Integrated Circuits, MOSFETs, OP-Amps and their Applications
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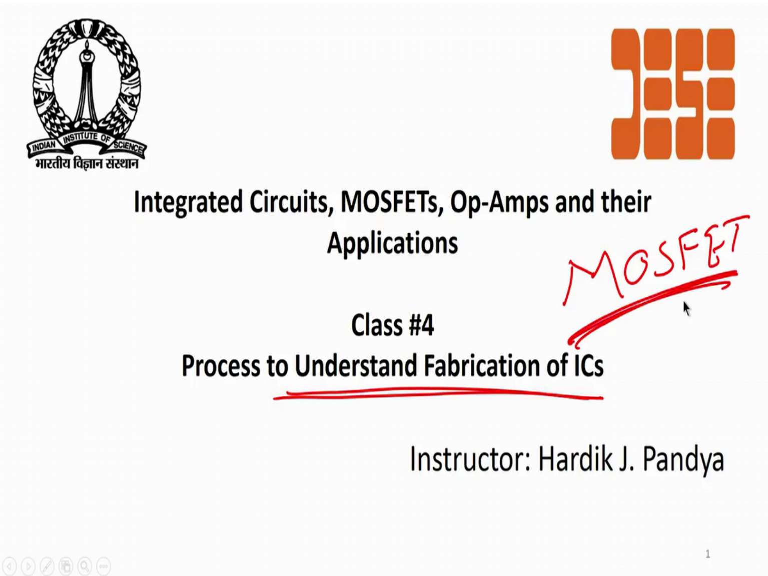
Lecture - 05
Introduction to the fabrication of sensors

Welcome to this lecture. And, this lecture is continuation of the last lecture where we understood how we can design or we can fabricate interdigitated electrodes in an SU-8 well. The reason of designing that particular sensor was to give you an idea of how we can fabricate a MOSFET, right.

So, the point was that if I want to fabricate a MOSFET then what is the technique, what are the process flow? So, to understand the technique, to understand that process flow I have to understand initially a simple example which was discussed in our last class. And that is nothing but my interdigitated electrodes, but which was nothing but my interdigitated electrodes.



Now, in this class let us see how we can design another sensor and how we can implement it using the same process flow which we have seen in the last class, alright. So, let us see. The topic is if you can see the screen process to understand fabrication of integrated circuits. But this time we will take an another example so that you guys understand how we can fabricate finally a MOSFET. That is our one line goal to understand how we can fabricate a MOSFET. To see this we are doing all this exercise.

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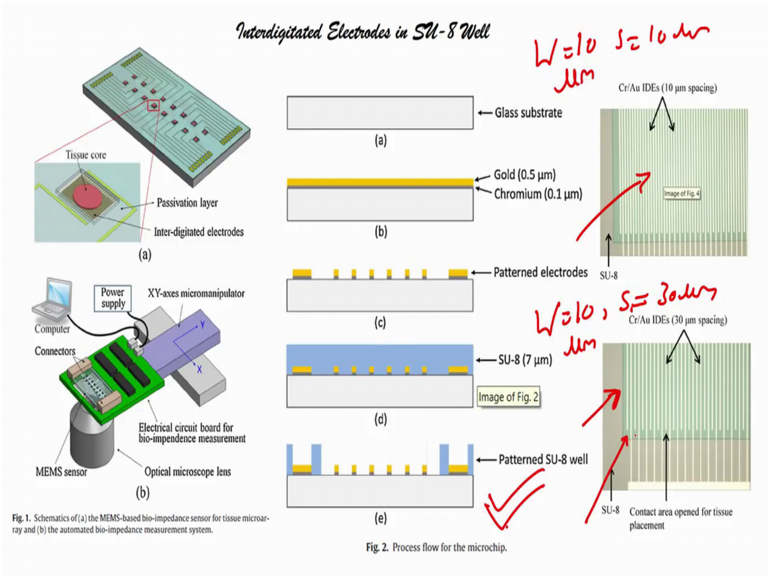

So, last class we have seen this which is our interdigitated electrodes within an SU-8 well. So, let me quickly repeat what we have seen and how can fabricate. I will continuously show the process flow. So, be with me, alright. For designing this particular pattern what we have done?

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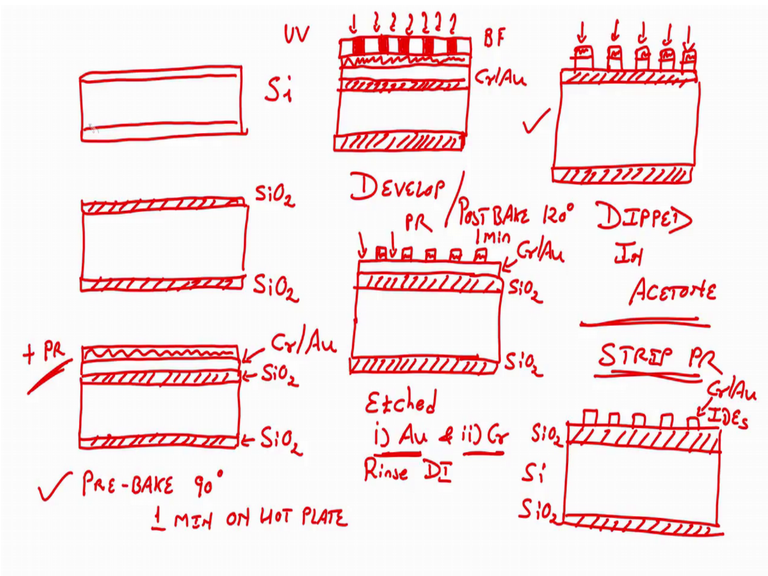

We took silicon, then we have grown thin layer of silicon dioxide. Then on this thin layer of silicon dioxide we have deposited a metal. I told you which one chrome; thin layer of chrome over with gold SiO 2; SiO 2. We have SiO 2; we have SiO 2. Then, we spin coated photoresist, then we did pre-bake at 90 degree this was positive photoresist; 90 degree for 1 minute on hot plate. Then, after doing that we have develop sorry, we expose this photoresist by placing a mask.

So, we have this chrome gold, we have photoresist, and then we placed or load the mask on the wafer then mask was similar to what I am drawing almost similar. And then I have exposed this using UV light. After doing that I have developed it, unload the masks develop photoresist, right. So I got a wafer, a oxidize wafer with photoresist, because I am using bright field mask; this is bright field. And I have used positive photoresist; that means, I will retain the similar pattern that I had on the mask on the wafer correct. So, now, I have got of what is the positive photoresist on the area which were not exposed which were not exposed in UV, right.

So, all the bright area on the mask I can retain on the photoresist. After that what I have done? I have edged this wafer this metal chrome gold edged first in gold agent and second in chrome agent in between I have rinse it with the help of DI water; I have rinse it with DI. Once I do that what I got? I got a wafer with metal on the area where photo resist was there and the rest of the area the metal got edged. Now I have dipped this wafer; dipped the d i p p e d- dipped this wafer in acetone. And it will strip, this acetone will strip my photoresist.

So, when my acetone strips or if on strip the photoresist what I will have, I will have an oxidized silicon wafer with interdigitated electrons, right. So, these are my chrome gold, these are nothing my interdigitated electrodes, this is my SiO 2, this is silicon, this is SiO 2.

You got the process? Let us repeat once again quickly. Silicon first step, silicon dioxide grown second step, chrome gold deposit third step, deposit of spin coat of photoresist four step, after that we had to lower the mask before that after spin coating the photoresist you are to pre-bake at 90 degree for 1 minute. After that you lower the mask do the UV lithography and then you develop your photoresist. Then after developing photoresist you can go for post bake. After developing photoresist you go for post bake at 120 degree for 1 minute. Then you have the photo resist on the metal.

Now whenever the photoresist is there the metal below it is saved, and whenever photoresist is not there like in this area the metal will get edge. Now we have chrome and gold; gold is on the top of chrome. So, first we will etch the gold and that is why we will dip this wafer in gold etchant which is 1, then we will rinse it with DI, we will then etch the wafer with chrome again raise it with DI and then we get the wafer which you can see here; the photoresist is there and the metal below photoresist is saved. The metal which is not covered by photoresist got edged. After this we have removed the photoresist by dipping the wafer in acetone. And when you dip the wafer in acetone the PR will give a strip, and then we will have the oxidized silicon wafer with interdigitated electrodes.

Now, once you have this oxidized silicon wafer with an inter general electrodes or let us just draw in a next slide.

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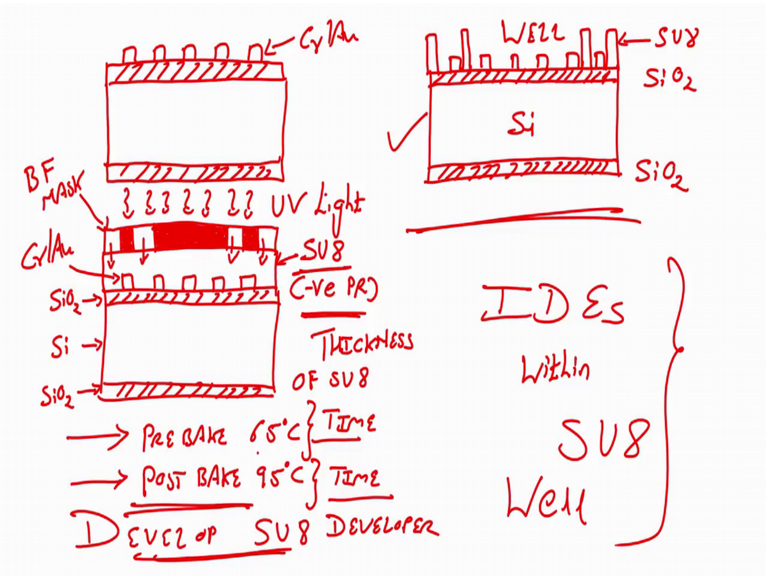

So, once I have inter digitated electrodes then what is my goal? My goal is to have these interdigitated electrodes inside the SU-8 well, right. My goal is to form a SU-8 well. So, what what did I perform, last time what did I do? On this interdigitated electrodes I have spin coated photoresist which is my SU-8; this is my SU-8. I said photoresist, because SU-8 works like a negative photoresist. This is my silicon dioxide. This is my silicon, this is silicon dioxide. These are chrome gold interdigitated electrodes; inter digital electrodes, easy.

Now SU-8 is negative photo resist. So, what is the next step? Next step is, that I will load a mask; so after SU-8 is there I have to pre-bake it, right; pre-baked. In SU-8 we had to pre-bake it at 65 degree centigrade, then we load the mask such that I had to open the; I had to create the well. So, this is my bright fill mask right, this is my bright fill mask. And you have seen what is bright fill mask you have seen what is dark film mask, correct? Now you have this. So, this is a mask and then I will expose my wafer; expose the wafer with UV light. On exposing the wafer with UV light what will happen the area here it is negative photoresist which is opposite to for positive photoresist. That means, the area which are exposed will be strong and the area which are not exposed will be weak. So, the area which is dark shaded, this area, this one, this one, they will be weak this areas would be weak and the areas which are not exposed will be strong, easy.

Now, we have to post bake; it this is little bit different than our other photoresist at 95 degree centigrade, right. Again the time is given, depending on the thickness of the photoresist of SU-8 the time for pre baking time will be different; time for post baking would be different. This is not anymore 1 minute like we have seen in positive photoresist, alright. After this what will get? After post baking I will develop it- d e v e l o p; develop the wafer in a SU-8 developer; develop SU-8. When I do that what I will get? I will get an oxidized silicon wafer with electrodes and SU-8.

So, this is my SU-8, this is silicon dioxide, this is silicon dioxide, this is silicon, right and this is my well, right. So, this is how I can create an interdigitated electrodes within SU-8 well, easy.

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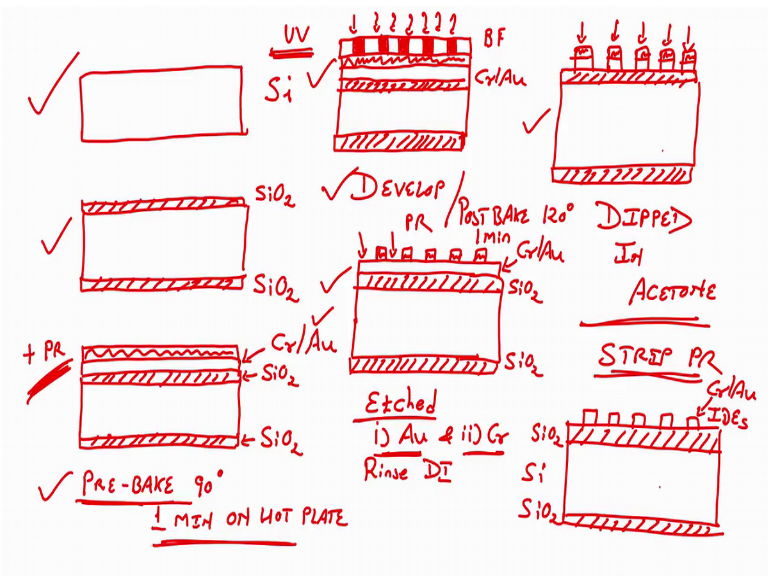

Now see I have continuously told you from; showing you the process I have continuously shown you the process so that you do not get lost we have started with silicon and then we reach to oxidized silicon substrate which is by growing the oxide. And then we have deposited chrome gold, and on chrome gold we have deposited spin coated photoresist. After the spin coating photoresist, then we have after spin coating photoresist we have pre-baked it for 90 degree for 1 minute on hot plate. And then we have loaded the bright filled mask; bright fill mask is a pattern like this. And then we have expose it using UV. After exposing it with the UV we have post bake it; we have after you are exposing with UV we have developed it develop what develop photoresist, and the photoresist which were exposed because it is positive photoresist; the photoresist which all which is exposed will be etched, the photoresist which is not exposed will remain; the photoresist which is not exposed will remain, alright.

So, after developing photoresist I will have patterns like this. And this you can see there is a metal, then there is a photoresist as a metal and then there is a photoresist, and as a metal there is a photoresist. And then you have metal below it and then what you do? You have to etch the gold, then you have to etch the chrome and you rinse the DI; in between your two drains with DI. Once you do that you will have photoresist on the metal saved, there is a metal below the photoresist will be saved and the metal which was not covered by photoresist will get etched.

After this you place the wafer in acetone and you can remove the photoresist to obtain for interdigitated electrodes made from chrome chrome gold. Once you have interdigitated electrodes made from chrome and gold, here chrome and gold then you spin coat SU-8; SU-8 is nothing but your negative photoresist. And, after spin coating SU-8 you pre-bake the SU-8 at 65 degree centigrade. After prevailing SU-8 at 65 degree centigrade you can lower the mask, here you have to create the window here you have to create the well which should look similar to this. So, that is why we have a bright film mask; we have our this one is your bright filled mask. And you can see that the exposed area I will export with UV; the exposed area that means this area, this area, this one and this one the exposed area will get stronger and the unexposed area will get weaker. This is the exactly opposite of your positive PR; positive photoresist. This is the exactly opposite of the positive photoresist.

So now, what we have done? We have pre-baked it then we have exposed it, then we have post make it, after post baking we have developed the photoresist using SU-8 developer. And then once you develop the SU-8 you will have a wafer with your interdigitated electrodes inside the SU-8 well.

So, by doing this what we will get? We will get this pattern which you can see here, right this one. And if you take the microscope image then you will have interdigitated electrodes, here your mask was such that your width was 10 micron and your spacing was 10 micron. Here the mask is such that your width is 10 micron and your spacing is 30 microns. And then this is your SU-8 well you can see. This is your well and you can see green color is your oxidized silicon wafer.

Now, once you have this, if I give you another example.

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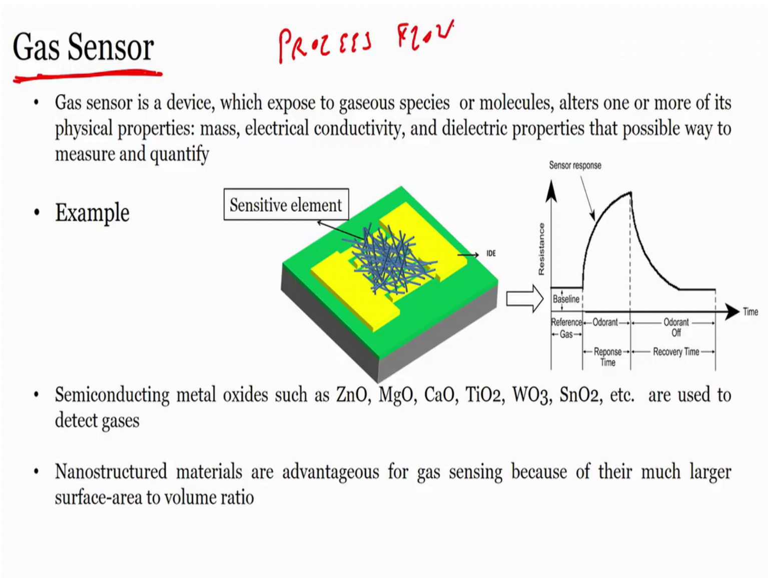

If I give you another example and quickly let us see: if I want to understand the process flow for designing a gas sensor. Now then why I am taking the example again, so that you are confident of how you can use the process flow for developing or for designing the MOSFET, right. We will see and you will understand why we have taken this example right, this is an example.

So, when we are already making a sensor let us also understand what is this, what is a use of this particular sensor, right. So, we are designing now a gas sensor with a process flow.

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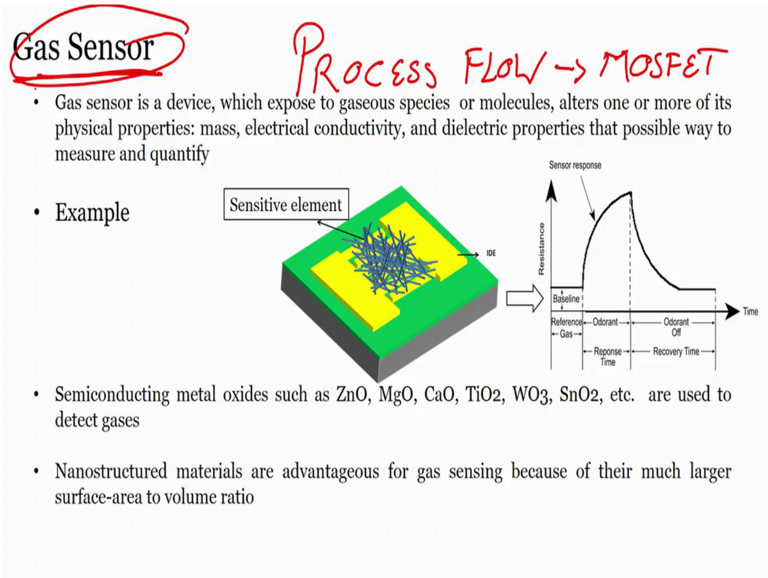

With a process flow that will help us to understand how can we fabricate MOSFET; that will help us how can we fabricate MOSFET, alright.

So, let us understand first gas sensor; how can we have a gate gas sensor.

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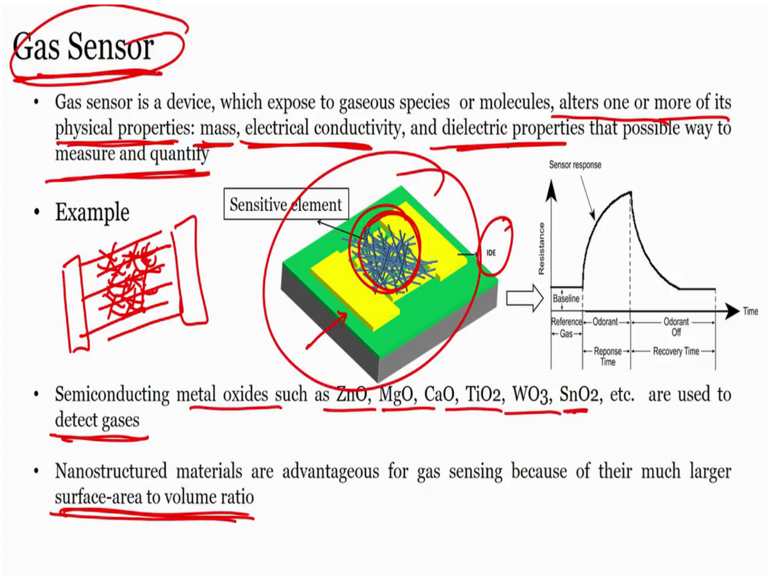

If that is the case let us see what are the gas sensors or gas sensors is a device which exposed to get species, which on exposed one arm or which one exposure to gaseous species or molecules alters one or more of its physical properties. That is either it will change its mass or it will change the electrical conductivity and dilatory properties that is possible way to measure and quantify. That is possible to a to measure and quantify. So, here if you see this is nothing but interdigitated electrodes on which there is some sensitive element. What is sensitive element? That is sensitive to particular ags.

So, now what you have is an interdigitated electrodes on which this some nano wires or nano structures are formed, alright. And this is oxidized silicon wafer, this is oxidized silicon wafer, right. So, the semi conductor metal oxides such as zinc oxide, MgO, CaO, TiO 2, Wo 3, what is this? Zinc oxide, magnesium oxide, calcium oxide, tin oxide, tungsten oxide, tin oxide is here sorry titanium oxide, titanium dioxide, tungsten oxide, tin oxide, etcetera are used to detect cases and many more and many more, alright.

And if you want to grow nano structure, nano structure advantage because of their higher surface to volume ratio. We do not care this one, we just see that how we can design this gas sensor; we have can design the gas sensor, alright.

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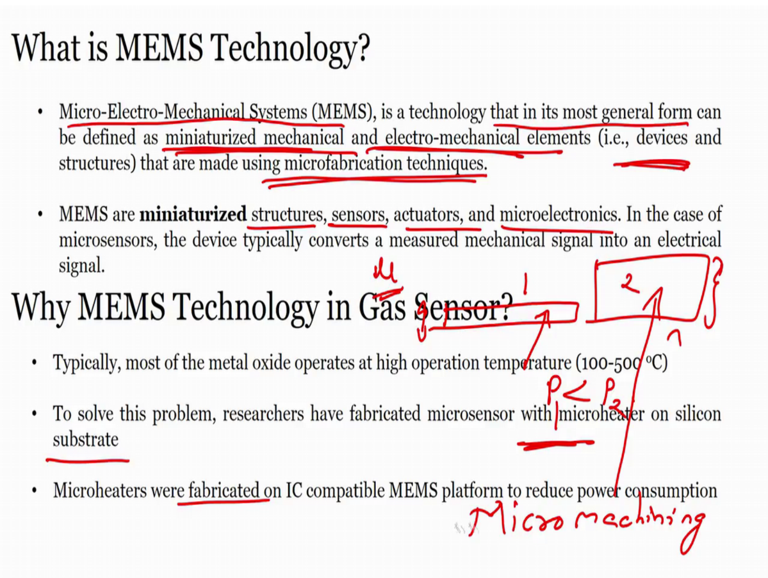

So, again we will use the MEMS technology, that is why I have given a slide so that you understand what exactly is a MEMS technology. We have discussed in last slide the MEMS is nothing but Micro-Electro-Mechanical Systems, that in most general form can be defined as miniaturized mechanical and electromechanical elements such as devices and structures which are made using micro fabrication techniques, alright. So, MEMS are miniaturized structures such as sensors actuators microelectronics.

In the case of micro sensors the device typically covers a measured mechanical signal into a electrical signal. However, why we use this per gate sensor; if you just want to know that metal oxide operates at high operating temperature, to solve this problem researchers have a bigger micro sensor, with micro heater on silicon substrate whether it is a fabricated or icy comfortable mass spectrum to reduce the power consumption. So, if I generally you see that metal oxides that we have seen in last slide they all operate at very high temperature, but if I that very high temperature requires high power I want to reduce the power; how can I reduce the power, by using a substrate which is thin.

So, if I have this substrate and if I have another substrate which is thin then the power required to hit this substrate compared to this substrate will be less. So, power required for substrate 1 will be less than power required to substrate 2. So, how can I reduce the thickness of the substrate? I had to do machining- m a c h i n i n g machining. So, but in this case we have to make the thickness in terms of microns; that is why this is called micro machining- micro m a c h i n i n g micromachining. So, the point is that is why we had to use the MEMS in gate sensors.

Again do we care? No, absolutely not, we do not care why MEMS is using a sensor we do not care.

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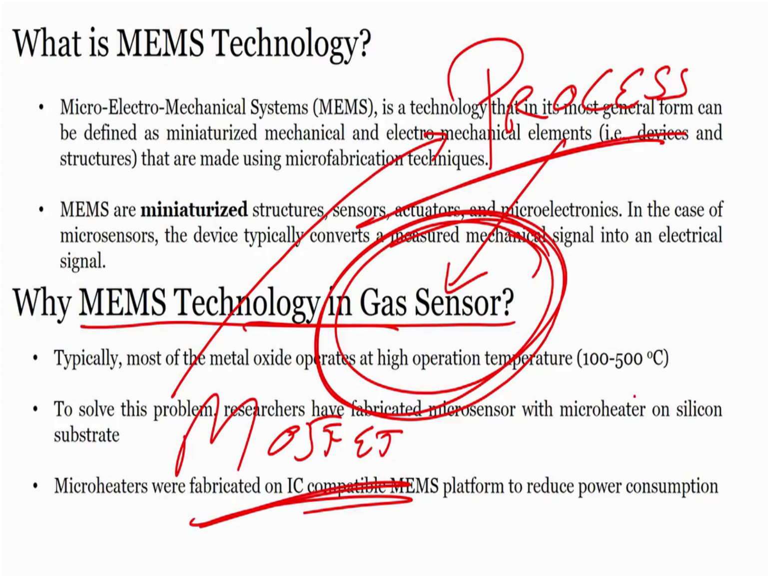

What we care is how can we fabricate the gas sensor or how can we fabricate the sensor; why we care. So, that once we know how we fabricate, once you understand process you need to use this process to understand MOSFET; one line goal. How can I understand process of MOSFET that is why we are taking different examples so that when I come to the MOSFET your life would be very easy will be extremely easy.

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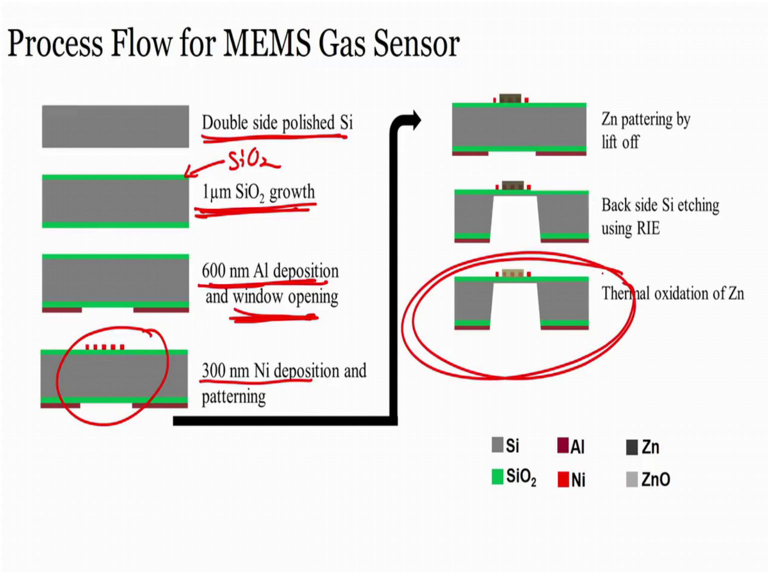

So, let us see the process flow for MEMS sensor. So, what is it? First is you have a double side polished silicon. We have seen a silicon wafer which are single side polished, we can also have silicon wafer which a double side polished. Now you grow one micron silicon dioxide; you can see here green color is your SiO 2. Then you have 600 nanometer of aluminum deposition on the bottom and you can open the window. How you will do that? I will do that we will see.

Then you have the pattern for heater. Finally, what you want is this structure. What is this structure? You will see here, let us see.

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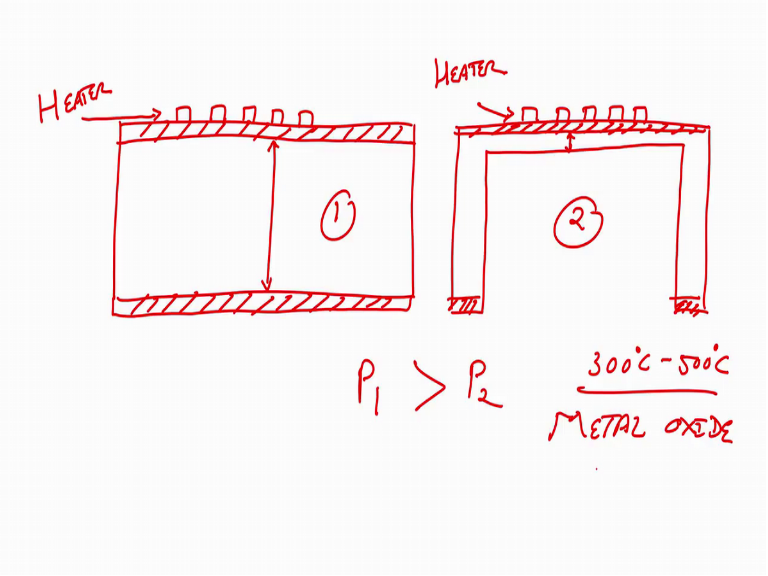

What I want is, I want a substrate; you guys tell me or think with substrate will require less power if there is a heater on the substrate. So, let us say that this one is your heater, this one is your heater; which substrate we require less power? Obviously, right this substrate, correct because the thickness is extremely small. You can see this is all empty, only thickness is of this particular wafer. Here the thickness is very high is a thick wafer. So, in this case the power required let us say this is 2 this is 1; the power required for 1 will be higher than power required for 2.

Now, on this heater; why we require heater, because in case of sensor we say that we had to heat the sensor at high temperature from 300 degree centigrade to 500 degree centigrade. Why, because we are using metal oxide; we are using metal oxide semiconductor. So, this particular material requires a temperature of 300 to 500 degree centigrade.

Now what? Now what is the case? Once you have heater you need a sensing material.

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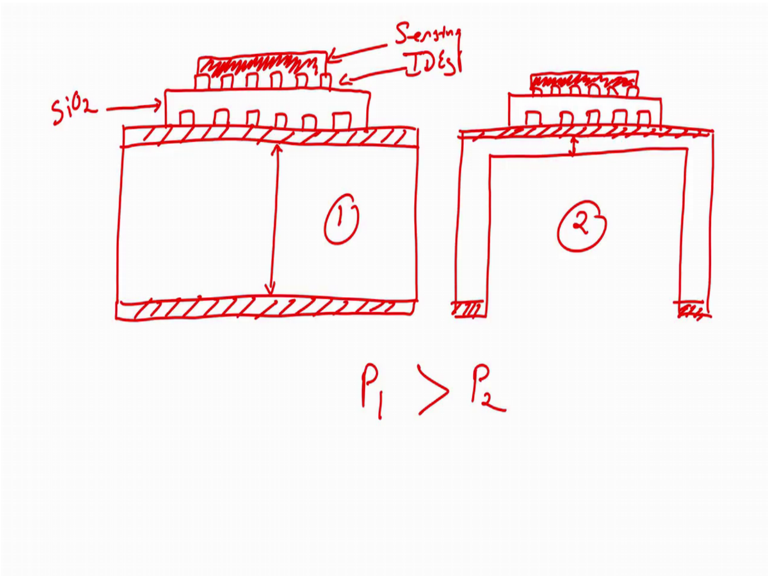

So, on this heater let us say because it is bigger I have to have an insulator right, I have to have an insulating material let us say this is SiO 2. On this insulating material I can have my interdigitated electrodes. What will I have? I will have interdigitated electrodes. On these interdigitated electrodes I want to have my sensing material. I want to have my sensing material, correct. This is my sensor, but instead of using this I will use this substrate, I will use this substrate, I will use an insulator, I will have my interdigitated electrodes, and I will have my sensing material.

Advantage is the thickness here is less, correct. So, to obtain this particular sensor; to obtain or to fabricate this particular sensor what is a process flow; what are the process flows. You understand this you have to remember what we want is this structure; we want to want to have this structure.

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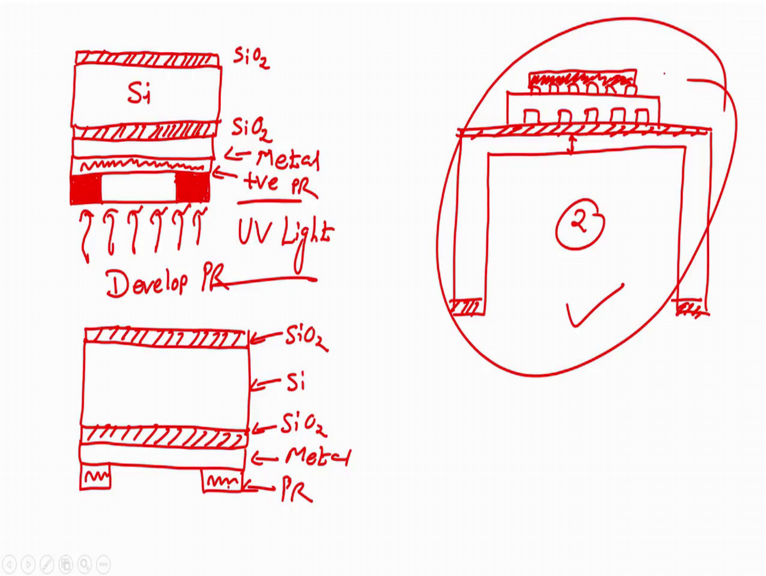

So first is, now you see if I use a silicon wafer then I grow oxide. I have silicon, I am growing oxide, then I am depositing aluminum on the back, and I am etching the aluminum this is aluminum or metal and I am etching the metal using process which is our lithography. What we do? We spin coat photoresist. So, I will spin coat photoresist. Then after spin coating we pre-bake it, so I will pre make it at 90 degree this is my photoresist; positive photoresist. After pre baking I will load the mask, I will load the mask which kind of mask I load the mask like this. I load the mask. Now after loading the mask what I will do? I will expose this wafer with UV light; expose this wafer with UV light, alright.

So, what will happen? That after I unload the mask if I do this, after I unload the mask and I develop my wafer; I unload the mask and I develop my photoresist then what I will have. I will have oxidized wafer like this and I will have metal and photoresist. Once I unload the mask right, this is see; what I have done silicon dioxide oxidize then I had deposit metal on metal I have for photoresist, photoresist I have pre-bake it at 90 degree, then I load the mask, I expose the mask, then I am unloading the mask, I am developing photoresist, after developing photoresist I will have this particular structure because this is my positive photoresist.

So, the same structure I can retain. Or the exposed area is weaker and unexposed area is stronger. So, I am retaining this particular structure. After this, this is what my photoresist. This is my SiO 2, this is silicon, this is SiO 2, right. What I want? I want this structure. You remember what I want, now let me remove it. Let me remove it so that you can see what are the process flows. So, this is my another one.

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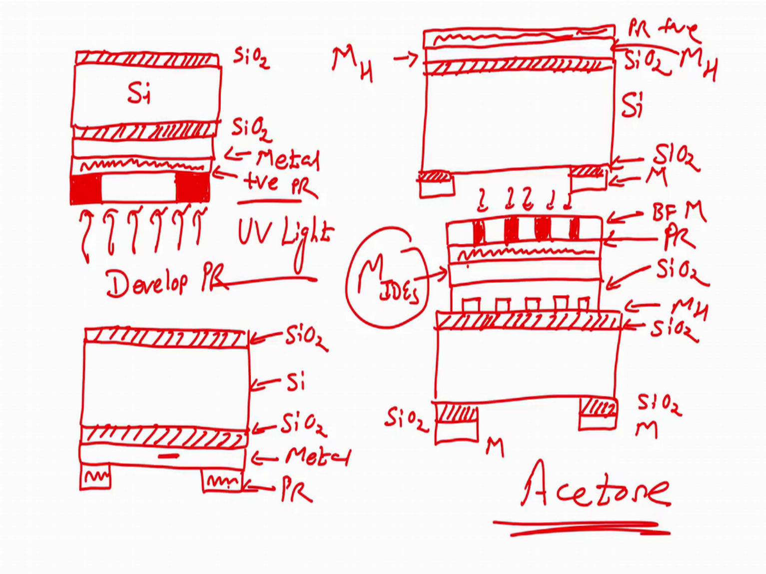

Now I will dip this wafer in metal. So, after this what is the next step? After this we will do post baking post baking at 120 degree for 1 minute. After this, after post baking I will etch my metal. So, when I etch my metal what structure will I have, I will have structure which will look like this, right this is metal, this is PR- photoresist, this is my SiO 2, this is silicon, this is SiO 2. You see difference here the metal was here in this one, here this metal is not there because I have after post baking I have etched the metal, alright.

So, after this what I will do? I will etch the SiO 2. So, by for etching SiO 2 I can dip this wafer in buffer hydrofluoric acid; I can dip this wafer in BHF. BHF why, because BHF is SiO 2 etchant; BHF is SiO 2 etchant, soI can dip this wafer in BHF. If I dip this wafer in BHF what will I have, I will have SiO 2 only in this place; I will have SiO 2 only this way, because this is covered by this is protected by photoresist; is protected by photoresist. So, I have photoresist metal and SiO 2, easy; very easy.

Now I will strip off my photoresist, I will remove my photoresist; I will strip up my photoresist. Now, I will deposit a metal on the top of the wafer and this metal is my metal for heater. Then I will spin coat photoresist, this is my positive photoresist. After spin coating photoresist we will pre-bake it, pre-baked 90 degree 1 minute. After prebaking I will expose the photoresist using a mask. And you will see how useful this process is when we look at the MOSFET fabrication, guys.

So, please focus. What we are using? A bright filled mask, we have here photoresist positive, we have here SiO 2 and I am exposing with UV; I am exposing with UV. When I expose it with UV I have to; after exposure I will unload this mask, right I will unload this mask. And I will dip this mask in photoresist developer. When I dip this mask in photoresist developer what will I have; I will have photoresist only in this area. Why, because same pattern of the mask I can get on the photoresist.

After this I have to; actually we missed one step; no not actually missed one step I have not drawn correctly. We have this metal here. You see here this one is your metal for heater, right. So, we have here your metal for heater and here we have your photo resist. This is same pattern which we had on the mask, so we have your photo resist; we have your metal for heater.

Now, I will post bake the wafer this chip, this wafer; I will post bake this wafer. And then I will dip this wafer; post -bake this at 120 degree you know and I will dip this wafer in the etchant- e t c h a n t etchant for the metal that is used for heater. That is the metal which is used for heater; I will leave this wafer into this etchant. What will happen if I do that? If I do that then I will have metal protected only beneath the photoresist correct; only beneath the photoresistr rest of the metal was not protected it will get etched, it will get etched.

Now, I will dip this wafer in acetone; I will leave this wafer in acetone- acetone. If I dip the wafer in acetone what will happen is a strip for photoresist; that means my photoresist will go. And what I will have, I have oxidized silicon substrate with a heater. On this, I will deposit or I will grow insulator, alright. This is my second mask.

And then I will have, I can protect the contact area somewhere I cannot grow insulator on that area so that is fine. On this insulator we can deposit another metal; on insulator we are using another metal. This metal is for interdigitated electrodes. After depositing this metal we will spin coat, once again we have to do the same process with spin coat photoresist.

Then what you have to do pre-bake at 90 degree, then what you have to do load the mask. This mask is for patterning the metal for interdigitated electrodes; matter for, masks for, this is my bright filled mask for patterning the interdigitated electrodes, right. After this what we will do you will expose using UV. When you expose using UV after that you have to unload the mask.

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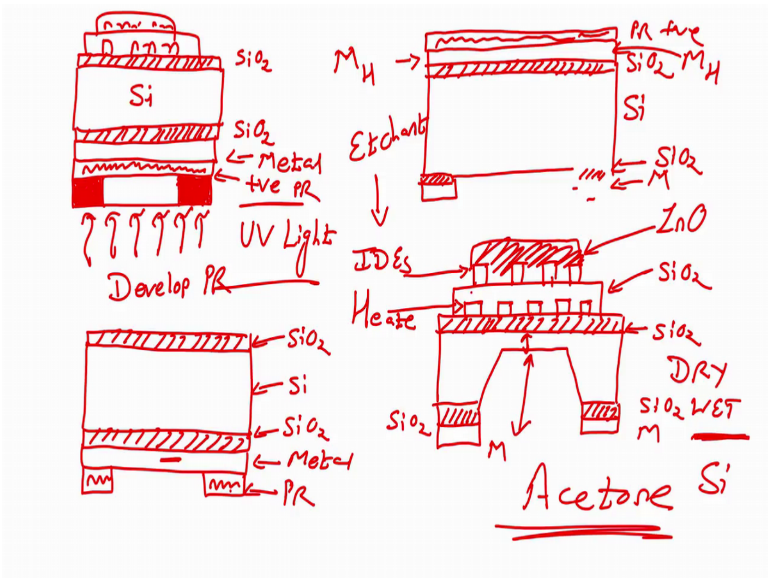

When you load the mask then you what you have to do, you have to dip the wafer in photoresist developer. So, when you dip the wafer in photoresist developer what you get, you get photoresist saved in the area which were not exposed. This is photoresist which is saved in the area which was not exposed. That is it is retaining the same pattern with the mask head.

After this I had to dip this wafer in the etchant for metal which is used for inter digital electrons. After this we have to etch this wafer or dip this wafer in the metal etchant which is used for the matter which is used for inter digital electrons. So, we will dip this wafer in the etchant that can etch the metal which is used for inter digital electrons. When we dip this wafer what will get? What will get? The metal below the photoresist would be protected.

After that we will dip this wafer in acetone, when we dip this wafer in acetone what we get we get photoresist is stripped off. When photoresist is stripped off you have interdigitated electrodes. Now what you have you have heater right, you do not have this metal you have actual heater, you have insulator, you have interdigitated electrodes. On these individual electrodes we can deposit material which is your semiconducting oxide or metal oxide; metal oxide semiconductor; metal oxide semiconductor such as ZnO such as ZnO, right.

Now, after this you have the sensor ready, but the silicon is thick. So, you have to reduce the size of silicon. So, for that you have to etch the wafer and when you dip this wafer you can do two things: one is called dry etching we will see, another is called wet etching. If you use dry etching then you can etch the wafer by protecting the front area you can even put this wafer in the dry etchant. And what you will see is it will keep on etching until the thickness that you require. This is dry etching, right this is a protection, this is a front protection, front area we are protecting; protection.

Or if you use wet etching for silicon, this is we are etching silicon right, then what you will have. If I have wet etching then I have a diaphragm this is called a diaphragm d i a diaphragm p h r a m- d i a p h r a g m diaphragm, alright.

So, you can have this thin diaphragm of the sensor and then you can remove the front area protection thing. You got it. So, it is a lot of process. So, if I do not do this backside etching then it is easy. If I do not do this backside etching then my sensor becomes extremely easy, because I had to just keep on growing the heater, then I had to grow the oxide on that interdigitated electrodes, on that I had to grow the sensing layer that is it. But the power consumption is high that is why I have to etch the wafer from backside, that I had to etch the wafer from backside.

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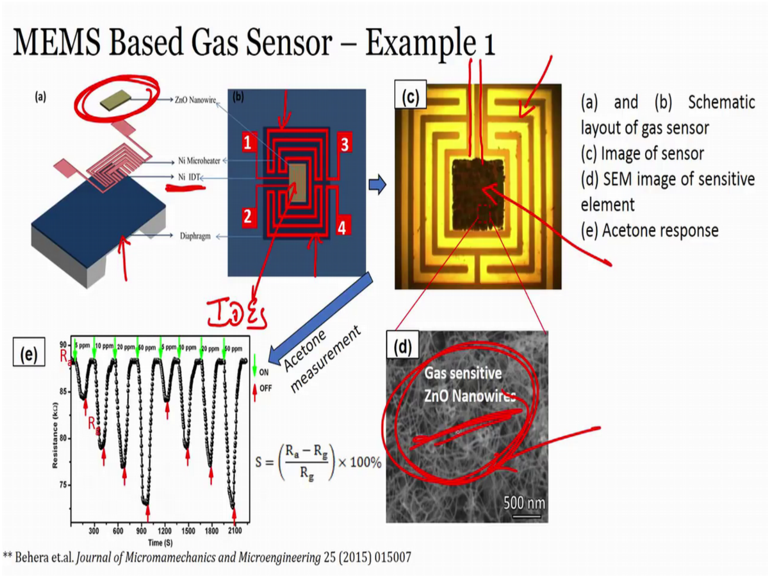

So when you do this, how the sensor looks like. You see this is a cross section or blown up diagram where you see there is a diaphragm right, and you can see there is there are interdigitated electrodes and there is a heater which is nickel; we are use nickel as microheater right you can see. And this micrometer is all the way here, here, here. And in center there are interdigitated electrodes on which we have grown zinc oxide nanowires. How zinc oxide nanowires look like? You can see the SEM image right over here; zinc oxide unaware.

So, when you actually operate this is how the heater is operating. You can see this yellow color this one right this heater is on, these are connection to the interdigitated electrodes this is connection to the interdigitated ectrodes. And this one this one is your zinc oxide sensing layer you can see here in gas sensitive ZnO nano wires, right.

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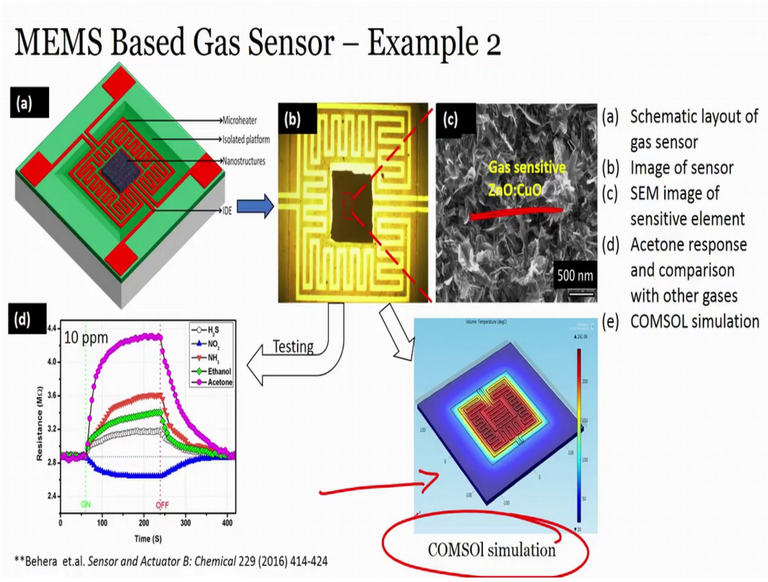

This is another cross section is the same thing right just the material is different. And you can see that you can also perform the COMSOL simulation; COMSOL simulation to understand what is the heating characteristics of the micro heater that you have designed on this oxidized silicon substrate, right.

So, the idea is not to confuse you with why we had to use gas sensor or how this ZnO nanowires are created we do not care.

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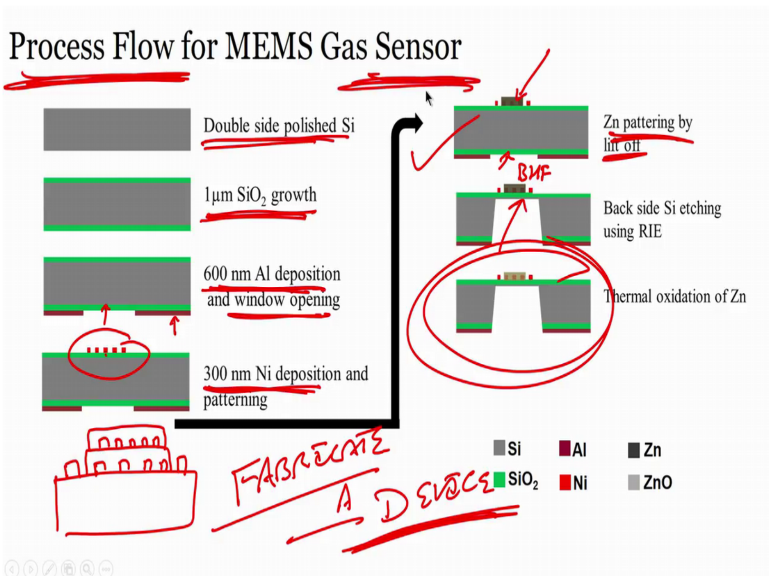

What we care is how we can grow or how you can process or how we can fabricate, right a device that is the idea; how you can fabricate a device. And for fabricating a device you should know the process flow; you should know the process flow, right. So, if you quickly see this particular slide you will understand what I was talking about right. You start with double side poly silicon wafer, then you grow 1 micron oxide, easy. Then you grow 16 nanometer metal here, you can see metal is here. And you open the window; that means, you grow the metal, you do the lithography, then create a window, this window this SiO 2 there can be etched, right, but as it can be etched by using BHF.

Now in the front side you can have the nickel micro heater, on nickel micro meter you can have electrodes. This is just an electrode alright; there is no heater here that is why. But actually there is a nickel devotion; so this is a heater right. So, after the heater after this particular process we have this nickel micro heater on which there is a insulator; there is this insulator on which there are interdigitated electrodes on which there is a sensing layer. This is what it is here.

So, we have double side polysilicon, and we have 6 micron SiO 2, then we have 600 nanometer aluminum backside, then we have frontside 300 mn nickel deposition we pattern it, then we grow the oxide and then under the oxide we grow the interdigitated electrodes and then on that we have the zinc pattern by a technique called lift off or lithography. Then when the backside we remove this oxide with help of buffer hydrofluoric acid we etch the wafer, right. And when you do this one you can have the sensor.

This is a process flow for fabricating a sensor. Now, until now we have seen two process flow: one is the process flow that is used for creating interdigitated electrodes in SU-8 well, second is the process flow for understanding how you can fabricate a sensor; how you can fabricate a gas sensor. Two process flows we have seen. So, this is enough for us to understand when you look at the MOSFET fabrication; when you look at the MOSFET fabrication.

So, in the next class let us quickly see what are the process, what are the techniques that we can use to fabricate or to fabricate the MOSFET. So, the techniques that we will be using or techniques that we will be understanding would be oxidation, it would be oxidation or thermal oxidation. And then we will see how metals are deposited. Then we have to see how the lithography is done. And then we will see; what are the etching techniques, then we will see how the MOSFET is fabricated. And that will, that particular set of experiments will help us to understand how we can fabricate a MOSFET.

Once you are able to understand how you can fabricate a MOSFET, then you can fabricate lot of devices. So, the role of this particular exercise understanding how interdigitated electrodes are fabricated within a SU-8 well or a sensor that is fabricated on the oxidized silicon wafer or if you want to create a diaphragm or you want to create a heater, on that heater we have insulator, on insulator we have individual electrodes, on their generators we have sensor, sensing material which is your metal oxide semiconductor materials which is like zinc oxide tin oxide indium oxide and so and so forth, all this exercise that we are doing; I am repeating it 10 times so that you understand the process.

The process is extremely simple, when we go to the MOSFET then you will understand why or which techniques we have used to grow the oxide layer on silicon, which techniques we have used to etch the silicon, which techniques we have used to open the window, right. Because we had to understand how source and drain are diffused in the MOSFET. So, to understand how source and drain are diffused in the MOSFET these processes is that we are discussing today will be extremely useful, alright.

So I will see you in the next class, and till then learn, again look at the video micro fabrication, it looks very simple; when I am explaining you on the on the screen, but in reality it is difficult to understand. But once you understand it is very easy to understand a lot of process flows, lot of recipes, alright.

So, I hope that you have understood something from today's lecture, and you read it you understand further, and if you have any questions you can ask me. Ask me questions when we reach to the lecture where I am explaining you the MOSFET, because at that particular point you can go back and correlate your things and then you ask me your question. Here you may have lot of questions, but let you wait have some patience until we read to the lecture where I explain you how you can fabricate our MOSFET, alright.

So, I will see you in the next class. Till then you take care, have a nice day, bye.