Electronic Systems for Cancer Diagnosis
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Lecture – 44
MEMS based Force Sensor for Catheter Contact Force Measurement

So, we have seen now how the experiment can be performed to measure the ECG signal right. Now, so the idea here is that if you know different circuits and if you know how to place them together, you can use this entire unit for as a signal conditioning unit for different applications. One such application we have shown it to you which is ECG, but you can also use it in EEG right. You can because the difference there is that the signals that are at the output are in the micro volts when in ECG the signals were about few millivolts right.

So, it is little bit trickier when we talk about the signal conditioning unit for EEG; however, we will see the EEG platform in one of the cases, but not for this particular; not for this particular course. However, let us see how can you use some, some other electronic system to measure the force sensor, change in force sensor and how can you can display it using controller right on the screen.

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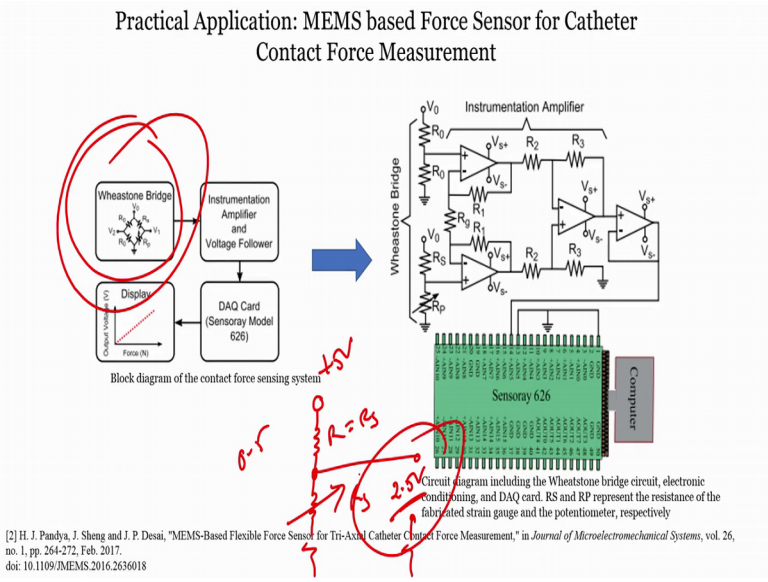

So, the point is if I apply a certain amount of force that force should correspond to that force I want to see on my computer. So, what is the electronic module? So, here you can

see the first thing that we are using is a Wheatstone bridge right. We have seen the advantage of Wheatstone bridge over potential divider if you do not know you can just quickly see that why we are opting for Wheatstone bridge instead of a potential divider or a resistive divider circuits all right. This is a resistive divider circuit. And if I have this resister as sensor resister, this is a fixed resistor, I equals to R s when there is no force applied right.

If I apply 5 volts as a supply, then what is the output? Output starts from 2.5 volts right, output starts from 2.5 volts right. So, now, if I go for Wheatstone bridge, I can use the entire signal from 0 to 5. And here I am limited from 0 to 2.5. Thus the we are Wheatstone bridge over the potential divider or a resistive divider circuit. Now, if I have a sensor that we will show the change in resistance right on applying up force right, then it can work as a force sensor. Now, this force sensor can be a piezoresistive sensor right.

So, let us see that if I have a sensor that changes the resistance how can I and that resistance is because of the force how can I display the force on the computer. So, first block in this particular block diagram for contact force measurement, the first block is of Wheatstone bridge. Then the output is you know connected to the instrument amplifier and voltage follower which is further connected to the data acquisition system. Here we are using sensory model 6 to 6, but you can use another controller as well. And finally, you are displaying the you know output in terms of force versus voltage, you can also show in terms of how what is the value of the force that you are applying on the sensor.

So, we see the block diagram of contact force sensing system and the circuit diagram, this is a circuit diagram right where you can see the instrumentation amplifier. This is a Wheatstone bridge right; this is also Wheatstone bridge and then you are connected is to instrumentation amplifier, now followed by a voltage follower right and this voltage follower is connected to the sensor array and the sensor array is connected to the system. So, the here you can see that the there as R o and R o these are fixed resistors; this RS and RP represents the resistance of the fabricator strain gauge in a potentiometer respectively.

So, in fact, what we can do is? We have to also use this as this particular symbol because resistance would change when you apply given amount of force right. So, this is the this is how this signal conditioning circuit can be used when you want to measure the force,

but let us now see quickly how the piezo resistive sensor will work. Because finally, you are designing a system that can be used for piezo resistivity.

Now, the first question to that comes is why we want to discussed force sensing in the course which is focusing on electronic systems for cancer diagnosis right, because we are interested in understanding the tissue elasticity. And you can understand the tissue elasticity when you apply a certain amount of force and you see how much force is actually translated to the sensor. And based on that you can understand whether the tissue is stiffer or is the less stiffer or more stiffer, so that is the indirectly we are talking about the tissue elasticity right.

So, but how the sensor would work and how can you fabricate the sensor. So, let us quickly see how can we fabricate the sensor and how sensor would work? So, if you see the screen, what I will do is? I will just have two more slides. So, that is the easier for you to understand and I will quickly show it to you how can we fabricate such a force sensor right using a standard lithography technique right and then we will end up this particular module ok.

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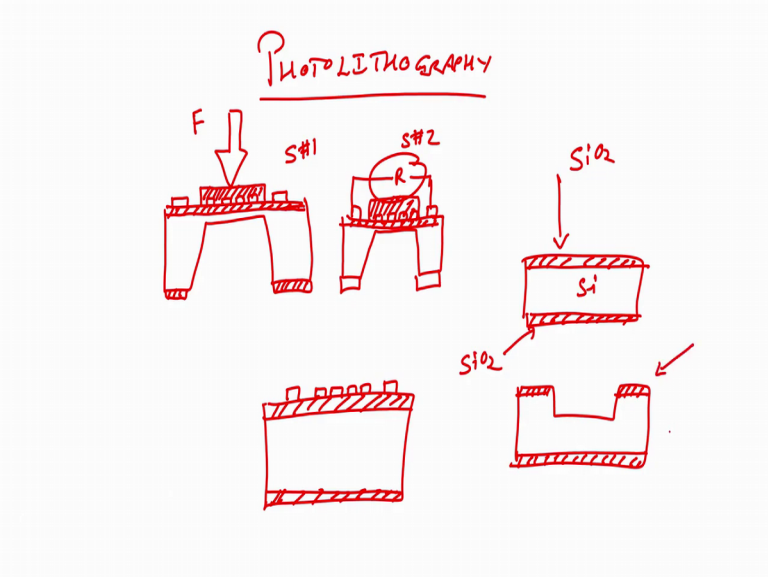

So, let us quickly see photolithography. Photolithography photo litho graphy right. So, we have seen photo lithography techniques right in the earlier modules right. So, I do not want to get into too much detail in this particular module. But using photolithography you know that I can design; I can design a strain gauge right, I can design a strain gauge,

these are the strain gauge, this is the contact pad right. And then you have the PDMS let us say you have bump.

Now, if I apply a force what will happen this diaphragm will bend. So, this will have this effect right. So, this bending because we are applying a force right, this bending causes change in resistance right. This is schematic 1; this is schematic 2. And because of the source there is a bending like this. This bending will cause change in resistance, because there is a strain on this strain gauge. And there is this change in resistance, we can measure with the help of a multi meter as simple as that. We can use a multi meter to see the change in resistance right.

Now, what is this? So, this is I just to this draw oxide right, because we cannot have as metal on semiconductor, we all know right we all know that we cannot have metal on semiconductor. So, now, what will having? We are having a thin layer of oxide to start with. So, the process is like this, there is a silicon wafer, then we grow oxide right which is our silicon dioxide. Then the next step is I am depositing piezoresistive material on this particular oxidized silicon substrate and then I am performing photolithography.

When I perform photolithography, I will have the pattern that I am interested in. After that I will deposit I will take another silicon wafer right, create a well like this right, oxide, oxide a silicon wafer, create a well. Now, I am running faster because I am assuming that now you guys know very well what we are talking in terms of micro fabrication how to create this well it is very easy. Again you open the window, you etch silicon right, open the window etch silicon and you get this mold. What I mean by open the window etch silicon? Suppose this is your Si O 2this is Si this is Si O 2 right.

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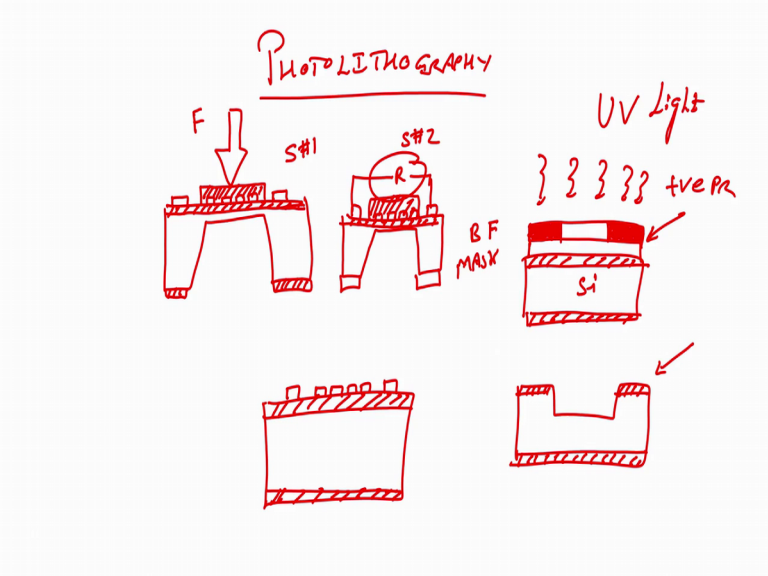

Now, if I want to get this particular pattern what will I do? I will let me go quickly to the steps. First step that I will do is spin code positive photo resist right. Next step is I will perform the soft bake at 90 degree 1 minute. Next step is I will expose the wafer right, I will expose the wafer such that I can create the window on the oxidized silicon substrate. This is my mask, this is what kind of mask is a bright field mask. Bright field mask ok. This is bright field mask, then we will expose the wafer with UV light all right. After that what we will do? We will develop the wafer. When you develop the wafer, what will happen expose the wafer then we will develop the wafer.

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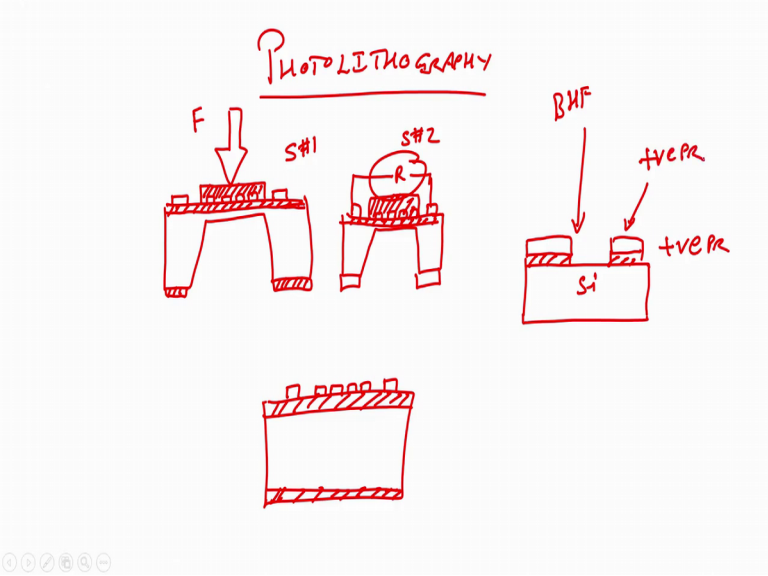

When you develop the wafer, the photoresist is stay in this area right, because this area was not exposed and this is a positive photoresist correct. Now, what we will do? We will dip this wafer in BHF. When we dip this wafer in BHF, what will happen the oxide will get etched right; the oxide will get etched like this correct.

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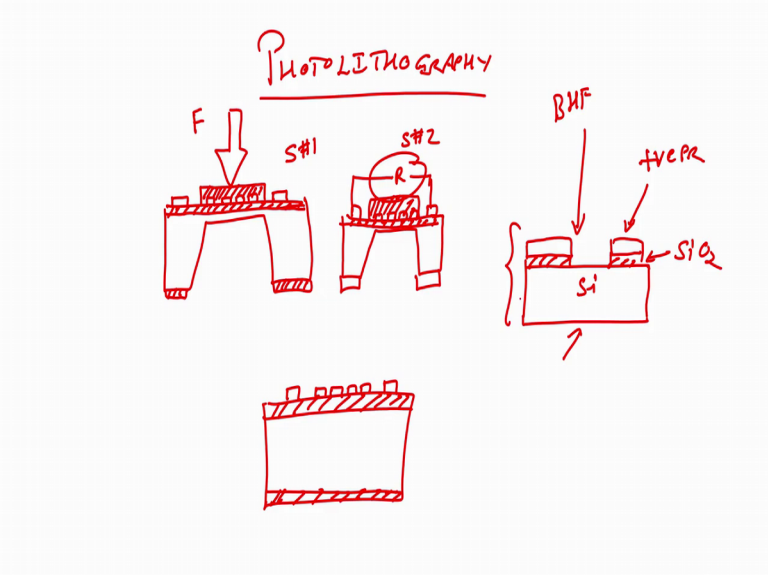

So, what we have here? We have a positive photoresist. And here we have silicon dioxide right. If you observed the oxide from the backside also gets etched because it is not protected with positive photoresist. Next, what we will do? We will now strip off the positive photoresist. Strip off of positive photoresist can be done using acetone said be said we if I dip this wafer; if I dip this wafer in acetone, what will I have? I will have this particular pattern right. Si O 2 will not be affected right. And the photoresist will be stripped off correct.

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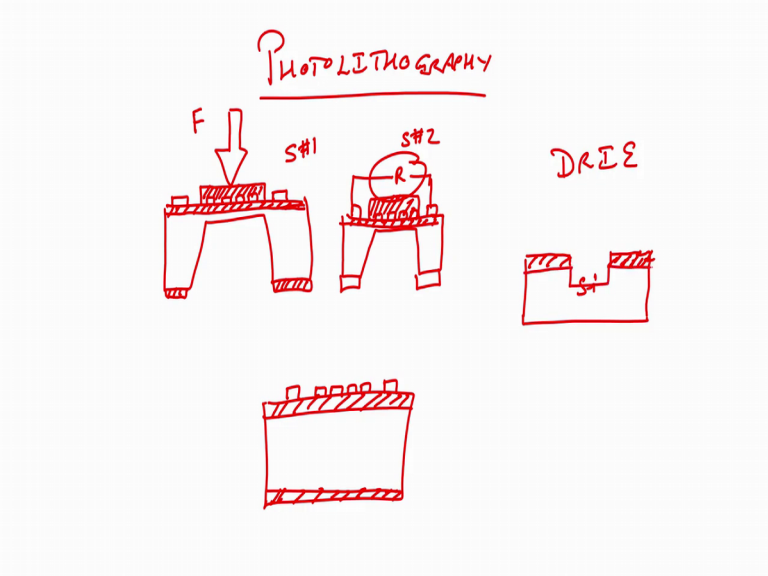

Now, the next step is I will go for DRI Deep Reactive Ion etching. What will happen? It will etch silicon, it will etch silicon and it will give me a step; it will give me a step correct.

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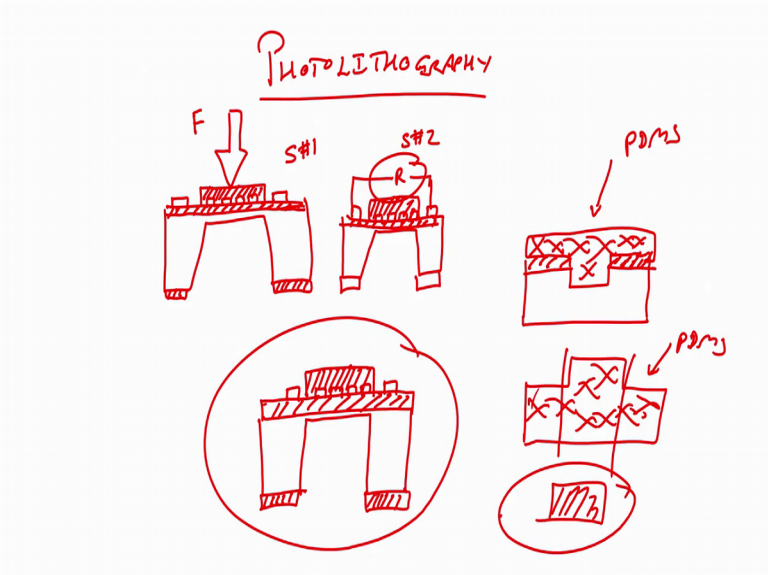

This is what I want; this is what I want, why, because now the next step would be I will pour PDMS and pour PDMS cure it and take it out. So, what will I have? I will have this structure correct, arise the structure. Now, I will cut PDMS from this side. So, what will I

have? I have a bump. This bump I will attach to my piezo resistive material, this bump I will attach to my piezo resistive material.

So, let us say PDMS, let me show you in this particular pattern right this is my PDMS right, this is like mold. So, whatever is there in the mold, the reverse of that will come in the PDMS. You have seen this thing in the micro phonic you know design in the actual experiments that we performed in the lab right. So, it is easy.

So, now, after if I cut it, then it becomes like this particular bump. This I will attach to the strain gauge. And then what I will do? I will open I will do the same lithography and I will open the window from the backside; I will open the window from the backside. What I said mean let me just show it to you, I will have I will remove silicon dioxide from the backside and then I will do DRI right, I will do DRI. And when I perform DRI what will happen my silicon will get etch to get me the piezo resistive sensor.

Now, if I apply force then this diaphragm will bend and depending on the force the there will be change in the resistance in the force resistive sensor. Now, how we are going to understand or use this particular sensor to understand the properties of tissue, so that is the question. So, if you see what we can do? We can plays a tissue on this particular; on this particular sensor let me just quickly remove these things. So, now, our idea is that we place our tissue is from the biopsy right.

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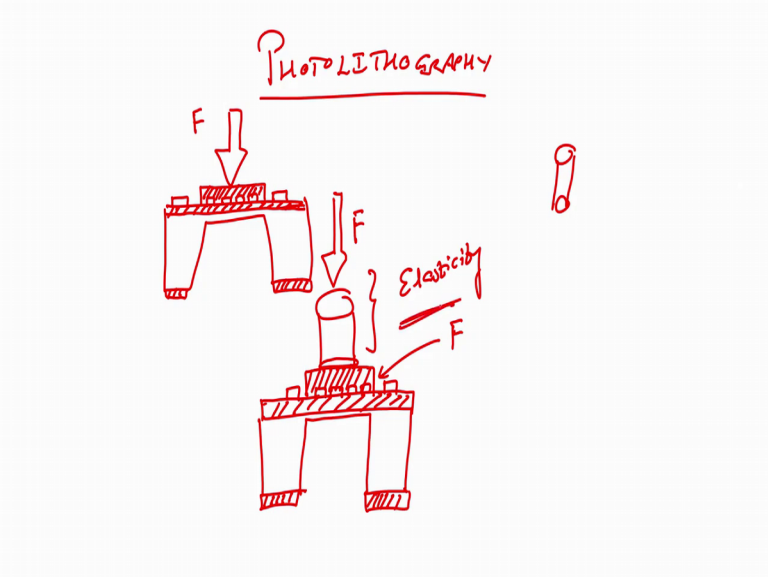

So, it is like a cylinder. If I place a cylinder right on this sensor like this right and now if I apply a force right, so the amount of force that I am applying here and the amount of force that my sensor is able to measure that depends on or the amount of force that I am applying here and amount of force is translated to the sensor that depends on the elasticity of the tissue right, elasticity of the tissue. So, if the tissue is stiffer right less amount of the change in the translation or the force would be different and the tissue is less stiff right is more elastic, then correspondingly different force will be translated to the sensor.

So, what I have, what I get from this, what literature shows that as cancer progresses as the disease progresses. The tissue related cancer progresses there is change in the elastic property of the tissue. You may know that the people who suffer from cancer and if there is a tissue later cancer the tissue becomes harder that hardness is the stiffness right. So, it will be less elastic. So, now, that elasticity we can measure with the help of this particular sensor, how because I am looking at the change in resistance. So, how can I use this particular change in resistance and understand what is amount of force and how to change it to elasticity right, for that we have to go for the electronic module.

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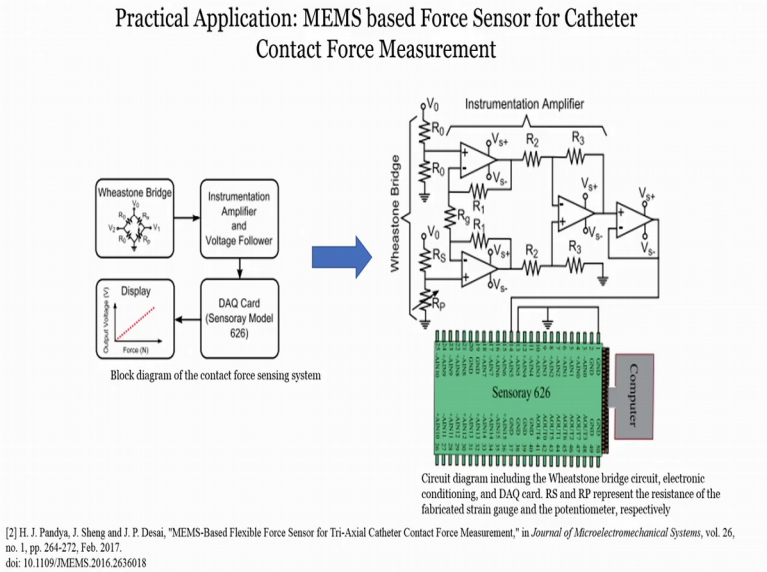

And that is why the signal conditioning system that you have seen in this particular slide if you can see the slide right is the one that we had used for understanding the force

sensor. Now, I have here shown you for the Catheter contact force measurement, but you can also use for the tissue elasticity measurement as we have discussed in the slide right.

So, this will be the last slide for this particular module. If any equations feel free to ask me ask you know ask in the forum and I will very happy to you know address your questions. If you further have any you know comments or you are really stuck with the so some of the parts where you do not understanding, please feel free to you also email me right.

I will try to respond to your email as soon as I can the point is here we are understanding how can we bring different you know aspect of the circuits integrated together and to apply it to understand the change in the tissue property and correlate it with the cancer progression right. So, this can be and interesting study if you study the change in the elasticity as cancer progresses, so that is one research problem for you. So, this is a last slide for this module.

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