Fabrication Techniques for Mems-based Sensors: Clinical Perspective
Prof. Hardik J Pandya
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 18
Process flow for Fabrication of Micro Heater

Welcome to this module. And in the last module what we have seen? We have seen diagnosis tool for cancer right. And we have seen that if you want to understand the change in the tissue properties, you have to have a biochip which can be integrated with three different kinds of sensors. And there three different kinds of sensors can help us to understand which kind of property of tissue mechanical property, electrical property and thermal property of tissue right.

So, if you want to design and now we want to understand the process flow, right what we can do? If you remember the process flow or you can just look at the screen and you will again remember what is a process flow.

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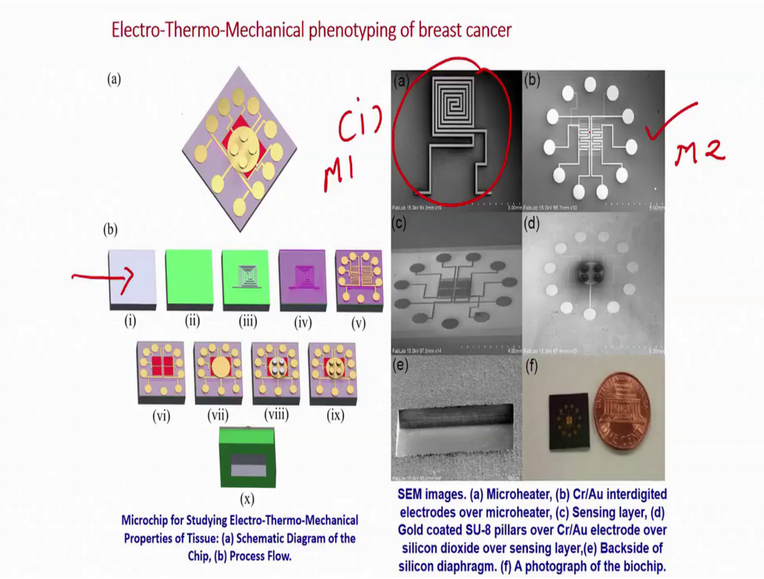

The process flow is we will start with a silicon and then we move onto fabricating different structures. The first structure is our heater; first structure is our heater right.

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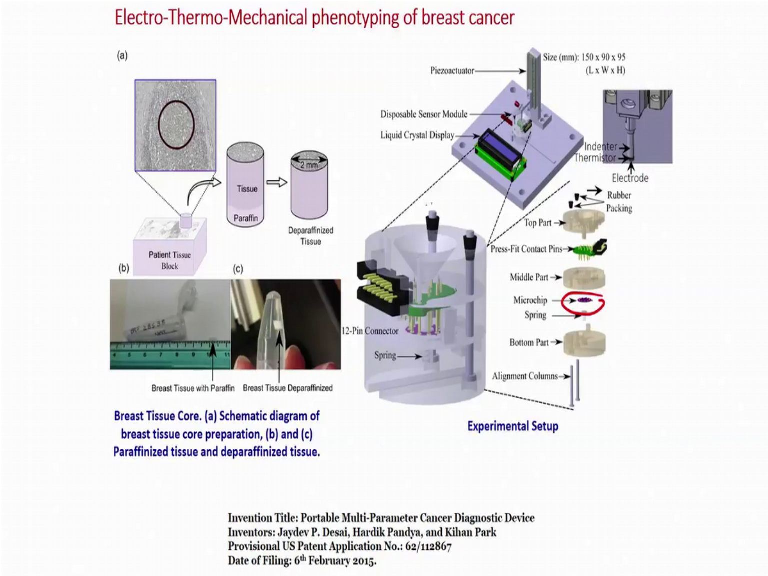

And this chip is loaded within this 3D printed device or tool and chip is right over here as you can see a microchip or a biochip right and surface with contact you can load that tissue in this area.

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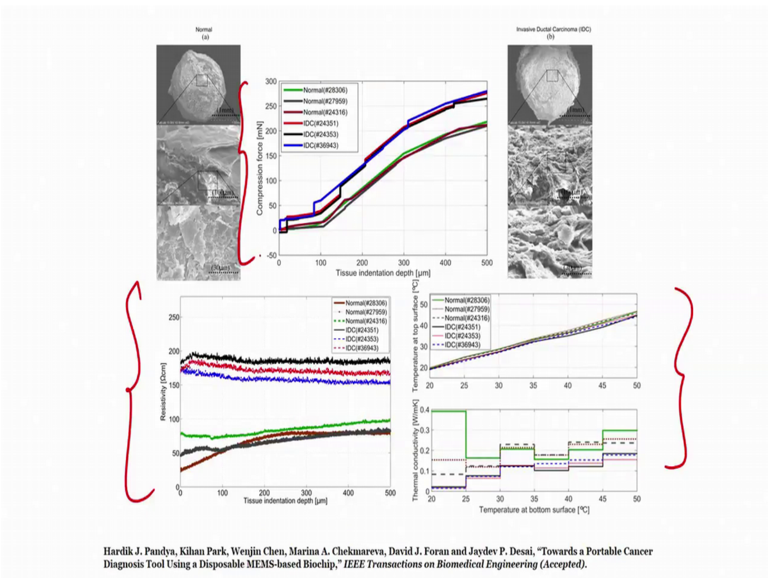

And we have already discuss how we can work on getting the properties of tissue are understanding the property of tissue. This is thermal property of tissue electrical property of tissue and mechanical property of tissue right.

So, let us now know see the first step that is our heater. If I want to fabricate the heater on the silicon substrate, what is the process? Process is our lithography standard lithography.

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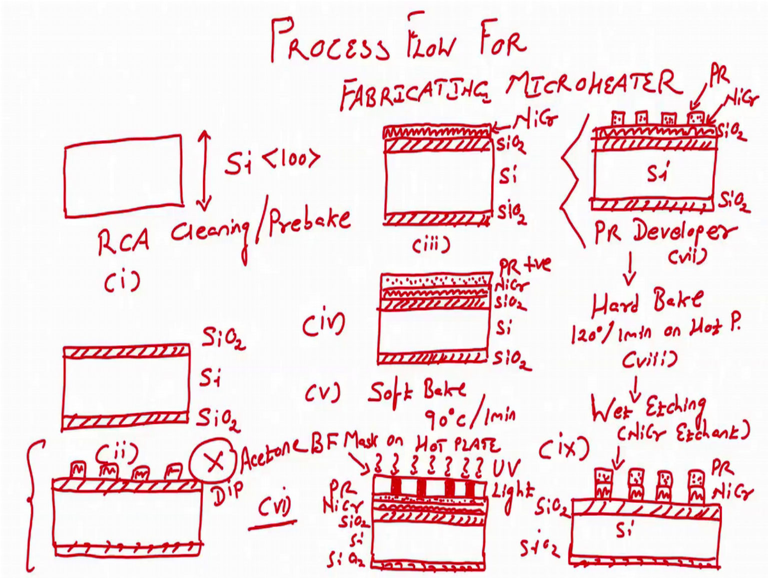

So, I will draw it here and you follow it. First step: so, what we have write; know what we are doing here drawing a process flow for fabricating micro heater ok. So, the first step is you take the silicon wafer you take the silicon wafer ok. This is my this is my silicon wafer all right 100. On the silicon wafer, I will perform RCA cleaning. We all know that we have to perform RCA cleaning that includes the cleaning or remove the contamination and remove a thin layer of oxide write, but 1 to 10 2 nanometer that is present on the silicon; and then we have to pre bake the silicon wafer pre bake to remove and humidity content on the silicon wafer. These are first step second step this is step 1. Step 2 is step 2 is I will grow I will grow silicon dioxide, silicon dioxide, silicon dioxide silicon step number 2 step 3.

What is step three? Step three is I will deposit I will deposit the material that will be used to form the microheater right. I will deposit a material use to form microheater. So, let us say this material is Nichrome, this is my SiO 2 silicon SiO 2 right. Next step, what is the next step is on next step number 3, step number 4 step number four will be to spin coat to spin coat, what is spin coat? Photo resist right to spin coat photo resist on the metal spin coat photo resist. We show photo resist by dotted pattern so that we can distinguish between different pattern.

This is your photo resist, then you are nichrome, then you are silicon dioxide, then silicon, then silicon dioxide. After photo resist spin coating photo resist, what you we have to do? We have to perform soft bake. Now assuming this is positive photo resist, we know the role of positive photo resist, the role of negative photo resist. So, if we perform soft bake, we can perform at 90 degree centigrade for 1 minute on hot plate right.

Next what we require? Next we have to we have to load the mask right SiO 2 SiO 2 right and then I have nichrome, then I have photo resist photo resist nichrome SiO 2 Si SiO 2 right. And on this, what will I do? I will load the mask. What is this kind of mask? I will use a bright filed mask I will use a bright field mask all right. What we are using? We are using positive photo resist and we are using bright field mask. After loading the mask and aligning the mask, I will expose it.

So, this is my fourth step, soft bake will be my fifth right and then loading mask performing. So, I am just I am not writing in detail, but let us say this is a fifth step soft bake is p r. When you spin coat for photo resist, then you have to perform soft bake, then you have to load the mask load the mask. Then after that you are exposing the wafer with UV light UV light right. After that what us the next step? Source fifth would be loading the mask and exposing the wafer. Sixth would be loading the mask and exposing the wafer with UV light. Seven step: seven step would be unloading the mask unloading the mask and dipping the wafer dipping the wafer in photo resist developer. Unloading the mask and dipping the wafer in photo resist developer.

So, when you dip the wafer in photo resist developer when you dip the wafer in photo resist developer, then what do you have? You have photo resist you have nichrome, SiO 2 Si SiO 2 with this step right. When you dip the wafer in photo resist developer you have this pattern, now you can now you can perform after this next step, this one would be.

Seven step next step would be hard bake hard bake, hard bake is an at 120 degree 1 minute on hot plate right. So, that will be my eighth step. After this I will dip this wafer or I will perform wet etching wet etching by dipping the wafer by dipping the wafer in nichrome etchant. After this, what will I have? I will have a wafer I will have a wafer I will have a wafer with what I will have wafer with nichrome on the area which was protected by photo resist right I will have wafer with nichrome with the area protected by photo resist.

Correct after this, what us the next step? So, if I say this is step number step number 9 9. What is a step 10? Step 10 I will draw it here I will draw it here. After this one is step number 10, but I have look do I require photo resist? I do not require photo resist right. I do not require photo resist. So, I have to strip of the photo resist strip of this photo resist. I do not require photo resist; I have to strip of the photo resist and the stripping of can be done the stripping of can be done by dipping the wafer by dipping the wafer in acetone.

So, you can say acetone dept or acetone dip acetone dipping. So, if you see if you see, what you get here? After performing this tenth steps, we get nichrome pattern on oxidize silicon substrate right. Let me repeat this process quickly silicon, then we have oxidize silicon, then we have nichrome on silicon oxidize silicon, then we spin coat photo resist. We perform soft bake at 90 degree centigrade for 1 minute. We load the mask we aligned the mask, then we expose the mask with UV light, after that we unload the mask right, dip this wafer in photo resist developer and develop the photo resist since it is a positive photo resist.

The exposed area will become weaker and the unexposed area will become stronger is what we see here in the photo resist that was exposed become weaker in it got developed photo resist developer. The photo resist that was not export was stronger and it is still there. After this, what we are looking at after this? We had performed hard bake at one 20 degree centigrade 1 minute on hot plate. Next step would be wet etching wet etching can be done in nichrome etchant since our metal used for microheater is nichrome.

And after that when you do perform a wet etching; then you will see that the nichrome in the area which was not protected by photo resist got etched. After the after this strep in the next step would be we have to remove the photo resist or we have to strip of the photo resist. And for stripping of the photo resist, we can dip this wafer in acetone dip in acetone dip right. When we do that right and when within the wafer, we can see microheater pattern on the oxidize silicon substrate. This microheater we can inspect in the microscope.

So, after these steps after this step, what we obtain? We obtained our step number 1 which is the microheater which is the microheater. You got it? Now what is the next step? Next step is we have to we have to pattern interdigitated electrode on this microheater, but can we do that? No because this is a metal this is metal. Let us say this is metal number 2, microheater is our metal number 1. We cannot have two metal on each other at are by which will cause shorting. So, we should have a insulator between microheater and the interdigitated electrodes, we should have insulating material.

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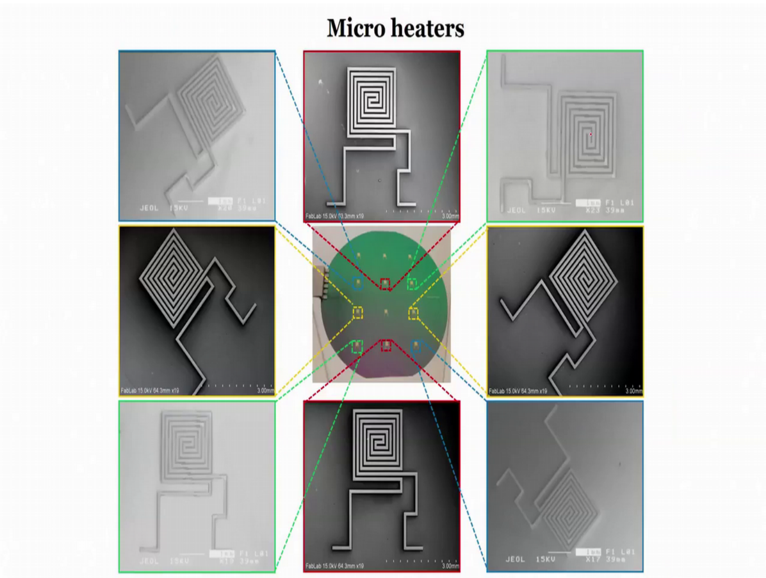

So, let us perform that step let us perform that step and so, we will get? This kind of microheaters.

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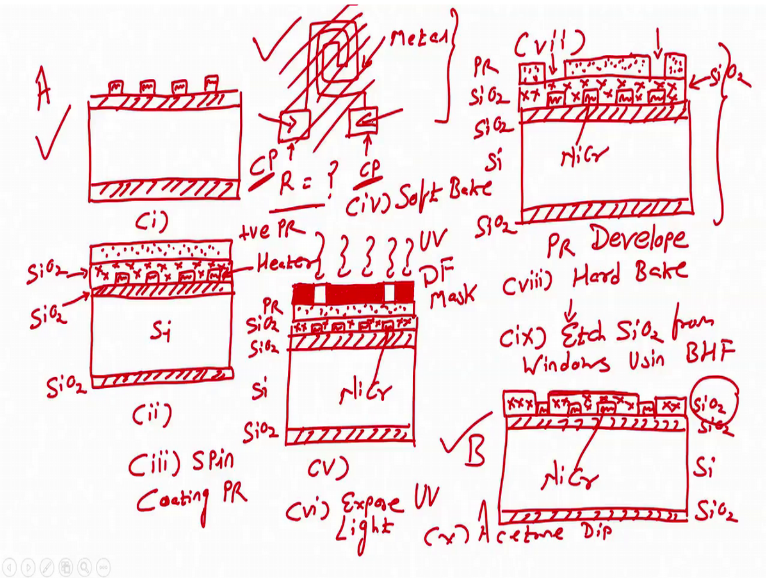

Now, we know it. So, now, what we have let us start from microheater. So, we have we have microheater with us. Then microheater we have just seen the process flow you have just in the process flow and let us draw here. So, we have this microheater ready with us. This is our first substrate with microheater. What is the next step? The next step is that we have to grow silicon dioxide on this microheater.

We have to grow silicon dioxide on the microheater right and let us make silicon dioxide like this. This is our grown silicon dioxide or deposited silicon dioxide this is our silicon dioxide that is grown by l p c v d is silicon, this is silicon dioxide is again silicon dioxide and inside this one is our heater this is our heater right. Next step would be, so if you have this heater right, you have let us say heater and it go something like this right. I does not look good, let us say draw it properly. Then we draw it was like this ok.

So, is not good, but this is what? I can draw. So, now, you have now you have metal right and on this metal what we have? We have insulator everywhere. Now if I ask you to tell me, what is the resistance of this heater? Can you measure the resistance? You cannot right, because there is an insulating material on the microheater. But how can I measure the resistance? If I open or if I remove the insulator from the contact area right, this is contact area contact pad; this one is contact pad. If I remove the insulating material from the contact pad, then I can tell whether I can take a proper contact or not or I can measure the resistance in a simpler word.

So, here when we have grown silicon dioxide, what we have to do? We have to open this contact area that is why we have to use micro engineering right; otherwise, we will have this kind of pattern ok. So now, I have removed the silicon dioxide from the contact pad see, drawing becomes so easy. Now when you when to perform this one this step where after depositing silicon dioxide, we have to remove the silicon dioxide from the contact pad.

So, that we can measure the resistance, what are the steps? That is what we are looking at ok. So, this is our second step third step. So, I will these our first step. This is second step third step third step would be spin coating spin coating photo resist. So, for spin coating photo resist, what I will do? I will put here photo resist right, I will put here photo resist and I will let us say photo resist is shown by a dots. This is photo resist and here it is positive photo resist, what is it positive photo resist? So, what kind of mask I had to use if I want to remove? Just metal pad and keep the rest of the area as it is I will use the dark field mask I will use a dark field mask.

So, let us see here 3; step 3. We have coated photo resist, step number 4 step number 4 step number 4 would be load the mask right to load the mask. So, for loading the mask, we will use a dark field mask why because we want to we want to etch only the area which is your window or contact area of the microheater all right. SiO 2, SiO 2 Si, SiO 2 and then we have here which is our heater which is nichrome right and then we have our photo resist.

So, will for photo resist which is shown by dots doted pad right and then on this, what will I have? I have a mask I have a mask which is dark field mask. Only the contact area of the heater would be exposed, only the contact area would be exposed. Just to make life easy, I had drawn that every PR obtain the contacts like this. When you actually take a cross section, only one side of the contact you will see here not both the contacts open like this right.

So, it is something like this and then we have. So, a mask a mask, this is your dark field mask dark field mask. After this, what is the next step? Next step is we will soft bake sorry after spin coating photo resist after this soft spin coating photo resist, next step would be I missed one step next step number 4 would be soft bake. Step number 5 would be this is our step number 5 would be load the mask. Step number 6 would be exposed or step number 5 and 6 would be load the mask and expose with UV light with UV light. So now, I expose this one with UC light, what will happen? What kind of photo resist is here? Photo resist is positive photo resist area which is exposed will get weaker area which is not exposed will get stronger. So, after this I have to perform, let us say step number 6, step number 7 right; 6 is drawn step number 7, I will dip this wafer I will dip this wafer in photo resist developer or I will develop this photo resist in a photo resist developer.

So, photo resist developer right, when I do that what will I obtain? I will get photo resist in this particular fashion photo resist SiO 2. This is your heater, this is again your SiO 2, this is your silicon and this is your SiO 2 right. After that what is the next step? After this what is the next step? We have to so you see photo resist is protecting the rest of the area of heater except the contact pads right. So, now, after this PR developer PR developer, I have to perform.

Next step which is my step number 8 that is your hard bake hard bake; next step would be next step number 9 would be etch SiO 2 from windows right. This is window right this one is window; We are etching silicon dioxide from windows using buffer hydrofluoric acid buffer hydrochloric acid. So, we are dip this wafer in BHF and you will see that the oxide is removed the oxide is removed. So, what you will see? What you will see after this would be would be, let me draw it once again. So, it is easier for us to understand, after dipping the vapor in the silicon dioxide etchant.

What we will be looking at? You get it and here I will have here I will have my photo resist photo resist silicon dioxide, silicon dioxide, silicon dioxide, silicon heater, got it? What is the difference here? You see here there is the silicon dioxide here everywhere on the heater, here silicon dioxide is etch from the window from the window. What is the next step? Step number 10 will be acetone dip acetone dip will etch. We will we will strip of the acetone by dipping we will strip of the photo resist I am sorry; we will strip of the photo resist by dipping the wafer inside the acetone.

So, if you strip of the photo resist, what you will have? I will draw here only if you strip of the photo resist you will have a wafer, you will have a wafer this looks like this correct. That is what we want. We wanted we started with this particular wafer, when we reach to this wafer where you see that the difference only between A and B is that now the contact area is opened, but rest of the area is protected by silicon dioxide. A contact area of the heater is open, but rest of the area of the heater is protected by silicon dioxide. So, if you see the top view. Now the see the top view will look similar to this where everything is silicon dioxide and only the contact area only the contact area, you can see there is no silicon dioxide. After this only we can start our next step and that is to deposit metal for interdigitated electrodes.

So, we will see the next module will see the next module how we can deposit a metal on such a structure two form interdigitated electrodes. You understand the reason right. The reason of removing the silicon dioxide or creating a window such that we can remove silicon dioxide was to take the contact from the heater. Otherwise you cannot take the contact from the heater because everything is insulating there everywhere the you can see insulating there, you get it.

So, there is advantage of removing silicon dioxide from your microheater and now we have to deposit a metal that can be used to or that can be pattern two form interdigitated electrodes, so that particular process of how to deposit a metal on this particular structure right to form interdigitated electrodes. And then you have to deposit piezo resister material. And then you are too also deposit a coolpad followed by SU 8 pillars, followed by a bulk micromachining which is etching this silica from the back side to create a diaphragm, We will see in the next module.

Till then you just look at this module, understand it thoroughly and I will see you in the next module. Till then you take care. Bye