Electronic Systems for Cancer Diagnosis
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Lecture – 19
Fabrication of MEMS-based sensor for electro-mechanical phenotyping of breast cancer

Hi. Welcome to this particular module. And in this module, we will be looking at how can we measure simultaneously electrical and mechanical property of pressed tissue. So, we can say phenotyping of breast tissue. And we in the last few modules we are concentrating on developing our novel platforms or at least novel sensors, right that can be indicated with additive manufacturing that is a 3D printing and a electronic system, so that we can measure the change in the elasticity of the tissue or we can measure the change in the resistance of that issue, right. We have also seen that we can measure the thermal conductivity of the tissue.

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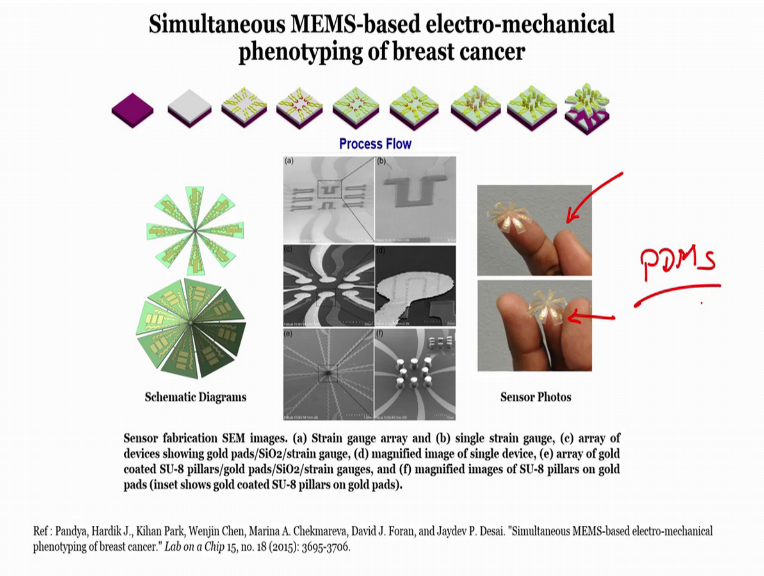

Now, let us focus and see how can we fabricate of a sensor that is integrated with a mechanical sensor or as a sensor that is integrated with two different kind of sensors, one is electrical and second is mechanical. Or in other ways a sensor that can measure a mechanical property in an electrical property of tissue, right. This you can see actual photograph of the fabricated sensor it is a flexible in nature, right. We are fabricating the sensor on a PDMS, this is a silicon PDMS, right.

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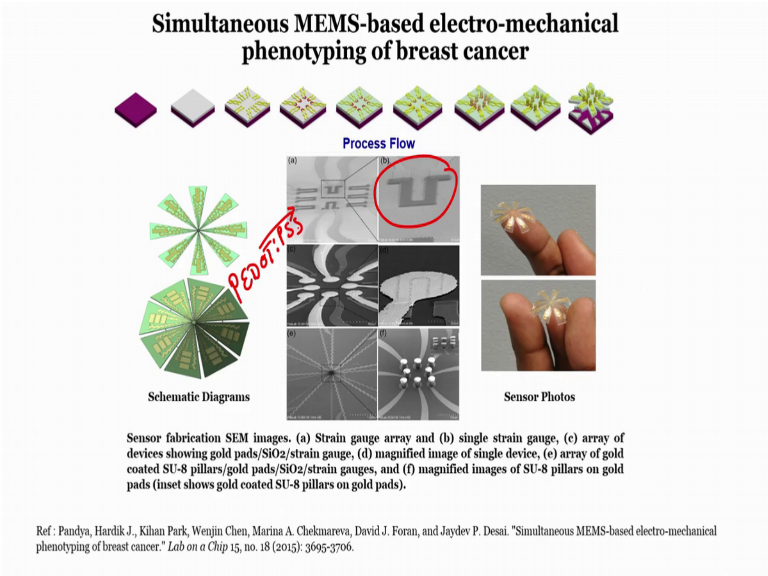

And what we can see here is that sensor consists of a piezoresistor. You can see a these are piezoresistors a magnified version of one single piezoresistor you can see here, right and this piezoresisters or area of this piece of resistors are made up from P dot PSS, P dot PSS, alright. Now, on this piezoresistors we want to have the gold pad.

Now, as you know we cannot have a gold pad or metal directly on semiconductor. So, we need to have an insulator. So, we will have a insulator on this array and on that we will have a gold pad, right. Now, insulator can be silicon nitride, can be silicon dioxide. Now, you can see a magnified image of a single goal pad right over here. These are all SEM image, S E M stands for scanning electron microscopy. Once you have that then on this electrode I want to have pillars and these pillars are my SU-8 pillars, these are my SU-8 pillars.

You can see the SU-8 pillars at over here when you zoom in you can see that SU-8 pillars very clearly and I am quoting this SU-8 pillars with gold when you coat with gold you can see inside showing the SU-8 pillars coated with gold, alright. So, now what will I do if I have a sensor which is flexible in nature and that can help us help us to measurement, help us to measure the mechanical and electrical property of tissue, right.

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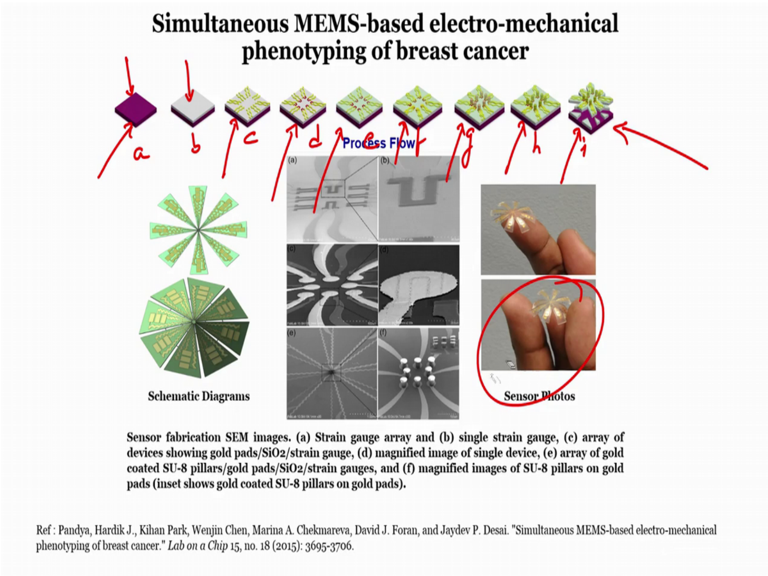

How can I use it? And first of all how can I fabricate it, right. So, you see the fabrication process is shown here from here to here. So, what exactly the fabricant process is all about? a b c d e f g h i, a to i, it is from a to i. So, it is not about abcdefghi, it is about understanding what is the first wafer first wafer is oxidized silicon wafer. Then what is there on a silicon wafer? We have PDMS or oxidized silicon wafer will cure PDMS. What is the next step? We will have chrome gold inter digitated electrodes. What is the next step? We will have P dot PSS spin coated and pattern to form piezoresistors.

What is the next step? We will deposit silicon dioxide on piezoresistors. What is the next step? We will open the contact and we will then deposit gold pad. What is the next step? We will it spin code SU-8 and pattern to form SU-8 pillars. What is the next step? Next step is to make SU-8 pillar conductive by coating it with a metal and finally, you have to release the device you have to strip the PDMS from the oxidized silicon wafer to realize the chip, right or realize the sensor.

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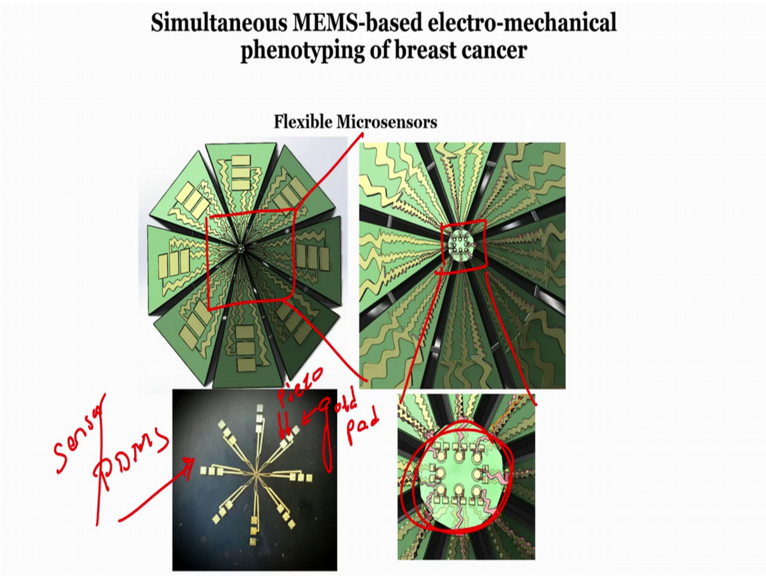

So now, let us see how can we fabricate this, right. Now, you all are I hope expert in fabricating the sensor. Now, if you just zoom in and see these schematics this is the such schematics drawn using software called solid works.

Now, at that time we use solid works and we can see clearly that this is a complete sensor and when you magnify it you can see a piezoresistors whether there are gold pads on this over there were SU-8 pillars which are conductive and you magnify this one as well. So, this is like see this area if I take this area and magnify it further it looks like this. If I take this area and magnify it further it looks like this, right, and this is an actual sensor on PDMS, right which is not stripped off fraud or not a stripped from the oxidized silicon wafer. So, this is PDMS and on PDMS there is a sensor.

So, this tiny part in the center here it is a sensor it consists of all these things, right these are contacts, these are contacts. Now, you can see there are 3 contacts, right 3 contacts or as I say, there are many contacts but 3 contact pads you have 1 2 3 4 5 6 7 8, 8 contacts, so 8 sensors should be there and two are for piezoresistors and one is for gold pad or SU-8 pillar coated with coal pad two alpha P 0 one for coal pad, ok. That is a why we have 3 contact pads in this particular design.

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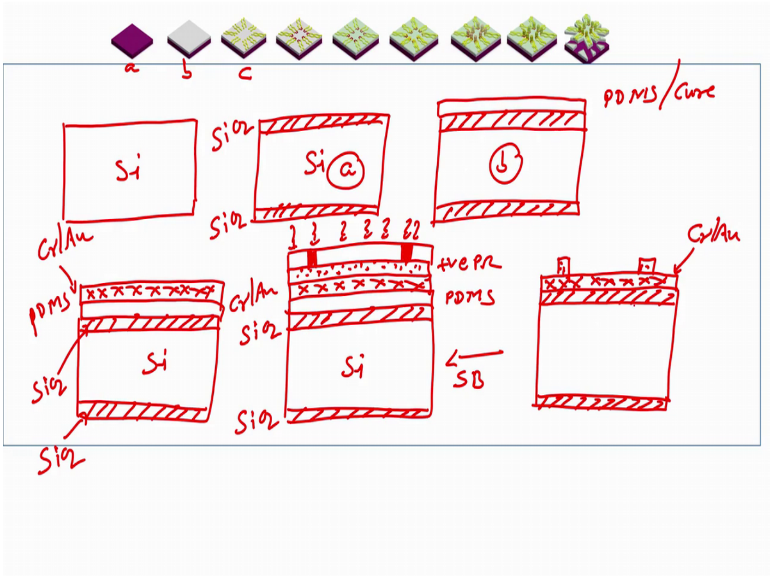

And then if I want to see how is going to work let us see, so oxidize silicon substrate. So, first is we will take a silicon wafer, next step is we will grow silicon dioxide this becomes my a, silicon dioxide. Next step is I will spin coat, I will spin coat PDMS, and cure it; spin coat, PDMS and cure it. This is my b, right.

Next step is I will deposit metal on PDMS, on PDMS and deposit a metal, alright. Next step is I will I have to pattern the metal, right I had to pattern the metal. So, next step would be we take the wafer and we spin coat. We spin coat what? We spin coat photoresist, right. After this what is the next step? Soft baked soft baked. Next step, soft bake next step is mask, right. What kind of mask? What kind of mask? Bright filled mask. Now, you can see only contact area, right.

So, I will just draw two just to make it easier, just draw to bright filled mask to obtain to obtain piezoresistive sensor to obtain piezoresistive sensor, right. So, why only two? Because we have to have these gold pads or contact that can help us to measure the change in the resistance from the piezoresistance. That is what I meant by my earlier sentence to obtain piezoresistance sensor is to understand the change in the piezo resistivity of the sensor with the help of gold pad, these are contact pads, ok. So, this is bright filled mask I will do the lithography, so I will go for the UV, after UV exposure, I will go for photoresist developer. When I developed my photoresist and what will I have? I will have my inter digitized electors, no that is wrong I will have my contact pads, right I will have my contact pads.

So, after this you will (Refer Time: 11:44) lithography what is the next step? Next step is photoresist developer. When you do photoresist developer what will you have? You will have photoresist only in this region, right and this is your chrome gold, right, chrome good. Then I will dip this wafer in chrome and gold etchant after doing hard bake, what will I have? I will have contact area with my photoresist, right.

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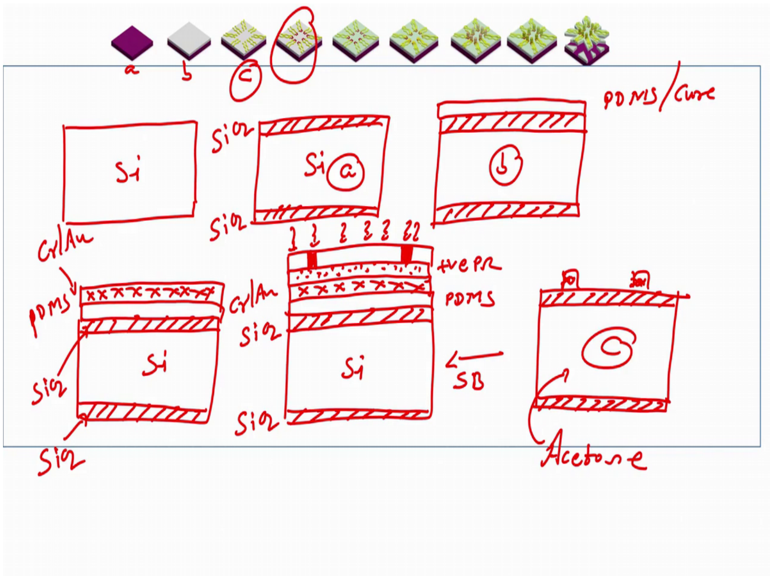

After this I will deposit or I will dip this wafer I will dip this wafer in acetone. When you dip the wafer in acetone, what will happen? My photoresist will be stripped off. When I photoresist will be stripped off what will I have? I will have contact pads, I will have the contact pads, right this is my d, this is my c c, ok. Now, what do we want? We want a piezoresistive materials, right we want a piezoresistive sensor.

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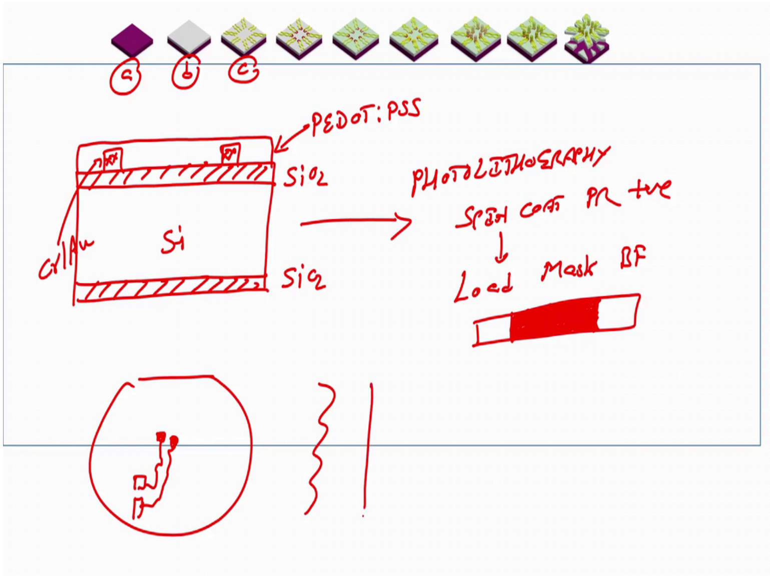

So, a we have seen, b we have seen, c we have seen, now it is time for d. So, we will have oxidized silicon substrate, contact pads, and then we will spin coat we will spin coat P dot PSS. Next step is perform the photolithography, That means, spin coat photoresist then load mask, right. Here we require bright filled mask. I will show you how mass will look like. Mask will look like this, because we want to protect the for the P dot PSS material such that it will pattern we want, if you want to see the top view what we have done until now is we are made this. Now, what we want is a piezoresistive material like this, alright.

So, this guy we have two pattern it, right this is what we are looking at right now, and then now we have only used this much without this like this contact pad, Now, I will show you why we have using this exact pattern like this. This exact pattern to take a contact instead of a straight pattern is to reduce the stress in the film is reduce the stress in the film because it is a flexible material. So, we are using a mask which is a bright filled mask.

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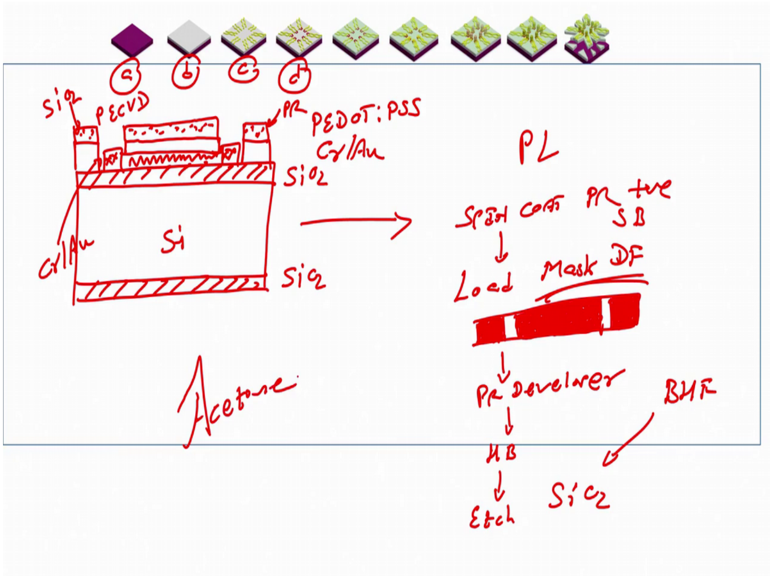

And then after that of course, after spin coating photoresist we have to do soft bake we already know that nor the mask, then do UV exposure, then you do photoresist developer right, photoresist developer, then after photoresist developer you have to do the hard bake and after hard bake you have to etch P dot PSS from the regions which are from the regions which we do not want to protect.

So, if I am etching the P dot PSS from the region which we do not want to protect, right then what will I have? I will have P dot PSS on my electrodes , alright I will have my P dot PSS on the electrode, that is my d, that is d, ok. Now, after this the next step is I want to I want to, so it is like somewhere let me draw like this it becomes a little bit easier to understand, alright. Let me give some design to P dot PSS. So, easy for us to differentiate, right this is P dot PSS, these are my inter digitated (Refer Time: 17:19), these are my contact pads made up of chrome gold, right made up of chrome gold.

Now, on this what we will do? We will we will deposit, we will deposit silicon dioxide using PECVD (Refer Time: 17:43) chemical wafer deposition, ok. And then we will again perform photolithography process, photolithography process where we will spin coat the positive photoresist. Then we will load the mask, this time our mask design would be we will use a dark filled mask, will use a dark filled mask. And why? Because we do not want silicon dioxide on the contact area on the contact area and remaining area remaining area we want silicon dioxide that is on the piezoresistive sensor, we want silicon dioxide from. The remaining area we will etch silicon dioxide that is from the contact pad, right from here and here after this PR developer (Refer Time: 19:02).

So, here it is not a bright fill mask as this will be my dark field mask filled dark pattern is bright, right. Then I had to go for photoresist developer. Again, please look at the slide photoresist developer, then (Refer Time: 19:19), then is this time we have to etch the silicon dioxide. So, for etching silicon dioxide we will use buffer hydrofluoric acid, BHF, alright. So, when I do that what will I have? I will have silicon dioxide with photoresist silicon dioxide with some photoresist.

Now, next step we have to strip out the photoresist. Stripping of the photoresist we have to dip the wafer in the acetone. When we dip this wafer in acetone what you will have? You will have your piezoresistive sensor on which there is an insulator and the contact pads are opened, right that will be my e, that will be my e. You got it.

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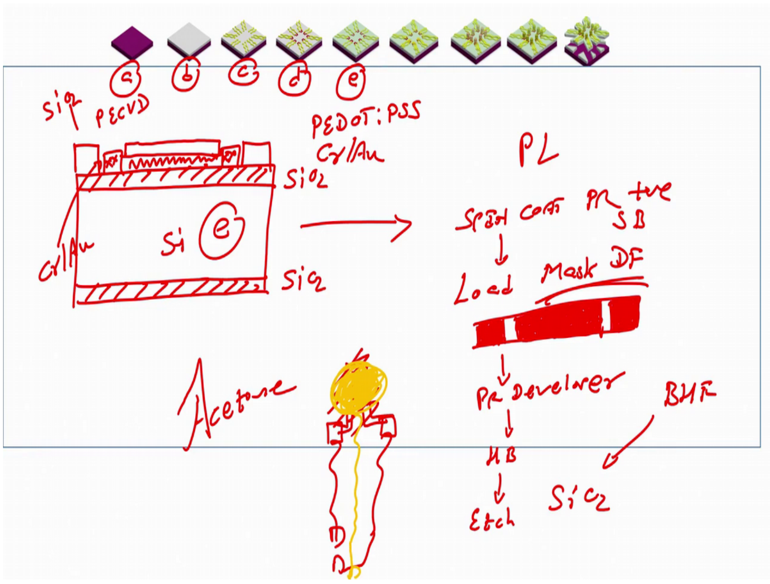

So, in the next module let us see how on this piezoresistive sensor, like you have this piezoresistive sensor, right, like this how on this piezoresistive sensor we will have already insulator is there we will have a gold pad, will have a gold pad. We will see in the next module how can do that to realize the next step for the device.

So, till then, till you just look at this module understand how we are using a PDMS which is a soft material which is the silicone s i l i c o n e to fabricate a flexible sensor, right. What we have seen until now, is you take a silicon wafer then this is our silicon wafer s i l i c o n, silicon wafer, you oxidize it with silicon dioxide, spin coat PDMS, right, cure PDMS, on that you deposit chrome gold, your pattern chrome gold chrome and gold, on that you spin coat P dot PSS which is a piezoresistive material, on that you pattern it using photolithography to form piezoresistive sensors, right over that you deposit silicon dioxide and you (Refer Time: 21:58) contact pads of the piezoresistive sensors.

In the next module, let us see how can you further deposit chrome gold from the gold pad on that how can deposit SU-8 pillar, make it conductive and then we will see how can you install this sensor to understand the change in the tissue property, right. Here with this we can understand simultaneously mechanical and electrical properties of the tissue because there is a piezoresistor and there is a gold pad with SU-8 pillar which acts as a electrical sensors, all in one probe of the electrical sensor, right. Till then you take care. I will see in the next class.

Bye.