Biomedical Ultrasound: Fundamentals of Imaging and Micromachined Transducers

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Lecture: 54

Wet bench lab demonstration

Welcome to this lab video lecture, It is a short lab video but an important one because here we have shown you how to perform a wet etching. Suppose you have a metal deposited onto a wafer and you want to etch the wafer. How to use etchant for that particular metal. You can also use wet etching if it is a silicon dioxide. For example, if you want to etch silicon dioxide, you can use buffer hydrofluoric acid or BHF. So, depending on what kind of material that you are depositing, you can use wet etching technique. In wet etching, if there is acid, there is an acid bench, and if there is a solvent, then there is a solvent bench. For every time when you use a wet etching technique, it follows by rinsing it with deionized water. and drying it with nitrogen air. So, enjoy the lab video. If you have any questions, feel free to ask us on the NPTEL forum and we will be very happy to reply to your queries and questions.

Hello and welcome back to another TA session. Today we will be working on the wet bench. So wet bench can be used for multiple purposes like solvent cleaning, acid cleaning, etching as well as lift off. So, today we will be starting first with the solvent cleaning. So, the importance of solvent cleaning is before moving to any further steps.

For example, we might have deposited some material and now we want to go for lithography. So, meanwhile it might happen that there will be some dust particles or some contaminants that are coming and sitting on your sample. And if these dust particles or particulate matter has a similar dimension as that of your critical dimension, then your lithography process might fail. So, you do a solvent cleaning before moving to lithography. So, the advantage of solvent cleaning over acid cleaning is that it does not remove most of the metal thin films like metals and dielectrics.

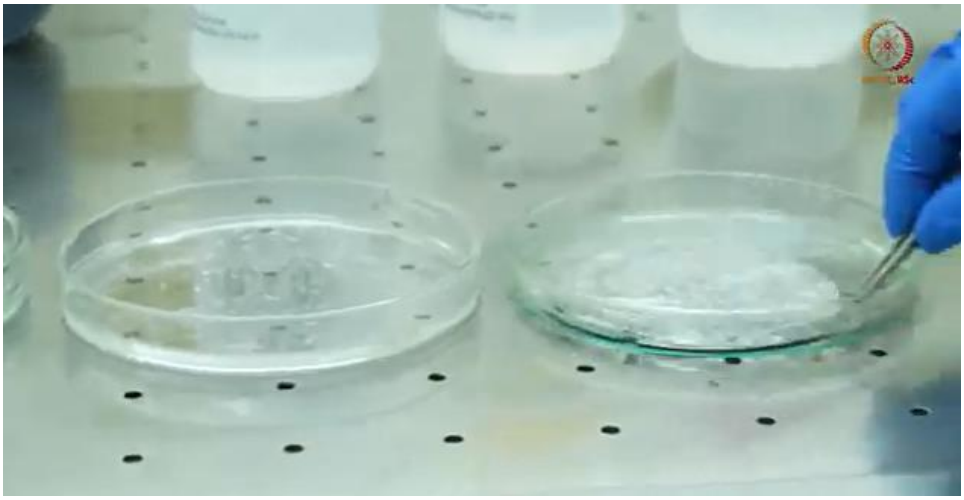
So, to start with, first and foremost the important thing is to wear the PPE, right now I am wearing my clean room gown as well as my hair net, mask and gloves. But this is for general purpose. When you are dealing with chemicals, depending upon the potency of chemicals or the hazard of the chemical, you might need specialized PPEs. So today for solvent cleaning, we'll be dealing with acetone, and isopropyl alcohol (IPA). So, when we are dealing with acetone and IPA, the required PPEs are a face shield and a gown and an extra set of gloves.

I am already wearing an extra set of gloves. So, only thing left to do is wear the apron as well as the face shield. So, here we have our apron. and our face shield. Once I'm ready with my PPE, now I can move to my wet bench and start the process.

So here as you can see I have my sample which is basically a 4 inch glass wafer which we have coated with aluminium using thermal deposition. So we will be doing a solvent cleaning on this and then we will move for lithography.

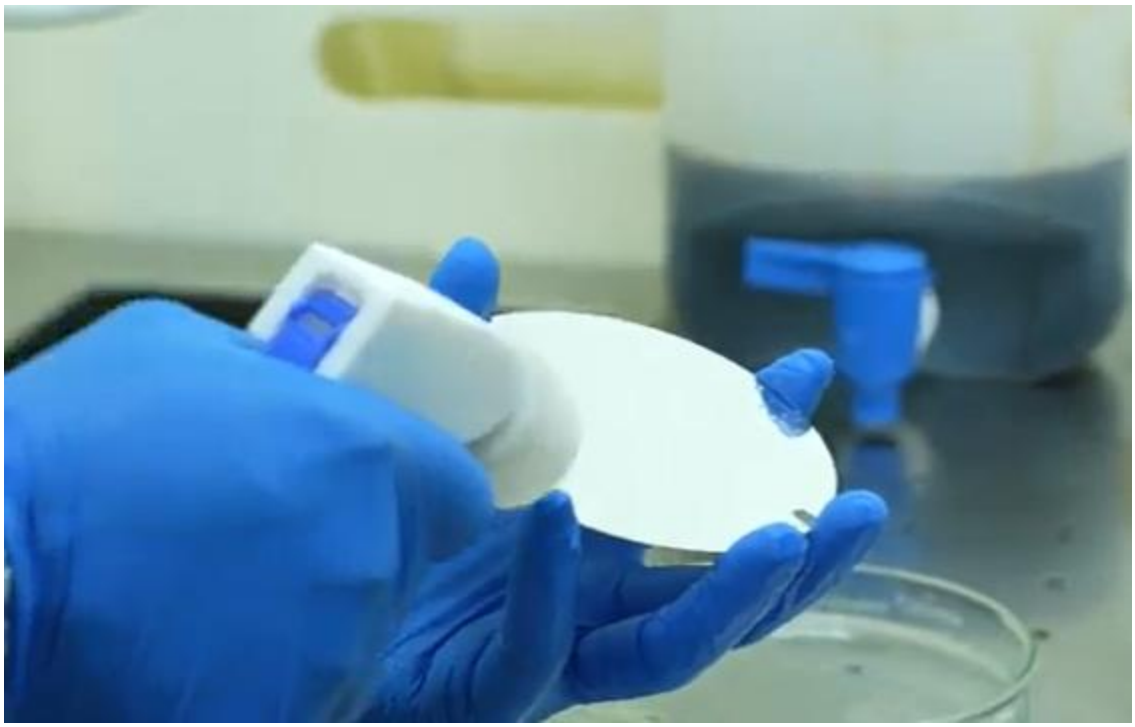
So the first step is to make sure you have all the chemicals that you need. So for my solvent cleaning, I'll be using acetone, isopropyl alcohol, and then to wash off this isopropyl alcohol, I'll be using deionized water. So let me keep my sample aside and I'll pour the chemicals.

So make sure that the quantity of the chemical which you are using, is just enough so that your sample is completely submerged inside. If a part of your sample is floating outside or not properly submerged, it is possible that the cleaning won't be proper and you will have some contamination left. Now, I will take my sample using this tweezer and with the support of my hand, I will dip it in acetone. Once it is completely dipped, I will start agitating it so that the cleaning is proper. I will continue this for about 2 minutes and then we will move to IPA.



So we have agitated it for two minutes and now we will move the sample from acetone to IPA that is the isopropyl alcohol or isopropanol again we will continue this agitation in IPA for two minutes and then we'll move to DI water. Once this is completed, I'll take it out and wash it with running water. This ensures that any residual IPA or acetone that I might have on my sample is completely washed away.

Now, once that is done, I will be blow drying it with nitrogen. Now, after washing my sample with DI water, I've ensured that there are no traces of acetone and IPA. Now I'll blow dry with nitrogen.



Now on visually inspection my sample looks dry but it is possible that there still might be some moisture so the next process before going to the next process we will be the first step would be to keep it on a dehydration bake where we will use a hot plate to heat our substrate, or sample at an elevated temperature for a few minutes which will ensure that all the moisture is dried up.

Now, you have seen how to do solvent cleaning of a sample before doing any kind of process. So today we will do etching of gold and we will see what all etchants are used and how the process goes. So, first and foremost requirement of using acid and solvent benches is wearing a proper PPE kit. For that, I have already worn an acid resistant apron and I have worn two pairs of gloves so that if any chemical spills happen, it won't affect my hands or it won't affect my skin. Also one more thing, for safety measures, we should not replace or exchange glassware of acid and solvent because acid and solvent doesn't go hand in hand and it can give an exothermic reaction and that may lead to fire hazard. So the ideal practice is we should keep separate glass wares for acid and solvent benches. Today the demonstration will be on acid bench. So I have separate glass wares for the acid bench and for the process which I will be going through.

Today we will be doing gold etching. So for that I need gold etchant which is potassium iodide and iodine solution. So I have prepared saturated potassium iodide in DI water and I have put one crystal of iodine into it. So it has become a etchant for gold and now we will have a closer look and we will see how the gold etching will work. Before having the closer look I should cover my face.

So for that I will use a face shield and that will complete my PPE except the gloves which are acid resistant which I will be wearing once we have a closer look onto the wet bench.

So before handling any chemical, I should wear one more set of gloves. Those are thick nitrile gloves and they are very much chemical resistant. We may call it as MAPA gloves. So these green colored gloves are those which I will be wearing.

These blue colored gloves are thin nitrile and they are very less chemical resistant. Already I have worn two set of gloves on my hand and on top of it I will wear these green gloves as well. So ideally you should not touch the fingers and the hand part because these gloves

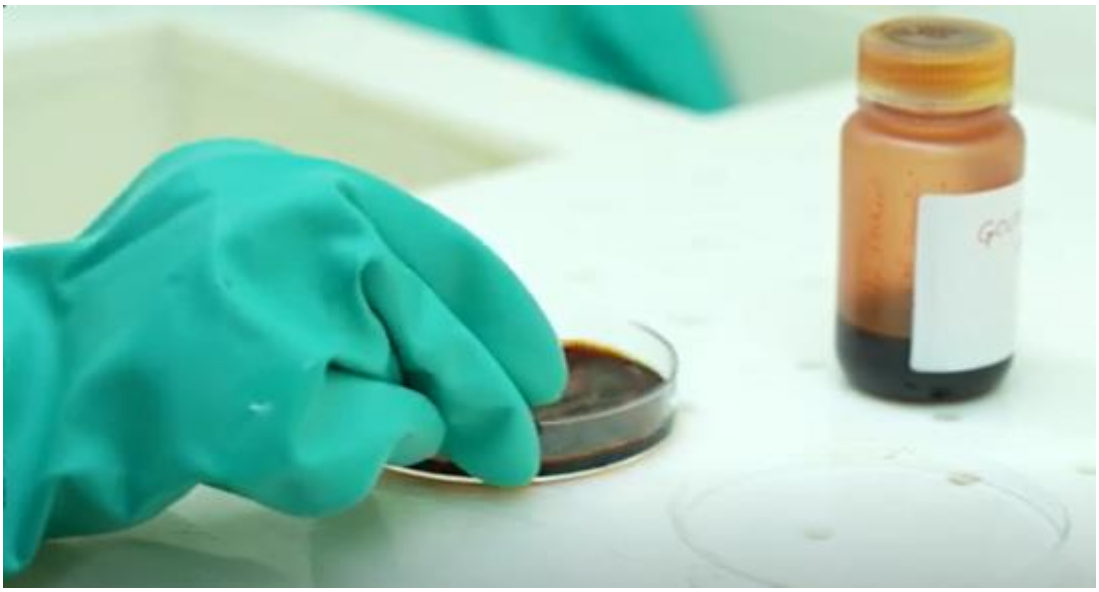
may be contaminated. So while wearing I will take care that I will not touch any fingers or the hand area in the glove. So I have put on my gloves and now we can look forward to the solution which I will be using for gold etching.

So I have already prepared this gold etchant solution. It is potassium iodide saturated in DI water and one crystal of iodine. So this is a dark brown color solution as you can see.

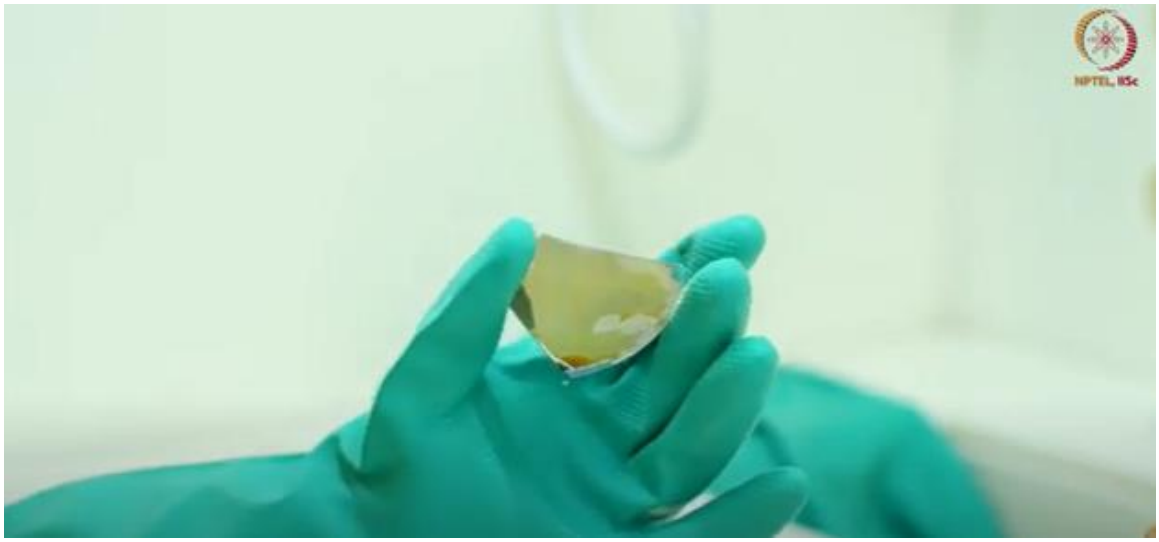
Now it's time to pour the solution into the petri dish. So i'll take a small amount such that my sample dips into my etchant solution and I have my sample in this petri dish, this is a gold coated sample. I have coated 200 nanometers of gold onto it. So this is a glass wafer and I have coated gold onto it. As you might be seeing, this is a plastic tweezers. So, when we are dealing with acids, we should ideally use plastic tweezers because metal may

corrode when we are dealing with acid. So, I am using this plastic or polymer based tweezers.

This is a timed etch. So how much ever is my thickness is, it will etch for that much amount of time. So the ideal etching rate is 0.5 micron per minute. So I have 200 nanometers of film. So it will take about 30 seconds to etch and that I can visually see when my sample will be inside the gold etchant. So I'm putting the gold sample inside the gold etching and I'll start agitating it so that the etchant comes over the sample and I'll agitate for 30 seconds.

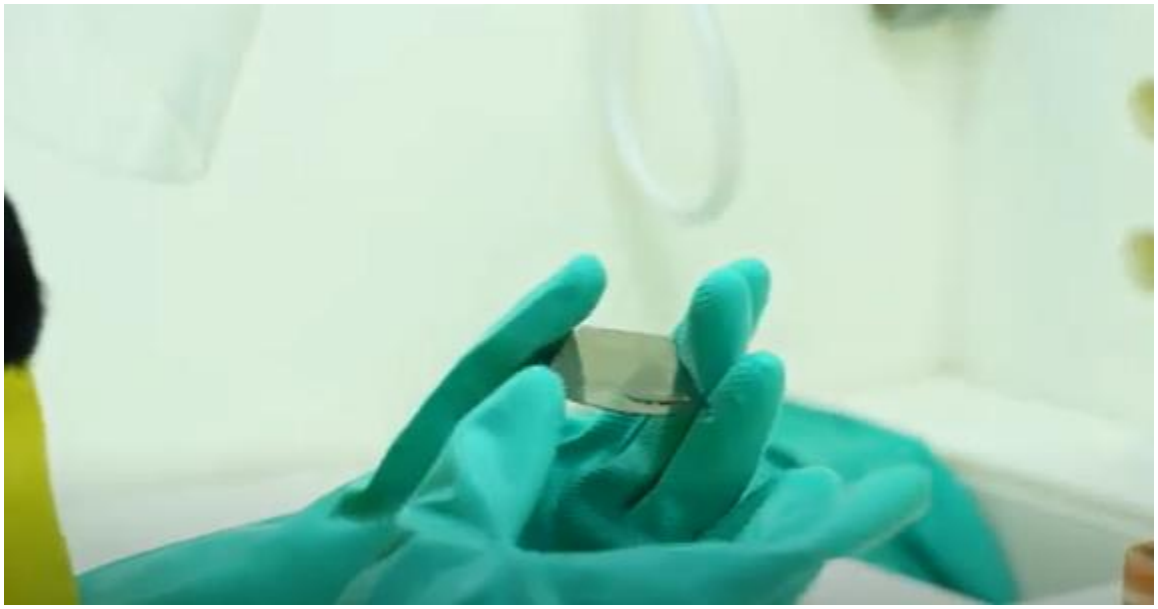


now let's see what is the result and we'll take out the sample. It's already 30 seconds so we'll have a look at the sample.



Some gold is still there i'll put it for 10 more seconds and our gold etching will be done.

I think it's done now, we'll put the sample in DI water so that the gold etchant will wash out. So i'm putting the sample in the petri dish, in which DI water is already filled, and i'll just agitate.



Now you can see the sample which was yellowish in color because of gold, has now turned silverish because we have coated titanium onto it for the adhesion of gold. Now to remove this DI water i'll use the blow dry nitrogen nitrogen gun to make it dry so i'll go to the nitrogen gun and we'll have a closer look of the nitrogen gun as well. Now before touching any other things, I should remove my contaminated gloves and I should not touch the contaminated part. So I carefully remove my gloves and I am ensuring that I am not touching any contaminated part.

Again the sample can go for one more DI water rinse before I put it for blow dry. So I have taken the sample out of my DI water and we will give it a blow dry.

So this is the nitrogen gun. It contains high pressure nitrogen and I will blow dry to remove all my water particles or water droplets from my substrate.

So this completes my gold etching. I will place back the sample onto my petri dish and now I can take it for further process, if required. So this is all for etching.

Now we will have another session where we will give a demo of lift off. Lift off is one of the different techniques from conventional lithography. So what happens in conventional

lithography is we first coat a metal or we deposit a metal, and to pattern that metal, we do photolithography wherein we pattern photoresist. So we first coat photoresist, then with the help of photo mask, we place the photo mask on top of the coated wafer and then we expose it with UV. So wherever the opaque regions are there in the mask, the light will not pass and through and it will pass through the transparent region and the properties of photoresist will change.

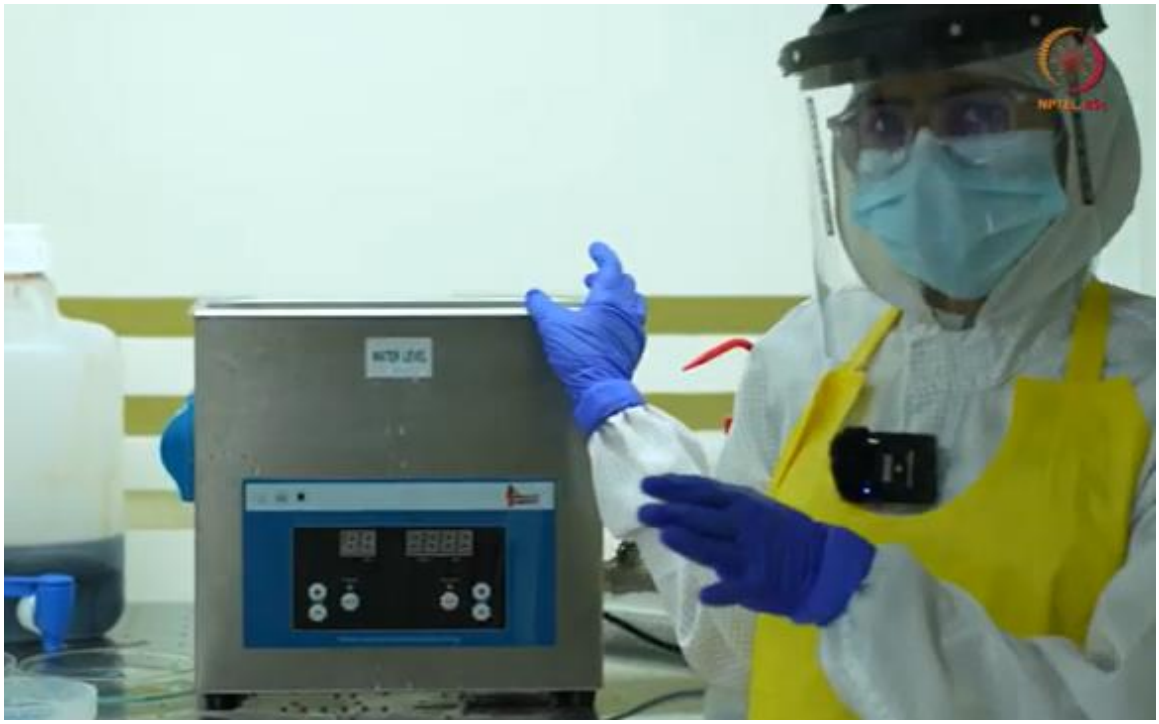
And when we develop this photoresist coated wafer, wherever the light has exposed, wherever the chemical reaction has started, that part will dissolve and we will get the pattern of the mask onto the photoresist. So now we have a layer wherein we have the substrate. On top of that we have blanket deposition or everywhere there is a metal. and on top of that we have some patterns of photoresist wherein somewhere photoresist is present on some region photoresist is not present and when we go for etching of those, the etchant will only target the regions wherein photoresist is not present or wherein metal is exposed. So wherever the metal is exposed that region will etch out and then the patterns of photoresist is transferred to the metals and then that photoresist can be stripped off using acetone.

However, in the lift-off what happens is we first do the lithography wherein we first coat the wafer with photoresist then we put a mask, shine light so wherever there is an opaque region, the light will not pass and wherever there is transparent region light will pass. Again the chemical reaction will happen. So once we develop, wherever the light was exposed, that part will dissolve and we will get the patterns on photoresist.

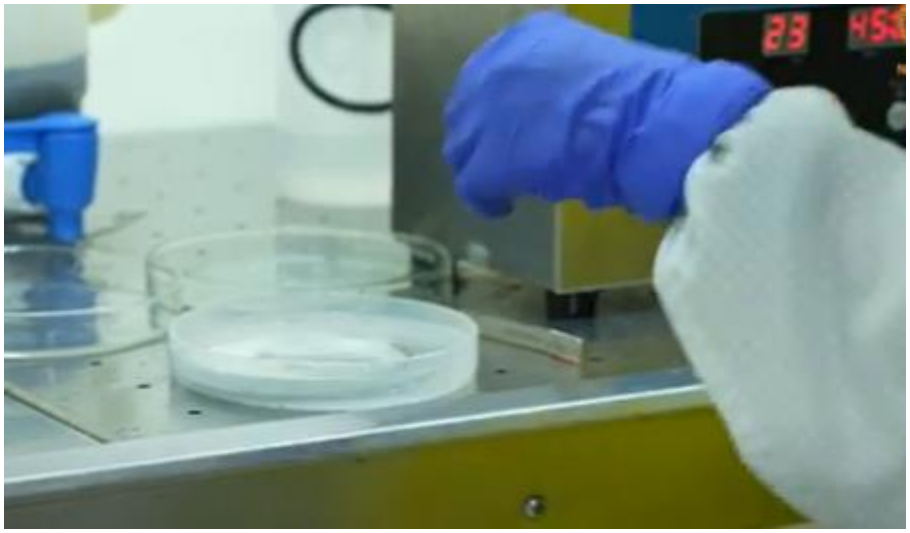
Now we have a substrate wherein in some region there is photoresist and in some region there is it is a plain wafer. Now this wafer, we will put for deposition wherein a thin layer of metal is deposited. So we will have a substrate, on top of that somewhere there is photoresist somewhere it is plain wafer and on top of that we have a blanket deposition of metal. This lift off technique is used when we don't have etchant to etch the metal. So what will happen when we put this substrate or this wafer into acetone. Acetone is a photoresist stripper. So acetone will go inside the metal and it will take out the photoresist. When it takes out the photoresist, it will automatically take out the metal as well, along with the photoresist. So in that way we are patterning our metal with respect to our patterned photoresist and that's how we get the pattern. So these are the two techniques one is the conventional lithography and another another is the lift off to create patterns on your added additive layer metal or any oxide layer.

So now we'll have a closer look of the tool which we'll be using and how we'll carry forward our lift off process. Before I start any process and start handling the solvent bench, again, I'll have to wear this chemical resistant apron. And one set of gloves is enough because here we are dealing with solvent. So if anything falls, and the skin is exposed, as such, nothing will happen. But I should cover my face. So again, I'll wear the face shield.

And for the liftoff technique, as i have told you that acetone should go inside the metal and search for the photoresist and along with the photoresist, the metal will come out. So for this, the acetone should go inside the metal and for that we need a higher agitation and that higher agitation is provided with the help of ultrasonic bath. So the ultrasonic bath has an ultrasound frequency applied to the water bath, which is kept inside, and that water will start shaking and will agitate my acetone which is kept inside the petri dish That's how the acetone will reach the photoresist and the photoresist along with the metal will come out.



Now we'll have a closer look of this machine and we'll see how we'll start the process. So I have my wafer into this petri dish. I'll put acetone and fully cover this wafer with the acetone.



Once I do that, I will switch on the ultrasonic bath, and I will place this petri dish into the water.

We will have the closer look of this process and see how the agitation is happening. So this acetone is getting agitated and you can see the photoresist was present here and it has started coming out along with the metal on top of it. I'll just make sure that the petri dish is parallel and you can see small small metal particles that has come out as we were agitating this acetone.

So I feel this is almost done. Now I will transfer the wafer to IPA and clean the wafer using IPA. So, I have stopped the equipment and I have taken out the petri dish. Now, as we have seen some small small metal particles were floating around. So, I want to clean it. So, again I will put IPA in another petri dish and I will transfer this wafer into the petri dish where i have kept the IPA and again i will do the same process for cleaning the wafer. Now the the lift off is done and we are just cleaning. So i'll wait for a couple of seconds, 30 seconds or so because i just need the extra metal particles to go out and we'll be done. Once done, I'll stop the tool and I'll take this out And one last step is to put it in DI water and blow dry the wafer to take out the water droplets. Now the wafer was in IPA. I will transfer it to DI water to give a final rinse.

I will give some amount of agitation just to get rid of any contaminants or the metal particles. And I will take it out. And now I will give the nitrogen blow dry. So as to the

water droplets which are there on the wafer will go away. And now this is my final wafer wherein my lithography pattern has really come up well onto my metal thin film.

So with this I will place back the wafer again to my original petri dish from where I took out my wafer, so as to take it for further processing and this ends the wet bench session with first part of solvent cleaning wherein before any step or before lithography the solvent cleaning is done. In second part, we have seen the gold etching wherein using conventional lithography how we will pattern the metal using metal etchant. So we have used the gold etchant to etch the gold. And in third part we have seen if we don't have etchant to etch the metal then how we can pattern the metal with the help of lift off. So this ends the wet bench session and that's all for today's lab demo. Thank you.