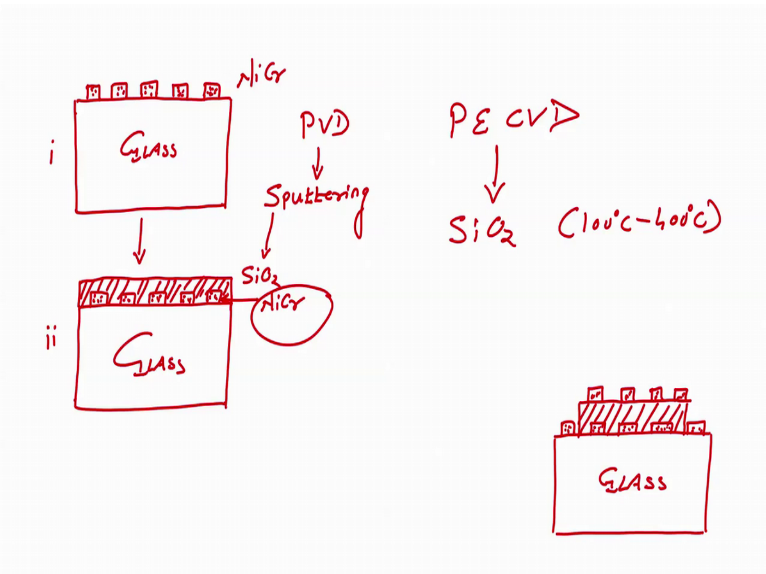

So, what is alternative, alternative is either you go for PVD, which is your sputtering or you go for plasma enhanced chemical vapour deposition. Since, the plasma enhanced chemical vapour deposition; the silicon dioxide can be grown from 100 degree centigrade to 400 degree centigrade. As low as 100 degree centigrade, you can grow silicon dioxide.

Thus you are sure that the micro heater or the heater on the substrate would not get melt, when we are using PECVD that is the beauty of chemical vapour deposition. And that is why we can go for plasma enhanced chemical vapour deposition. You have two options either sputtering or PECVD. Now, once you deposit silicon dioxide, then what will happen? So, you have to understand you have to understand that, whenever you fabricate a heater right.

Let us I I will show you a mask right, you can see very clearly from there also. So, you have this heater, and you have this contact pairs correct, you have a contact pairs. Now, if I put insulating layer everywhere, then initially let us say, I can measure the resistance of a heater, and it is about 120 ohms.

Now, I am depositing insulating layer all on every on the heater on let us say this is a wafer. This is a wafer, and I am depositing insulating layer on this wafer. Now, if I want to measure resistance of the heater, can I measure resistance no, because there is a insulating layer on this contact pairs right. So, I cannot measure the resistance of the heater, since I have a insulating layer on this contact pair.

So, what have to do? I have to remove insulting layer only from this contact pairs right. My my idea is my idea is that I should have a heater on the substrate on which there is a insulating layer on which there are interdigitated electrodes. But, if I do not remove insulating layer from the contacts, then I cannot access my heater. Then my process of fabricating heater will become useless, I cannot use heater.

So, what needs to be done to take out or open the window right, so that I can access the contact region. You have to remove silicon dioxide, how can you remove silicon dioxide by performing photolithography right. So, if you see the screen, what we have, we have silicon dioxide we have silicon dioxide.

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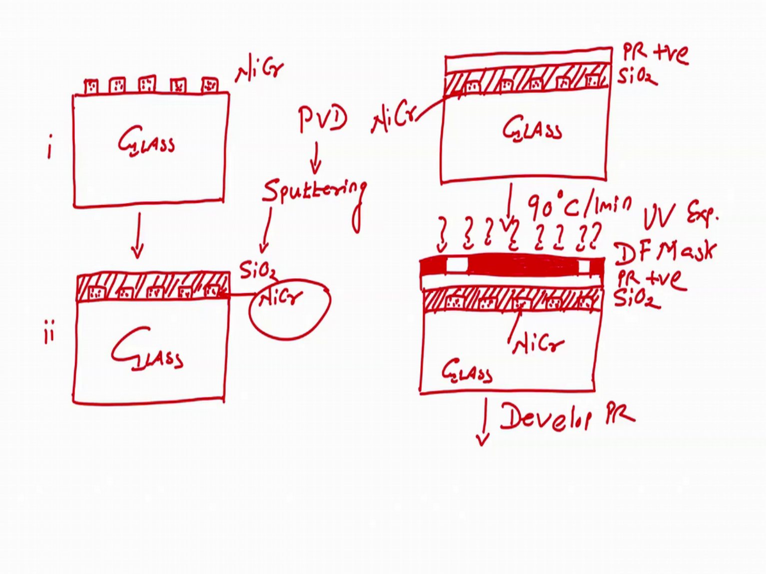

So, next step would be next step would be to spin coat photoresist right spin coat photoresist. Why we are using this, to remove the silicon dioxide from the contact area right, you see here ok. So, this is our photoresist, silicon dioxide, nichrome nichrome, glass correct positive photoresist positive photoresist. Now, after this, we know we have to softbake 90 degree 1 minute hot plate.

Next step, what will next step next step would be load the mask right mask. We have to protect silicon dioxide from all the area except except contact region of the micro heater correct except contact region of the micro heater right. What we are done, we have used dark field mask dark field mark. This is photoresist positive, silicon dioxide, nichrome, and glass right. And what we are doing, we are just creating a window, so that we can access micro heater contacts.

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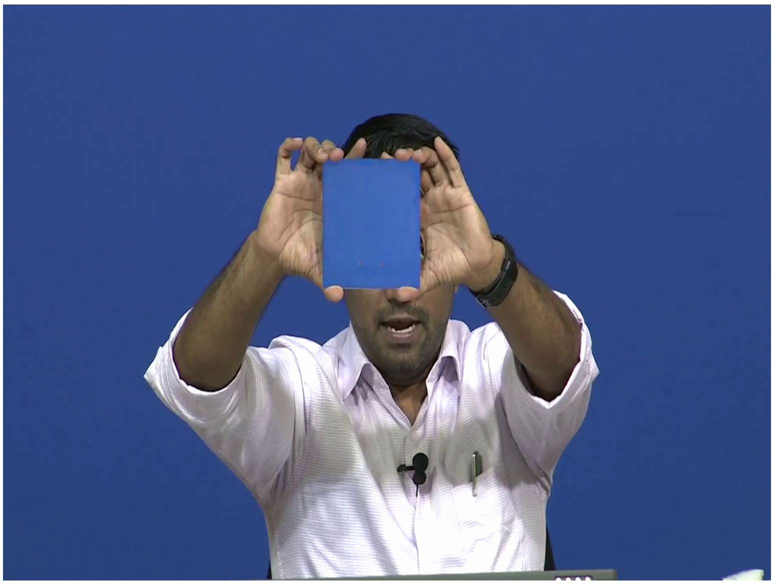

So, how dark field mask work, and dark field mask we can use, you can see here this is dark field mask right. And you can see here, contacts right. Earlier, we have a micro heater on which there is on which there is insulating layer right. This is a micro heater on which there is insulating layer.

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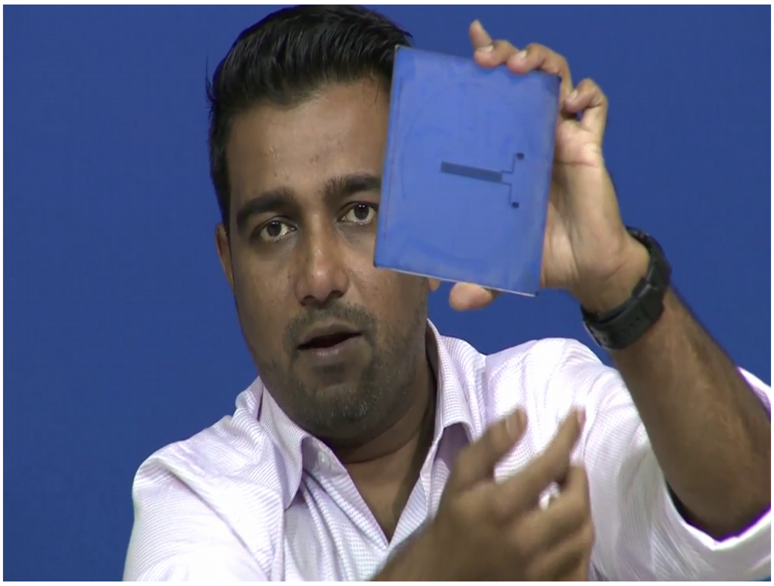

Now, if I align this mask with my previous wafer, you can see here that exactly where my micro heater contacts were there micro heater contacts were there right. I have opening I have opening through what, I have opening through my dark field mask I have opening through my dark field mask, you can see very clearly here right.

So, the advantage of using dark field mask is now very clear in this particular example. If I have a micro heater if I have a micro heater, then I had to have a dark field mask, so that I can etch, I can remove the contact silicon dioxide from the contact pairs of the micro heater, you got it. So, now I am using I am using dark field mask I am using dark field mask to etch out silicon dioxide from the contact region of this micro heater ok.

So, now if you come back to the screen, what we see, that we have a dark field mask, see the screen, we have dark field mask. And now, we have to perform UV exposure correct U V exposure. After you perform UV exposure, what will happen, UV exposure you have to develop photoresist, you have to develop photoresist um.

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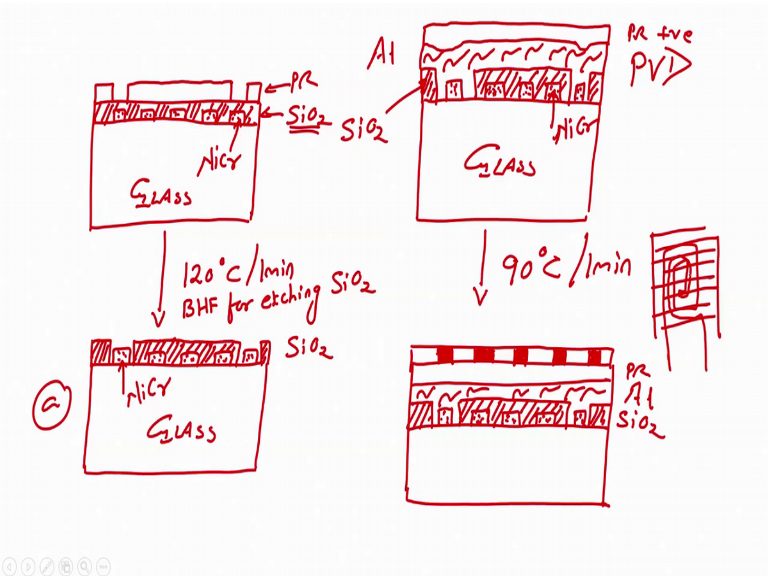

So, when you develop photoresist, you will get glass, heater, photoresist, nichrome, photoresist, silicon dioxide, glass right. After you perform, this development stage or developing photoresist and unload the mask, you will have this particular pattern.

Now, you go for hardbake 120 degree centigrade 1 minute. And then, you etch silicon oxide etch silicon dioxide see what happened the area, which was not exposed in positive photoresist that area got stronger. And that is why, the photoresist stays in that area the area, which was exposed in UV light got weaker right. And this is dark field mask, as we have seen.

Now, you perform hardbake, and you have to etch silicon dioxide. For etching silicon dioxide, what you have to use, you have to use buffer hydrofluoric acid BHF for etching silicon dioxide. So, we have now SiO2, we have our micro heater, which is made up of nichrome, and we have glass as a substrate, nice good.

Now, next step is to create interdigitated electrodes right. So, on this, what we will do. If I want to create an interdigitated electrodes, using this wafer; what is the next step? Next step would be I will take this wafer. And deposit let say interdigitated electrodes are made up of aluminium ok. I will deposit aluminium, in this area. This is glass.

So, how to deposit aluminium, let say aluminium is like this design. What I have done, over this wafer, so let us say wafer number a. I have I have deposited aluminium using PVD thermal evaporation. We can use thermal evaporation to deposit aluminium on to this wafer ok. What is the next step, what you think, next step would be to spin coat photoresist, spin coat positive photoresist.

What will be the next step, next step would be softbake at 90 degree centigrade for 1 minute soft bake at 90 degree centigrade for 1 minute right. After this, what should be next step, next step would be to load the mask correct load the mask. What kind of mask is this, bright field mask right, because you want to form interdigitated electrodes interdigitated electrodes right.

For people, who do not know, how interdigitated electrodes looks like is very simple. You see, this is called interdigitated electrodes, these are interdigitated. These like digits, which are interlinks, so but not connected ok. Interdigitated electrodes, this is what we are forming on below that; there is a micro heater right. And between interdigitated electrodes, and micro heater, there is a insulating material, which is our silicon dioxide, this is what we are forming ok.

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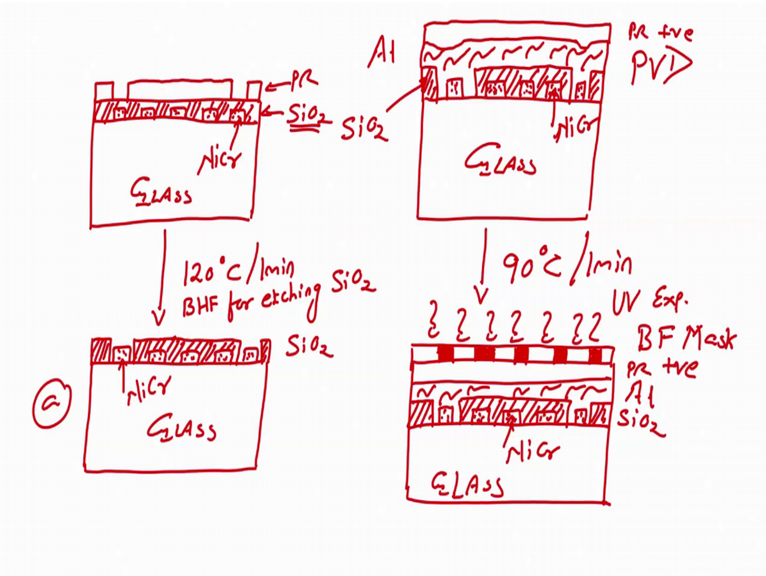

So, now you have bright field mask, that we have loaded positive photoresist, aluminium, silicon dioxide, we have micro heater, and we have your favourite glass substrate, can be your is can be my favourite also does not matter ok. After this, what is the next step next would be next step would be UV exposure next step would be UV exposure.

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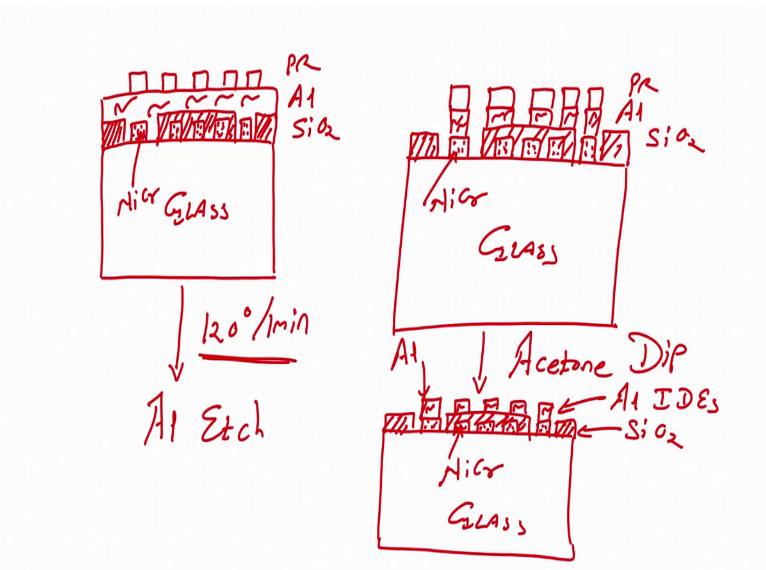

So, when we perform UV exposure, there is a bright field mask, what you will obtain, you will obtain a glass wafer, silicon dioxide, glass, nichrome, aluminium, photoresist, ok.

Next step hardbake 120 degree for 1 minute on hot plate right, hard bake for at 120 degree centigrade for 1 minute on hot plate. So, what is the next, what will I obtain, I will get I will get after 120 degree hot plate hardbake right. What is the next step, next step would be a aluminium etchant aluminium etchant. So, aluminium etchant aluminium etching, what we will have, we will have right, because the photoresist will protect the area protect aluminium, which is below it. So, photoresist will act as a mask for aluminium etching or for aluminium etchant.

Next step would be acetone dip; you are dipping the vapour in acetone. When you dip the wafer in acetone, we get, what we want, and what we want, we want a micro heater we want a micro heater at the bottom over, which there should be insulating material. These are contact pairs on which I am drawing aluminium, this is on micro heater, these are contact pairs.

So, this is, what we got, we got aluminium interdigitated electrodes. We have SiO2, we have nichrome, we have glass. Now, if you see, I have aluminium deposited on contact of micro heater, and that is fine, because we want the contact pair to be as thick as possible as thick as possible. So, if you perform this photolithography, then you obtain this kind of interdigitated electrodes, and and micro heater separated by an insulating material insulating material.

Now, if instead of aluminium right, I use a metal, which is like let us say chrome gold or platinum right or I can use any other material, which is having a semiconductor material, which has a better gauge factor. Then, how can I fabricate a presser sensor. Now, this just a example, how to use photolithography to form interdigitated electrodes right.

But, in case if I want to form a presser sensor, how can I form presser sensor using what you call using the same kind of photolithography, and oxidized silicon substrate oxidized silicon substrate. So, what we have learned is there is a heater, there is a insulating material, and then there is a interdigitated electrodes.

Now, assume that these interdigitated electrodes are formed in the form of first strain gauge first strain gauge right. So, instead of interdigitated electrodes, we have patterned a strain gauge. But, if have a oxidized silicon substrate, how can I use this material as a pressure sensor, you got it. So, because if you see silicon, if you see a silicon wafer silicon wafer is of course thin is thin, but it is very hard is bitter, but hard right it is bitter, but hard.

So, I even I press it, it will not bend. Suppose, I have an interdigitated electrodes on top of this oxidized silicon wafer. If I want to apply a pressure, because let us say not interdigitated electrodes, and let us say strain gauge. If I have a strain gauge on this oxidized silicon wafer, and if I apply a pressure, it has to bend to to get strain, and to get proper results right. So, if there is a piezoresistive sensor on this oxidized silicon wafer, how can I use this sensor as a pressure sensor or a force sensor. It is very simple extremely simple.

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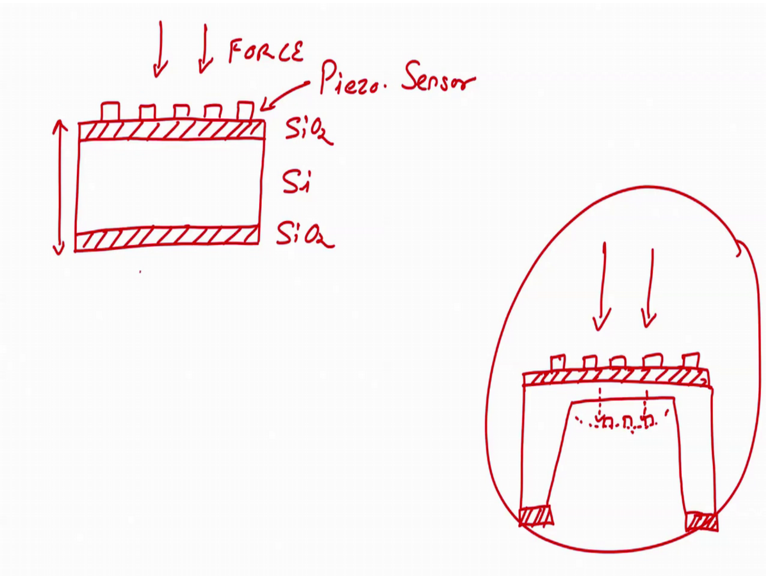

So, let us see how we can use this one for our this particular example. So, if you see the screen, if I have an oxidized silicon substrate, you understand this ok. Now, you guys know how to pattern a micro heater interdigitated electrodes or any pattern any given pattern right. So, we have silicon dioxide, we have silicon, we have silicon dioxide.

Now, what I am saying is if I have a strain gauge strain or let us say piezoresistive sensor is a matter is same thing piezo sensor, and if I apply, let us say a pressure or a force on this chip, because this is hard, it cannot bend. So, what can I do, I should have a piezoresistive sensor a (Refer Time: 61:04) contact with the sensing area contact on diaphragm on a diaphragm.

I can create a diaphragm using photolithography, so that now when I apply a force, this will bend this will bend right on applying force this will bend. So, my piezoresistive sensor would bend. And thus, I will have enough strain, so that I can see the change in resistance. So, how can I how can I obtain this particular device from this one.

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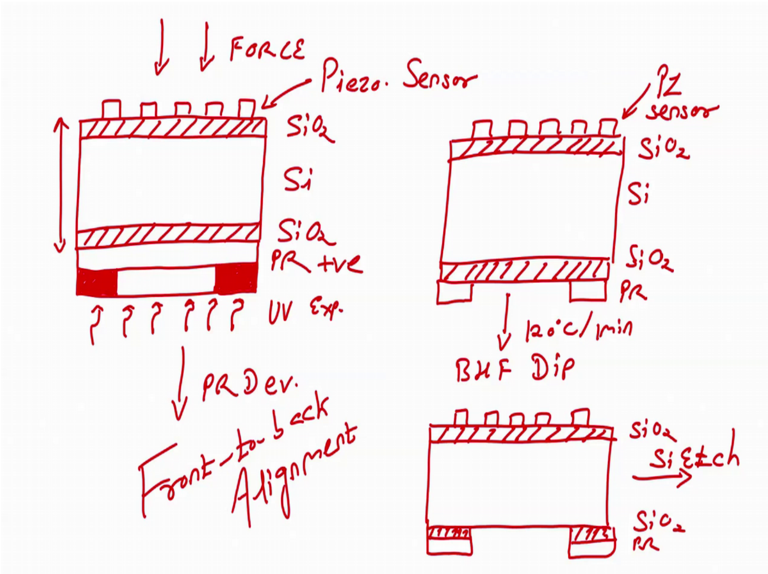

Then for that we have to use photolithography. And if you are seeing the last video in the photo lithography section, you will be able to see how to perform front to back alignment, and get this kind of design. In that case, we have to spin coat photoresist on the backside backside of the vapour right. And then, we perform a photolithography by loading the mask right.

And it can be a bright field mask it can be a bright field mask ok, and then UV exposure. So, whenever I say positive here, it is assume that we after positive PR coating. We are performing soft baking soft baking, load the mask, UV expose. So, what you will have, you will have after UV UV exposure, when you develop the photoresist, you will have oxidized silicon substrate with sensor and photoresist right.

Then what we have to do, we have to of course perform front to back alignment front to back alignment right, so that this is aligned with respect to your area, which you are do have, you want to etch and create a diaphragm. After this next step would be so PR developer, then you have to you will get this, then you of course performed hardbake followed by BHF BHF dip BHF dip will give you what BHF dip will give you this pattern right. The silicon dioxide will get etched from the area which is not protected by photoresist, the area which is not protected by photoresist.

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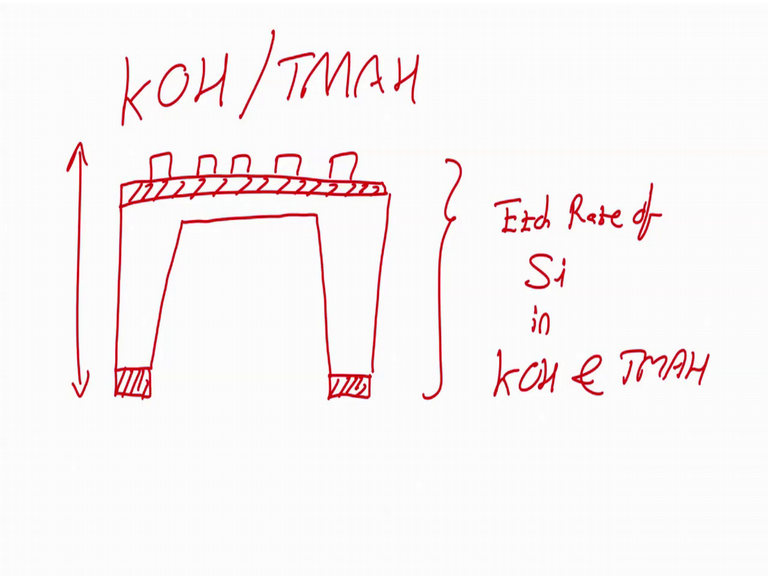

So, what will be the next step, next step would be to etch silicon. So, after this if I keep the wafer in silicon etchant in silicon etchant, what will I have, what are my silicon etchant, my silicon etchant are potassium hydroxide or TMAH right. So, if I did the wafer in silicon etchant, what will I have, I will have.

So, before we dip in the silicon wafer, we can remove the photoresist, because we do not require photo resisters. Silicon dioxide will act as a mask in silicon etchant, so we do not require photoresist. We can dip the wafer in the acetone dip followed by silicon etch. So, you have here silicon dioxide silicon dioxide, and we have silicon dioxide here as well on which we have our sensor right on which you have our sensor right. And we have to control the etching, so that it will not completely etch the wafer right, depending on what kind of diaphragm how much is the thickness of diaphragm, we have to etch stop the wafer.

So, in this case, we can stop the etching by if you know the time of etching like what is the etch rate, etching rate of silicon in KOH and TMAH. If you know the etching rate, we know for how much time, we have to dip the wafer to get a particular thickness of the diaphragm, this is your presser sensor, and this is your force sensor and presser sensor so easy. So, easy to fabricate right?

So, in this examples, that I have given to you today in this particular module right, what we have seen, we have seen how to utilize photolithography, how to utilize your micro engineering knowledge to fabricate or to design process flow for fabricating a pressure sensor, for fabricating a micro heater, for fabricating interdigitated electrodes, over micro heater separated by an insulating layer right.

And in that case, if you remember, we are using three masks. first mask for heater, seconnd mask to remove the contact the silicon dioxide from the contact window of the micro heater, and the third mask for interdigitated electrodes right. If you want to create a diaphragm, what techniques you can use. So, the the idea is that if you understand the concept of photolithography, everything becomes very easy in fabricating the device right.

So, learn, understand, any doubts feel free to ask me in forum right. Like I said, I will be there to answer your questions or the teaching assistance would be there to answer your questions, your query would be answered right. It is extremely easy, if you understand photolithography, when you want to fabricate any device.

So, let us see, what kind of devices we will be learning, and what kind of process flow to fabricate those devices we will be learning along with the application of this device right. The main idea is to understand, how to design a device for a particular clinical application right. So, clinical problems are extremely important. And can we solve the existing burning problems in clinical settings.

So, I will see you in the next class till then you take care, bye.