Electronic Systems for Cancer Diagnosis
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Lecture – 59
Etching Process

Welcome. In this module we will see a live demonstration of the Etching Process which you might have studied in the theory modules. Etching as you know is one process in the whole; in the whole micro fabrication process flow where you remove material from a pattern that you have formed using lithographic techniques like photolithography or electron beam lithography. So, it is subtractive process where you remove material, that is etching from a basic level basic point of view.

Before we go into the actual process of etching, you need to know that etching fundamentally is a chemical process. There is also a reactive ion etching which has physical and chemical processes involved in it, but my point is not about the science of it, but about the safety of it. So, because it involves handling chemicals you need to be governed properly. So, as you can see, I have put gloves, face mask, head mask and more importantly goggles to protect your eyes from any unaccounted for the reactions that might occur.

This is actually, even this is not enough if you are handling much sever chemicals like hydrogen fluoride, then you need to have a Teflon coated gloves on top of it. But since the chemical that we are handling today in this demonstration are not that dangerous we can afford to use this much protection to demonstrate the etching process. Conventionally etching is done on a wet bench, this is a wet bench process. What is a wet bench? Wet bench is a workstation where liquids, chemicals in liquid form are processed are used for making devices microfabricated devices.

Microfabricated devices it will have a flow of water, deionized water preferably and air to clear wash it and drive the samples that are used. So, today because again since it is a very simple demonstration of etching, we do not, we are not actually doing it on a wet bench where just doing it on our table top, benchtop and we will be demonstrating basic etching process.

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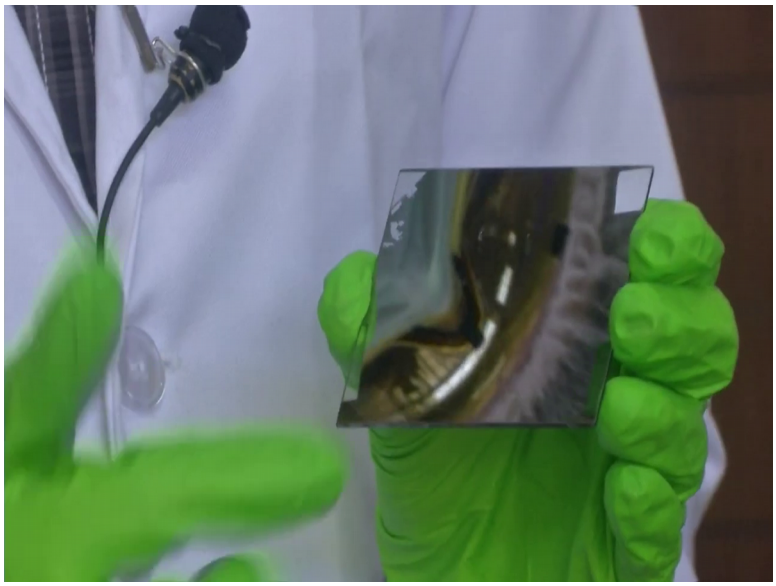

Now, what we are going to etch is, that pattern that we are going to etch is on this glass wafer ok. I am not sure whether you will be able to see the pattern, but it will be visible once the etching process completes. Now, let me quickly describe you the process flow of this. This is a 3 inch square glass wafer glass slide, where we have patterned a micro heater using nickel.

So, and then so what is the process flow? We take a glass 3 inch glass slide, we do piranha cleaning of the glass slide, we clear the clean the glass slide, then we do nickel metal deposition, nickel deposition on top blanket deposition using methods like either EDM evaporation or spattering. This is specifically a spattered deposited nickel. So, we do nickel deposition.

Then next what is the next step? Next step is to form the pattern on the microheater of the microheater on the glass slide. So, how do we do the patterning? We need the source, right. So, that source will come from the source design will come from the mask plate. So, mask plate is where the design of your microheater will be there and that mask plate will be used with the photolithography machine to create the pattern on your glass slide.

So, again coming back you have your glass slide, you put nickel material on top of the glass slide ok. Next is to pattern it, right. Before patterning what do you have to do? You have to coat the glass slide which has the nickel deposited with any photoresist material, ok. It can be a positive pr or a negative pr that you might have learnt in theory. You

record with a photo resist material. Then, how do you coat it? You coat it with spin coating, you put the material on top, then you put it in a spin coater in the spin coater this glass slide will rotate continuously and uniformly distribute the photo resist material on the glass slide. Once that is done you take the glass slide from the spin coater and then you put it on a hot plate to bake it ok.

So, that is that is for like 1 or 2 minutes of at 110 degree Celsius you will bake the glass slide, then photo resist is nicely coated on your surface, underneath is the nickel material. Then you take the glass slide you got your photo lithography machine. There, you load your mask plate, then you load your sample which is the glass slide with nickel and photoresist coated and then you expose the glass slide with the photo resist using your mask plate which has a design of the microheater on it.

So, why by exposure what do you mean? By exposure we mean flooding your sample which is the glass slide, using a UV light source through the mask plate. Then what happens? Wherever the design is there that part will not get exposed and the remaining part gets exposed depending on what type of pr you are using. It happens the other way if you are using a negative pr ok.

So, that is a method. Once exposure is done you take it out again, then you have to develop your photo resist material. So, that is again development process is there ok. After developing you do hard baking. So, then hard baking will be done. So, during developing in all the areas where the pattern is not there the photo resist will be removed. Photo resist will be there only as at the on top of the pattern. So, this photoresist that is there will act as the etch stop, while you are doing while you are doing etching ok.

Then you do the hard baking again at 110 degree for 2 minutes or depending on the process flow and after hard baking you take out the sample. Now, the sample is ready for etching. So, what I have in my hand right now is a sample that is ready for etching ok. So, are you able to see the pattern here? You will be slightly able to see the pattern once we come into focus, a small heater pattern. A pattern is visible inside, yes. So, this pattern is visible, but it is flooded with nickel material if you see in this portion, in this portion everywhere nickel is there and this is visible because pr is also there on top of it that is why its slightly visible in contrast with the nickel material.

Now, when we do etching, we do not want nickel here or here or anywhere else except where the pattern is there. So, we will do etching where the nickel will get removed from unwanted places and they will stay underneath the pr. Once that process is done next stop is to even if the process is done your pr will still cover your nickel material, right, so then you have to remove your photo resist that is the final process. Today we will be showing only the etching process where the nickel gets removed from the remaining parts apart from the pattern ok. So, before we actually do the experiment, I have some more few more things to you tell you.

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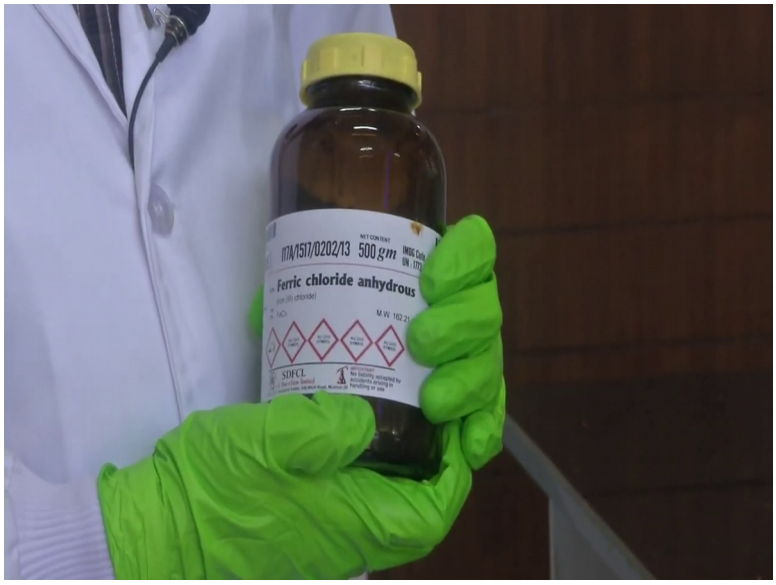

So, the etchant that we use for nickel etching is ferric chloride. So, this is ferric chloride anhydrous that means, its dry ferric chloride. So, we take a specific amount, depending upon the concentration that you need for the etchant. Let us say 3 grams, 10 grams and then dissolved it in 100 ml or 200 ml of the ionized water, ok. So, you can, so for every process. So, let us say you deposited your metal with the with spattering as compared to depositing your metal with EBM evaporation the metal coating that you have on your glass slide will vary, accordingly your etch rate will also vary.

So, when you are first proving your process flow to make a device you will have to optimise your etchant because at one etchant concentration that works for one device might not work for another device because how the materials where deposited might be different. And the processes which we are followed, like how much time it was heated, at

what temperature it was heated at previous steps, all this will affect the etch rate. So, before you fix the etch rate what we do is you start with a very dilute concentration of the etch rate. See how the etching is happening and then keep changing it. So, that finally, you get an optimum concentration of the etching and the etch time.

So, what are critical two critical factors in etching? It is the etch rate of the etchant which is directly related to the concentration of the etchant that you use and the time of etching how much time you want to do the etching. Why time of etching is important is, one thing is if you if you keep it in the solution for a long time even your pattern which you want to preserve underneath your pr even that will get etched off by seepage underneath the photo resist material.

And another thing is even if you are slightly over time you will get undercuts in your design. Let us say your features have to be perfect flats right, perpendicular features you have 190 nanometre metal coated and you have photo resist material on top and at the edges of the features you want perfect flat downs, but because of etching they form v shape structures. These are called undercuts. So, to avoid such undercuts you have to critically optimise your etch time and etch rate. So, this is these are very crucial parameters in process design and process finalization when you want to make a device, ok. So, let us get to the etching. So, we have already prepared the etchant which is ferric chloride.

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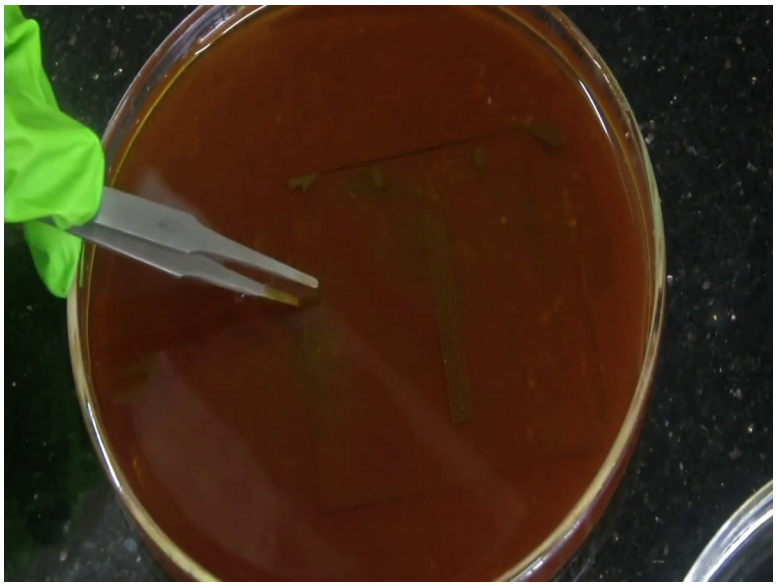

So, we have prepared the etchant material which is ferric chloride made a solution in DI water. So, that is there here. And once we do etching you we will directly put in the dish which contains de-ionized water which is this second dish ok. So, let us start doing it. So, what we have to do is take your glass slide which has the pattern and then we have to dip it in the etchant. So, we have to we have optimized the time, so it is around 1 minute, in 1 minute 10 seconds the etching will complete. So, we have put it I hope you will be able to see the substrate on it.

So, you can now you do not see any change. So, if just wait. After sometime you will start seeing material getting removed. Yes, now you can see here material is slowly getting removed from here, it will get removed from here. So, it is good to always good to agitate. Uniform agitation of the sample is always advised. So, you can see that material is getting removed. So, you can see that bottom part full part. So, if you see here full area the material is removed. You can see the pattern very more clearly now. But material has to be removed from this portion also do you see. So, it is slowly getting removed.

So, we will wait for the material as it is very clearly visible we will wait for the material to be removed from the proportion. So, some sometimes what happens is because of the any process variations, especially perturb deposited metal is very difficult to etch usually EBM evaporation is preferred to for etching. So, because this is perturb deposited gold there is some non-uniformity in the metal deposited also on the slide, that is why some part the metal is removed and some part it is still there. So, let just wait it out and see if it goes if it does not go also that is also again a problem with the metal that is deposited because of the process.

But here reasonably it is going. You can see now it is much clear, the pattern is much more clear, most of the metal has gone. And the photo resist material has protected the design and thus the nickel underneath. Yes, now it has been properly removed, fully removed, you can see the whole pattern very clearly once this is done the next step is to take it and put in de-ionized water. So, I am taking it, putting it in water, then we have to wash it. So, this is done.

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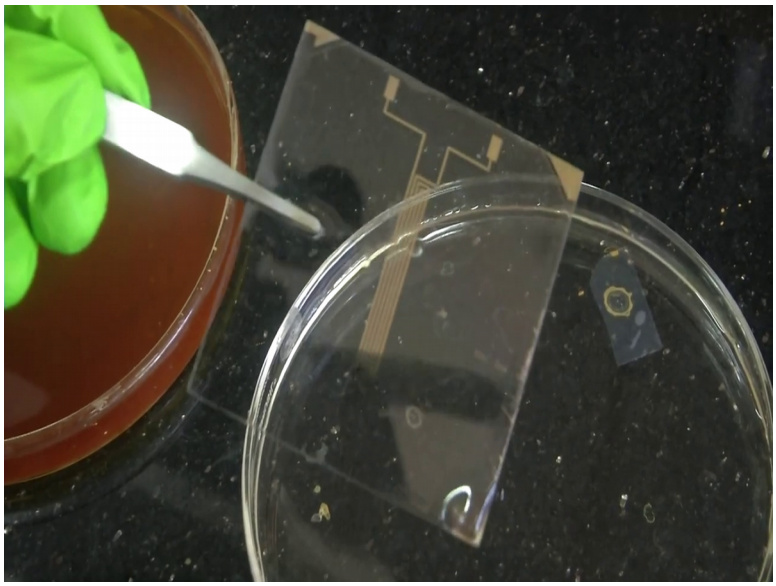

Next process is we will take it out we will blow dry it we will not show it here so that this wafer is dry. So, after this blow dried, I will show you these pattern under the microscope how it looks ok. So, you can see now very clearly the pattern is very clear now you can see how it was before and how it is now. The nickel has been removed from everywhere else except for the where the pattern is. Very nice nicely it has come it has got etched everywhere throughout and then next step we can see it under microscope.

So, please remind yourself that this is not the end of the process flow; next step is to you have to expose the metal, right. Now, metal is underneath the photoresist. So, you have to remove the photo resist also for that what you have to do is dip it in acetone, then IPA 30 seconds each and then wash it with water, that is final step. We will not be showing that here now or we will try to show it at a later point. Now, this module was to show you how etching is done, after I blow dry this we will also see this under the microscope.

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So, now as I have said we have blow dried the sample, so sample is dry now, next is to image it correct. As you might have seen the features or not that small, they are reasonably mix features. The overall device dimension is in centimetre scale. So, viewing it under the microscope does not give that much utility, but one thing we can see is see the metal underneath the photo resist and see if how the fee sharpness of the features that have been formed. These things you can see even if it is a large device ok. So, we have taken the glass slide and we are viewing it with the metallurgical microscope.

So, metallurgical microscope is something that has both bottom illumination and top illumination. And if it is a opaque sample, where which does not allow light to pass through you can use the top illumination to image your devices or whatever be the sample. And if it is a glass slide transparent sample like a glass slide what is in it in our case, we can even use the bottom illumination. So, here because we are using a glass slide, I have used the bottom illumination. So, the metallurgical microscope is also the conventional applied microscope, it is almost same, just that it is a slightly been more sophisticated instrument.

So, it has different types of magnifications, 5x magnification which is what I have kept it right now. So, the rings; the coloured rings on the objective pieces shows us what is the magnification. The red colour is a 5x magnification, the yellow colour is 10x, the green

colour its 20x, the blue is 50x, the white is 100x. But as I have said just now our features as I said are not that small. So, we can easily image the features with the 5x magnification itself. So, this is the 5x magnification you can easily image it with the 5x magnification itself.

So, we have, it is not actually again a miss normal, I should state it very clearly. The magnification is not 5x we have an eye piece here eye piece gives 10x magnification by default. So, that 10x into 5x, so its overall 50x magnification that we get ok. And what the eye piece sees is also captured by a camera here, you can see that. What the eye piece sees is captured by the camera, the camera is connected to a machine and finally, to a software which captures the video feed from the capture camera and that can we captured as an image for your further the (Refer Time: 17:47) for publication whatever, ok.

So, that is the brief introduction about the microscope that we are using. We have other microscopes also like stereo, inverted microscope. Inverted microscope is mainly used for imaging biological samples ok. Now, I have kept the sample underneath. I have put the view in the microheater area. We will just see how sharp the features are ok. Now, yes, I have seen it under the eye piece, now we are seeing it in the software in the video feed. You can see it on the screen ok.

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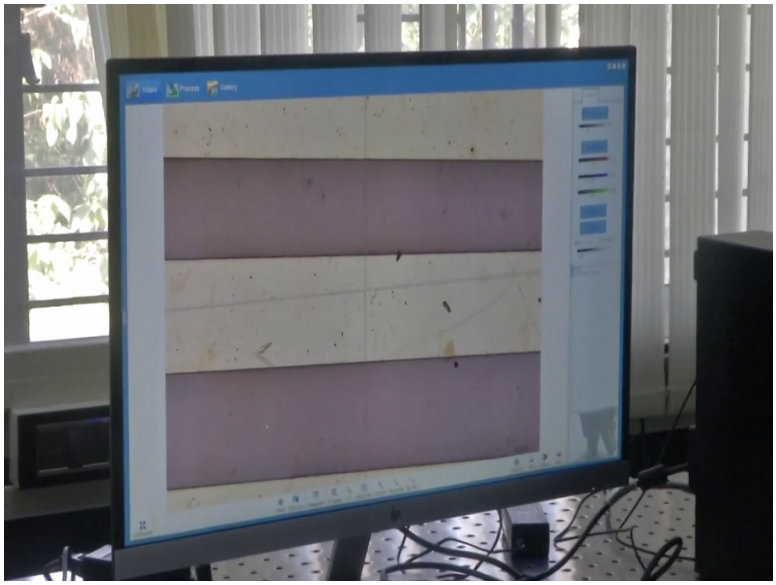

So, now you can see the very sharp features that have been formed. You can you can just ignore this small dots that are there, those are slight dust particles that have com settled because we were doing in this in the lab not using a wet bench. Just for the showing it to you; ideally, we should be doing it in a wet bench.

So, we can see how sharp the features are and the colour change shows you that it is the metal and the photo resist that is there ok. Metal has been removed from this light area and this dark area contains the metal and the photoresistor. So, with this way you will be able to see that the metal has not been etched it has become it has been a very perfect etch and there are no undercuts. If there was an undercut you would see a gradation of colour here at the boundary which we do not see. You see a sharp boundary here that means, there has not been any under etching and the etching is quite clear ok. We can see other area of the sample if you want.

So, this is the contact pad this. So, that is why it is so big, so big dark area is there because this is the contact pad and this is there a metal has been removed. So, hope this is clear to you. This is how we will use the microscope to see how the features have been formed on your etched sample.

So, what all we have done? We have used the post lithography, post development sample used a etchant, appropriate etchant, you choose your etchant depending upon the metal that you have used or other material non-metal also. What are the material that you have used? There is even silicon dioxide etching, so there many processes. Then you use a suitable etchant, you etch it, after optimising the etching time you etch it for that exact time so that your etching features are sharp and as per design.

Once etching is done you wash it and dry it, then you can see it under the microscope how features are formed. And final step would be to remove the photo resist material that is there on top of the features and then you can directly use your sample for either for you experiments or for further processes if yours is a multi-process process flow, multi-step process flow.

Hope you have understood the etching process clearly. See you again.