Advanced Neural Science for Engineers
Professor Hardik J. Pandya
Department of Electronic Systems Engineering, Division of EECS
Indian Institute of Science Bangalore

Lecture 14
Lab 04 E Beam Evaporation

(Refer Slide Time: 00:01)

Welcome to this lab module. Here today, we will be discussing something like PVD like physical vapor deposition and we will be demonstrating the part. So, till now, whatever we have

learned is, first we have shown do the governing procedure or what is the governing procedure? What is the importance of governing procedure and introduction to the clean room?

Then, we have a tour and then in the next module we have shown how the cleaning was performed? So, here we have shown piranha cleaning of a silicon wafer, but the same process can be done for the silicon wafer as well as for the glass wafers.

In the next module we have seen how we can spin code polyimide and how to make a polyimide layer? So, that much was like film preparation after that one of the main part of that fabrication came into picture that is lithography. So, in our last module, we have discussed what is with lithography? How to do this? And different types of photo masks different type of photo resist and using positive photo resist how we did that photolithography process? That much was described in the last till the last module.

In this module, as we have mentioned earlier, we will see how to deposit actinium and platinum using electron beam evaporation technique, and then we will go to, go for the lift up to get the metal patterning of that metal layer. So, here whatever system you can see, this is on electron beam evaporation system. However, this system has capability of being e beam operation as well as thermal evaporation.

In this module, we will be discussing only about the tool first. What are the different parts of the tool? And what is importance of these parts? And how to and will demonstrate electron beam evaporation technique and in some other module we will show how to go for thermal evaporation technique? And then in that module we will discuss what are the differences of the processes? And then if time permits, we will show you another technique, another PVD technique that is sputtering.

So, we will show all these module, I mean all these processes in subsequent modules, but for today, we will focus only on e-beam evaporation. So, this is the chamber of this tool. So, in this chamber whenever we will open the chamber we will see that in front side there is electron beam evaporation setup and the backside is a thermal operation setup. So, if let us say when deposition is going on that time the chamber will be under vacuum so we are not allowed to open the chamber.

At that time, we can just open this viewport and see whatever is going on inside, now tool is off and there is no like light source inside like when we do electron beam evaporation or deposition that time we would have one filament that filament generates light. So, that time we can see what is going on inside or even in thermal evaporation system that filament or the due to joules heating that will also generate some light so we can see what is going on inside, but now tool is off so we cannot see, but this is the viewport just so that we can observe the things inside.

So here you can see there are two pipes coming so these are water pipes, these are connected to the chiller. So here one of these is to supply the cold water or the chilled water and the temperature will be around 19 to 21 degrees C. So, when it will flow in the inside as well as outside here you can we will show that later on. So here inside outside everywhere the connection is there. So it will be used as a coolant, so, whatever temperature or the heat generated inside will be dispersed and using the other one will just mean maintain a flow of water so that we can cool down the tools inside as well as the chamber.

(Refer Slide Time: 04:31)

Now next, let us see the other parts like inlets and outlets to the chamber. So this is the other side that we are talking about, so, here are the pipes and here are the lines what you can see, like for water cooling; cooling of the chiller, so here let us come to the inlet. So here the first one you can see this is air supply. So this is a connection from the compression unit. So as you know that (most) I mean few of the valves are pneumatic valves. So just to switch on or off or for the operation we need air supply for some particular pressure that will be show showing inside what is the condition, this is a vent valve.

So, venting means putting air or inletting air in the chamber. So, here this is the vent valve you can see that just pipe is there and it is cut here. So, venting can be either in clean room

environment or it is actually recommended to vent it using nitrogen as we have enough purity of air inside like purity in sense less number of dust particles here inside so, we are venting it in a clean room environment only otherwise it is recommended to use nitrogen cylinder.

Here this is needle valve inlet, so, needle valve is used when you want any other gas to be inside like maybe argon maybe nitrogen or maybe oxygen for your deposition. So, if you want that type of environment in your chamber, then you can use this and here you can see the cooling water in and out as we have already shown there outside the chamber, this is the thing and here you can see that this is rotary pump exhaust.

So, you will be shown here that there are two types of pumps available, so, in any depositional system. The first one is used for taking the pressure from atmospheric pressure to some 10^{-4} m bar pressure, or 10^{-3} or 10^{-4} m bar pressure. So, rotary pump does that job and there is highway compounds like it may be a diffusion pump or it may be turbo molecular pump those will be used for high vacuum reaching the high vacuum, so, this is a rotary pump.

So, initially when rotary pump works so that will have some exhaust, so, that exhaust will be can be like oil based exhaust or just the air outlet. So, this whatever the exhausts are there you are taking it out and keeping it outside the clean room or just throwing it outside clean room because that may contaminate our clean room environment. So, this is the things that are connected directly to the chamber, so, now we will focus the other units as well.

So, after this you can see this, so, this is for liquid pouring liquid nitrogen. So, let us say this is the chamber. So, these pumps will take some time to create vacuum in this chamber, to make that process a little faster or not only a little faster, but also to hold at a, hold a particular vacuum level in the chamber we can use liquid nitrogen. So as you already know that liquid nitrogen is having a temperature of more than -150. So, that will help to get all the molecules here at the same place.

So that it will be easier for the pump for suction. So, here we can just pour liquid nitrogen it will go inside you can see the port from here it will be inside there below this chamber and as chamber is open there, whatever molecules are there that will go there and it will be stuck and suctioned eventually.

So, now, let us come to this front side, we will just open this and see what are the components that is inside, that is making this whole system work. So, here before opening, either it should make sure that power is off or here you can see already the things are written here that isolate main supply before removing this cover, this is connected to one of the safety interlocks. If this is ON then your tool can only create vacuum but it will not go to the process step or it cannot go to the deposition step that is because of your safety reasons and you can see here this is electrical hazard sign.

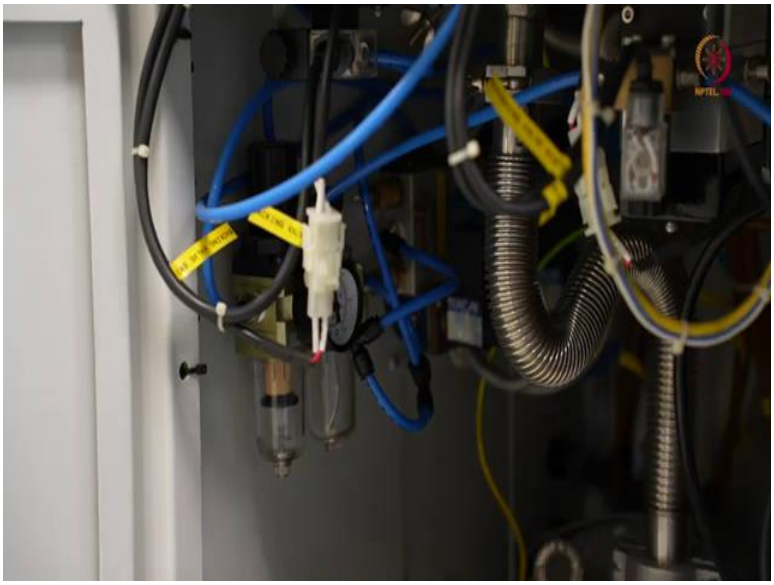
So, now you know what you are expecting inside. We open this, so, here you can see the first one this is a rotary pump that we were talking about this rotary pump, can create a vacuum up to 10-4 millibar range. So usually at atmospheric pressure first this pump starts working or these pumps starts creating vacuum and when the pressure reaches 10^{-3} millibar range, that time turbo molecular pump to cover the things.

So here from here if you see this is here, how is the line is connected here and here, the next thing we can show is that roughing valve, so like that you have two valve here roughing and backing valve. So, these two are actually connecting the lines because here you can see, so, this is this one is common to both the lines backing line as well as the roughing line, when it creates vacuum directly from the chamber, it was as the roughing line and when turbo molecular pump to cover the things that time these acts as a backing valve.

So, it helps turbo molecular pump by creating a continuous pressure of minus 4 to the remaining area and this turbo molecular pump will create vacuum in the chamber. So, as we have shown these two valves after that, this one as you can see, this is our turbo molecular pump so it can rotate up to 13000 RPM and it can drag the particles or the air in the chamber to this and through the line there, we cannot show it from here, through that line it will take the things out.

Next, after these valves we can see here the transformers, these transformers are so at least this and this we can see one more transformer is there for the e beam. So, these transformers we can see, these are useful for thermal evaporation, so, this we will discuss in the later modules.

(Refer Slide Time: 11:45)



So, now, let us come to this side. So, here you can see. So, as you remember that from outside we are showing on air supply port there are on air supply line and that channel came through this and from here we can see how much pressure is there and how much pressure will act on the pneumatic valves here because that is one of the main thing that will decide whether the valves will open or closed or will operate or not.

So, before starting the tool, if you are not sure, you can just check here whether you have the pressure or if somehow the process fails or if somehow the pump does not start working you can just come and check whether this is on and water cooling system is also there inside and here this

other shuttered things like whatever shuttered and all we will show it inside. So, those controllers are also inside and backside there are water supplies. So, here backside as you can see has focused there.

So, those are the supplies for DI water these DI water will come through the chiller, so that it can maintain a particular and preset temperature always for cooling the chamber as well as the electron beam gun. So, we have seen what are all things we could show to this from this distance and now we will come to this part.

(Refer Slide Time: 13:13)

This is another transformer. So, this transformer is used to generate electron beam. So, only when we use this tool for electron beam like generating electron beam for heating, that time we just switch it on like just on and we have one more supply that we will show later while I mean during the process we will show that.

So here you have to on and you can see here interlock and fan these two are very important here, because as long as all the interlocks are not met your system or this transformer output will not come because this is 5 kilowatt system or output is 5 kilovolt of this transformer. So, it can give you a one electrical shock hazard, so, as this is very hazardous this is you cannot even take it out without opening the other parts not like that. And the fan is required to cool down the area so this is basic of this.

Now after this as we will switch on the tool in some time and as we are done with that part so we will close that door first, so, that the safety interlock will not be affected. Then we will move to the other parts. We will close the door and here you can see on interlock so this one when this will be closed it will press this and that will work as one of the interlocks to make sure that the door is closed and now the user is safe and this tool can go to the process step, so, we will close it now and lock.

(Refer Slide Time: 15:00)


I/O
Reset
Safety Interlocks
Water Cooling
Source Enabled
EMERGENCY
STOP
EMO
SYSTEMS
X
Y


Source Enabled
EMERGENCY
STOP
EMO
THIN FILM SYSTEMS
X
Y
High Voltage kV
Beam / Filament mA
EB3 Source Control
EB3 Sweep Control
RATE
Å /SEC
THICKNESS
KÅ

After that part we will come to the controller part. So, these are the units that will be controlled by this much of area basically and this is the display. So, let us start from the top, this is the display, where the system status will be shown and we can so this is basically touchpad based system, so, this touchpad display. So, here we can select what are all operations we want this tool to perform, after this display let us come to this part.

So, here this is you can see here 1 and 0 which is basically ON and OFF. So, this is a press switch, like you can press it, it will be on if you press it again it will be OFF. So, this is this corresponds to main supply or the electrical supply of this tool, here is the reset. So, by any chance, if you switch off the tool in hurry or if you press this emergency stop button by something because of the emergency or if it is not on properly there is some clips some electrical issue then there will be a hardware reset option, you can just reset it and then start the tool.

And here if you see the next these three are the indicators, these are not press switches you can see here you cannot press it. Basically these are indicators the first one as you can see, this is safety interlock. So, safety interlock means whether the tool is safe for the user to go for the high power operations like as we have shown already that there is a 5 kilo volt transformer. So, we cannot directly switch it on without covering the area or without ensuring that we will not be in touch to the transformer, so, like that as we have shown one door here front door we have opened and showed you the things.

So, like that we have three doors to access the different areas. So, all these three doors are connected to the same safety interlock and with that the vacuum created in the chamber that is also connected to the safety interlock, we should ensure that at least some amount of vacuum is there before starting the process. So, all these things will be part of safety interlock that when we will operate the tool, we will show the things again like how vacuum affects it? How these opening doors will affect? All these things we will show, though it is not recommended to leave the doors open and run the tool because that will be electrical hazard for you.

And here you can see this, the second one is that water cooling will be shown here whether water cooling is on or not this is that indication. So, here as already discussed, that chiller is required for cooling the gun as well as the chamber. So, whether that chiller supply is on or not first, and second, whether the pressure created by the water or the water flow basically, whether the water flow is enough or not, that will be indicated by this, if it glows that means it is we are good to go or if it does not glow then you have to go back and check whether chiller unit is on or not first or to somehow like water the amount of water in the chiller unit is enough or not or the third one whether it is creating the pressure or not, these three things you have to check.

If this does not glow and the third one is also enabled as we are not using this tool in automated mode, so, there are different types of tools as you already know. So, the tool can be completely manual, can be automated and can be semi-automated type, this is a semi-automated type tool. I mean, if you see any automated tool, then their source enabled part will be there.

So whenever deposition will go on it will show but in our case, we will just check this and this before starting the starting deposition. And here these two will press these are the buttons that will press before starting the tools. And here one of the most important feature of any of the tools that is emergency stop. So, emergency stop button means you can just press it and when it is done, you can just rotate it if you rotate, it will come up if you press it, it will be off, it will off all the tools all the valves and the parts.

So here why I am telling this is very important because if there is an emergency situation like maybe for the tool, maybe sudden power cut, or for or maybe there is a fire or some other hazard comes so and maybe for some chemical hazards you have to leave the tool. Chemical hazard

imposed by someone else or happened because of some other tool, but you have to leave the place immediately then you can just press the emergency stop and leave that is utility of this.

After this we will come to the next part, the controller parts. So, this whole thing this complete part that is basically the controllers associated to e-beam evaporator or e-beam evaporation technique. Here the first one you can see this is source control, in source control so what are all you are expecting, so, basically the first will be how much voltage you are supplying, how much current you are supplying and how much current you are supplying that should be controlled. And there are other parameters to check whether these are on or not these are the indicators here let us discuss this thing first.

So, here this is the on-off button, which corresponds to only this much area. So, when your transformer is on that time like even transformer is on the 5 kilo volt transformer that shown then you can just press it this will be this is press button after that, you can wait for some time start the gun, this is this gun corresponds to the electron beam gun when the gun is on after that you will you can increase the current from here or decrease the current.

So, basically you can control your current with this and that indicator this will show this display will show what is your current level at that time the value you can check from here and this indicator the first one this power, this vacuum will show you, this power will show whether power is on or not this vacuum will show whether enough vacuum is created in the chamber, third one water will show you whether water supply is there or not for cooling the gun, then the rotary drive whether it is on or not, then whether the gun is on.

So, this part will come only when you switch on this gun, and here local and remote. So, local corresponds to whether the deposition is happening in manual mode and remote will show whether the deposition is happening in automated mode. So, as our tool is capable of only of manual mode deposition, so, this local will be glowing. So, these things will just show during deposition as well.

So, here these are the other indicators that will show whether your tool is doing fine or not with this HB adjustment you can actually adjust where the beam will fall you can change it through that and it is once it is fixed or finalized, it is recommended not to touch that and shift the beam. So, little bit beam steering can be done with this.

So, now let us come to the second part. So, in the second part you can see this is special swift control, swift control means whatever beam we are generating, so we are now we will control the beam. So, the beam may have maybe like a point or maybe any of these waveforms like sine wave, triangular wave, square wave and it will have two components like y component and x component, so, that we can see here that x component controller is this part, y component controller is this part. So, let us say this is x direction and this is y direction both can be controlled by these two controllers.

Here as you can see, both frequency we have set it at 29 hertz and here there is an offset like the HB adjustment this also once it is set offset did not to be changed for all the depositions, only what we are supposed to change is if we want it as a point source, then you can leave it as 0. So that this part will be off and it will generate a point source or point beam from the source and it will fall on the crucible. And now if you keep it as 1, so now this panel will be on and then you can select along y axis and along the x axis and along y axis whether you want the waveform to be sine or triangular or square that you have to decide.

And here these two will be used to define the amplitude. If you increase the amplitude, then it will take more area let us say, if you increase the amplitude it will take more area if you decrease the amplitude then it will take lesser area on the crucible that can be controlled by these two. Here as in closer shot you can probably see that platinum for diamond like for different materials, we have already noted the things, but that optimization that you can do for I mean that is too specific and you can do it for your tool as well.

Usually, we deposit always at the sine mode, so like sinusoidal type, so, along x axis it will be like this sine and along y axis it will be like this. So, that will generate our whole I mean superposition of these two will generate the beam.

Here now, coming to the third part, when we will open the tool that time we will show again that we have four (())(25:49) that we will show that and what are the materials are loaded that we will be discussing. So, before that, we can just show that 4 are there and this is the turret controller where you can switch on this controller and you can change whichever crucible you want to select and how fast that crucible change will happen that you can select from this. So, we always preferred to be preferred to change the crucible at its maximum speed possible.

And here as you can see, like these are the indicators that you will see which crucible is selected, so, we will come to the turret controller but later. Now, come to let us go to one of the another important part that is DTM. In this DTM we can mainly see two things you have two displays here, one is about the rate another one is about the thickness and here these are the parameters that defines on material for that QCM or the quartz crystal monitor.

The quartz crystal monitor is inside that will show once we open the chamber and here actually we can input properties of the materials so we can select a film number and correspond to that film number we can actually use the inputs as number basically like tooling factor then density then ACI or tooling factor. So, with this we can just define one material for this particular DTM. So, whenever we will go to that film number, let us say film number corresponds to titanium or film one corresponds to platinum. So let us say when we will deposit platinum, as all these values are already there.

So we just select film one and we will get that stored values there and from that whatever material will be deposited on the QCM or quartz crystal monitor we can get a rate, rate of deposition and thickness means total how much thickness has been deposited, these two will get and this is the controller like start, stop and test like that for refreshing or for starting that thing and increase and decrease these two useful to give the input about film number and about these things. So, this is what this is how we are using this DTM our digital thickness monitor.

(Refer Slide Time: 28:31)

So after DTM this is the next panel. So here this corresponds to mainly current levels then DTM on or off DTM power supply then shutters. So, let us come on by one. So, here this LT secondary current, HD primary current and this control like this current controllers these things will be discussed on the next day because this corresponds more to thermal evaporation, so, leave this part for this module let us focus on this part.

So, here as you see, if we switch it on then this is basically DTM will be on, if tool is on and here this is EBM shuttered. So, electron beam gun shuttered is here so on crucible on shuttered is there and it will be there as long as material is not completely ready for the deposition. So it will melt and it will start I mean we have optimized the recipe so as per the recipe it will start at some point it will be like it will be ready for deposition in a steady rate.

So till that time we have to wait so after that we can just open the shutter here again two things are there like local and remote, so, remote corresponds to automated thing that we do not have that option here available now, we have to build it for local and do it by ourselves like opening it or closing it ourselves in manual mode. So this is kind of I mean controller of the shutter part. Here this is rotary drive controller, so, if rotary drive is there so if we want to deposit material in static mode, then we can just keep it off, if we switch it on, then rotation mode will be on and after this rotation mode is on that whole chuck that we will be showing the chuck, the whole chuck will be rotating.

So, if we there are differences that we will be discussing, but this for rotation and here rotation controller, so, this will change the speed. Here for this tool, we fix it at one point and we optimized all the recipes, so, we do not prefer to change this or change this RPM, we just, if we want a stationary mode deposition, then we leave it here, if we want deposition in rotation mode, then we just switched on that you will have a better idea when you will see operation of the tools.

(Refer Slide Time: 31:09)

So now we are going to switch on that tool. So as I have already mentioned, the chiller and compressor should be on. So that is here on my right side that we will switch it on, eventually, and then main power will be on that connection, that supplies here. So, let us come to this first, so, here the first one is connection to the chiller and the second switch is for the compressor. So let us switch on the chiller and compressor then this is the kind of prerequisite for the tool for operating the tool then we will go to the main power supply.

So here I think you can see two switches here one, here the other one this as it is already we have written it for our purposes only that this is a system power and this is electron beam gun power EBG power as you can see here, and here you can see this supply basically these two are different types of supplies, this is just like on 230 volt normal connection as we use and this is to support a 5 kilo volt transformer, so, this has some better arrangement for this and on inbuilt ground line, you can see the copper strip here this is going, so, this is one copper strip that is going as earthing.

This anyway we will switch on these only when we are about to deposit something otherwise this should be off, just to avoid the electrical hazard and this is the system power that we will be switching on now. After switching on the main power, so, now we are here as we have already discussed about this panel. So, we have to turn on this power as we have switched it on, you can see here it is asking for a reset and with that it is showing that water cooling is already on.

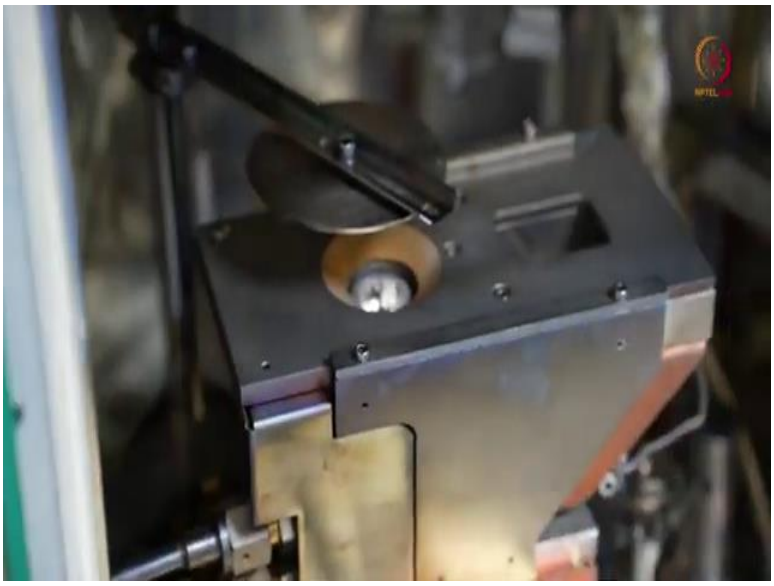
So as we have switched on the chiller, so, it is showing the water cooling thing, but safety interlock it is not displaying because it asked for on reset but reset then only it can sense that, so, let us go for reset. As we press the reset you can see the safety interlock is on, water cooling is on and so we are good to go with the system I mean with our next process.

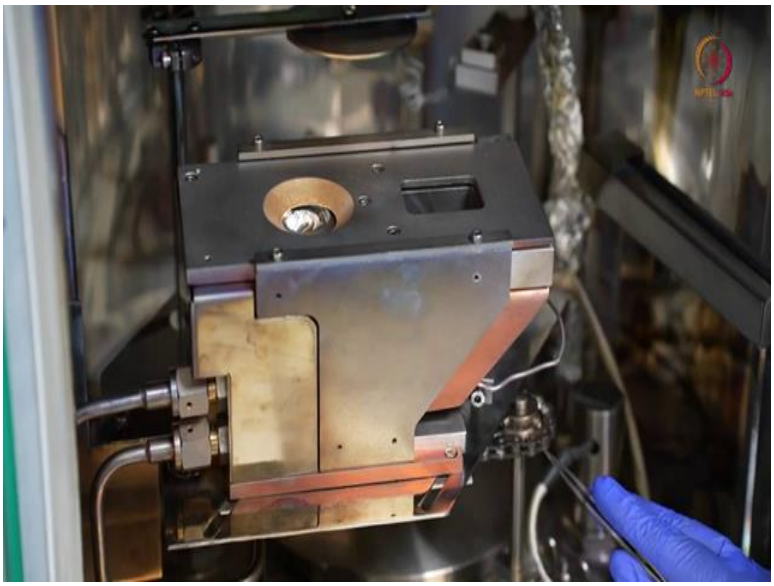
So, here we can see this is the display see the status here, system status is showing standby; standby means only I think if you can observe little closely you can see that one fan sound is coming extra so that is basically to cool down the tool whenever it is reset and other things are fine then it will switch on the fans. So, here you can see the system status has standby, then chamber pressure.

So, any vacuum tool is supposed to be kept under some vacuum always so that the chamber will be under some vacuum let us say minus 4 level minus whatever as you wish. Here as the Pirani gauge is showing this much vacuum is still remaining in the chamber. We did not use it for a long time still it is like that. And here we have two options like either start or vent. Start means it will start the pump and vent means we can open the chamber as we have to load our sample first, so, we have to vent open the chamber and then we can go for the next steps. So let me press vent and then open the chamber and see what is there.

Here you can see that after pressing vent the system status changed to chamber vent sequence and air admit valve open and you can see chamber pressure is falling now and it will reach atmospheric pressure. If you closely if you observe on extra air inlet sound you will get so this is from the display you can just check the things then let us wait when it is showing that it is under atmospheric pressure so we will try to open our chamber as air inlet was on and I mean now the chamber is under atmospheric pressure so we are not allowed to open the chamber.

(Refer Slide Time: 35:25)





So, let us open, so here this is the chamber inside I just I do not want to touch the things. So, here this part is basically for electron beam evaporation. So, here you may not be able to see here, here is the filament inside there is a filament. So, that filament will be heated and electron beam will be generated and pass through this. So, here we have one open area like one square rectangular open slot. So, from here the electron will come you will avoid this and fall here.

So, in the theory classes I think you have already you have taught that one filament will generate the electron beam and using the magnet here it will be there will be a 270 degree deflection of the film and it will fall on the crucible. So, you can see it here now, actually through this and with magnetic film it, magnetic field it will come and fall here, here you can see this is the

shutter. So, as long as this material is not properly melt or is not ready for evaporation still some amount of material will come out. So, the shutter will stop it and stop it from getting deposited on the chuck.

So, here is the chuck we will show the chuck again when we load the sample. So, and here you can see two pipes. So, basically these are the chiller these pipes are from the chiller unit and to the chiller unit.

One is inlet the other one is outlet, this will be useful to cool down the filament and this whole module during deposition and even after deposition you can just keep your chiller or you can keep your chiller on so that water will flow through this and it will be cooled down otherwise this is a filament made up of tungsten, the tungsten filament will be very hot and you should not open the chamber and let on hot filament to be exposed to the air there is a fair chance that it will be oxidized or it will go bad also, so, this is mainly about this module.

This here you can see this is a QCM or quartz crystal monitor this is here is the, here it will be deposited the front side here it will be deposited and the data we can get it from the DTM that we have already shown and discussed it is that. Here you can see on turret this is for movement of the turret but the crucibles that crucible will take it out and show.

Before that so this will be useful for moving the things and here you can see right side this facility is there to generate plasma inside for cleaning purpose, so, we can generate plasma and clean the chamber inside that is on and back side you can see that is for thermal evaporation that we will discuss in the next module or the upcoming modules in all of those.

Here this is basically a chamber before that let us come closer it to see the crucible. So, to get access to these crucibles we have to open the shutter first, so, let us remove the shutter I mean open the shutter so here you can see one of the materials as I already mentioned that there are four crucibles so let us just check what are the four crucible is there. So this one is so here titanium is loaded you can see so how to take the crucibles out? It is like you can take any tweezer like that and just slowly take it out and here you can see that this is these are basically the like holders for the crucible, this whole thing this turret can rotate or can move.

So, before checking the other things I just want to place it, so, before any deposition you should check whether enough material is there for the next deposition that is something you should follow, you should not end up depositing your crucible material on your sample that is something you should check. So this is the first one titanium loaded here, then we already changed the thing so you can check here see it is rotating moving to the next crucible.

Here I guess from the color you can understand that this is gold I am just taking out this and show. So, gold is loaded here you have to just remember which crucible corresponds to which material or what type of material is loaded in which crucible that you have to just keep a note before deposition so that you can like you can deposit without making any mistake. So, here if you see this crucible this is aluminum. So, one quick note for those who are not used to use these tools, so, you can see some extra material here right.

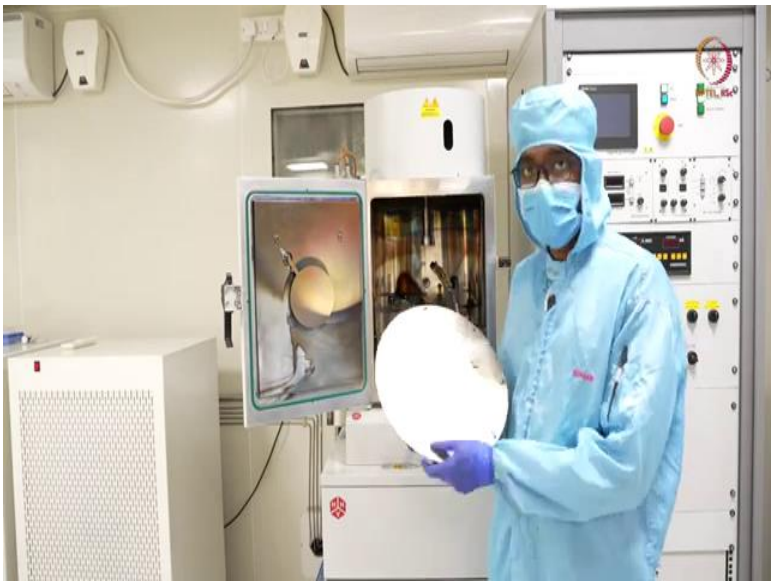
So, who are like not familiar that much to this tool, just a quick note for them you should not fill material more than 70 percent of any crucible, 70 to 80 percent max if you fill more than that it will spill. So, when we started this aluminum is like the cheapest material and for any for testing purpose usually people use aluminum. So, similar purpose we used aluminum and it just got spilled a little bit these type of problems may occur because of either like shifting of the beam or not proper placement of the beam or it may occur due to loading more amount of materials, so, you should take care of this, this is aluminum.

And as the next one we will show, you can see here this is platinum. So, as already discussed the other day that whatever patterns we have, we want titanium platinum basically platinum as the metal layer and titanium as the intermediate layer or the aeration layer. So, we need to deposit this and we have already shown that titanium is also that and that amount of material what we want to deposit that is also kind of, so, we can now go for the deposition that is our first thing.

So, as we will be depositing titanium first, so, you should make sure that titanium will be there first and then the gold or sorry, titanium will be there first and then we will change during the process, so, this is this how turret controller is used and how this can be used. And here if you can just see its rotating again take it from here if some problem happens here then definitely the rotation will be stopped. So as I was telling that it should be in our case it is crucible three for our tool we kept titanium at crucible three.

So let it move in each crucible three then we will stop this rotation or this will be start by itself basically, so, see now it is stopped and we have titanium there and we have check all the crucibles and the materials are fine. So after all this before starting the things will close this shutter so that during heating up or pre-deposition heating, it should not start the position directly on the wafer, so it is covered. So, now let us discuss general things and then we will show how to load the sample on that.

(Refer Slide Time: 44:13)



Till now we have actually shown the crucibles inside I mean with loaded materials. So, this is how the crucible look like this is the spare part, spare crucibles. So here we can actually if we want to load in a new material, we cannot reuse any crucible. So we have to have some spare crucibles with us. Now crucible material can be different like based on the material you are using it for crucible materials are different. Let us say if material x will diffuse in material y then x and y materials together you cannot use either as crucible material or the material to deposit then material x will diffuse through the material y and you will end up wasting the material.

So for using any or for before loading any material you should check whether the material diffuses through that and you will find there are various online sources where you will find for a particular material let us say for gold or let us say for platinum, what type of crucibles can be used? That you have to check first procured the crucibles according to that and then you can load the materials and load it inside the chamber, here two crucibles you can see here. So, here the left hand this is molybdenum based crucible and right hand this one is graphite based crucible in closer obviously, you can see the difference like its smoothness, how it is made and all this.

So, materials and even weight you can feel all these weight and you will understand the differences though from like a far look it may be of the similar color, but this is not the same material you will understand these things.

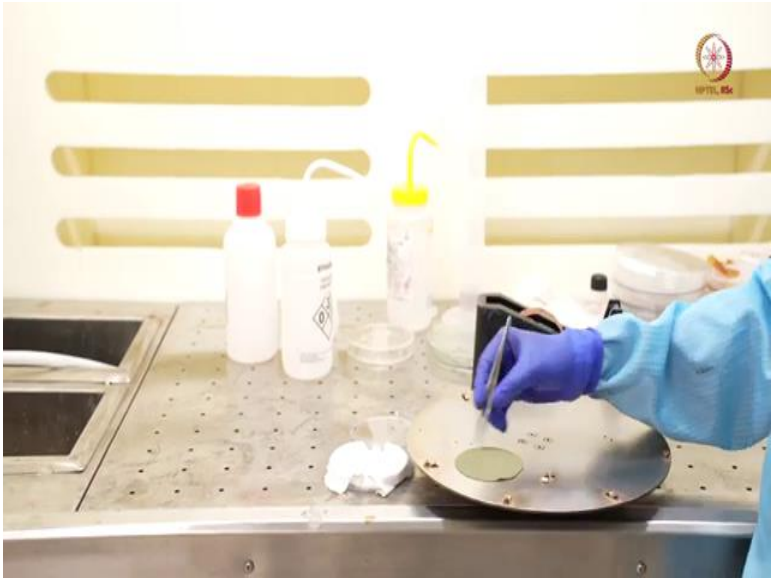
So, here before loading any crucible obviously, you should just wash it clean it once with solvents like acetone IP and then you can put your like put the material here and you can load it.

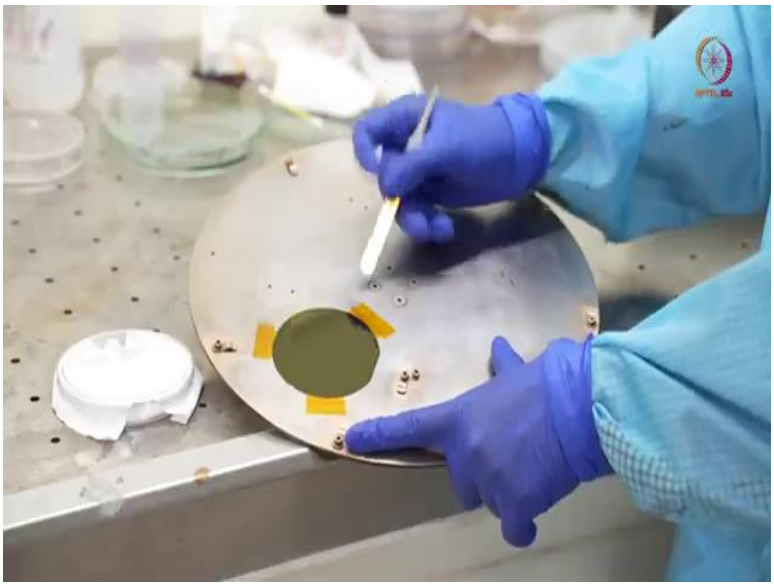
So, here if you see this is of 15 cc, so, like that crucibles are available for different volume. So, how much volume of material or how much material you want to place inside your chamber that can be governed by what type of crucible or how much volume you are getting, these are 15 cc.

So, like that you can have 15 cc 25 cc 40cc these are like you can check any of the vendors sheet and you can understand what type of crucibles are available and what are the volume of the crucibles. So, just a spare thing I just showed it to you and as you have already seen after on deposition how it looked like. So when deposition will be there or vacuum creation will be there that time I will show you the materials as well how the raw materials will look like.

So now let us take this chuck out and we will show how to load the things and will prefer to load these things in a solvent bench so we will go there and show the things. So, let us take it out this is the chuck that we will be using this is 12 inch chuck means 12 chuck, diameter is 12 inch, so, like that different diameters you can use as per and different materials you can use whether it is ss or it will be some other material that is of your choice when you procure it, let us load.

(Refer Slide Time: 48:05)





So, here as I kept here you can see that after lithography what are the sample was, it is already here, it was in a desiccated over night after post exposure break and development, and after development we have performed hard break for 3 minutes, after that this is a sample were actually last day we showed you the patterns as well, it was kind of visible that time. So we will load the sample on this chuck and place it inside, so, for loading the sample, there are multiple ways of loading the sample on the chuck.

So, you can see here the clamps, so, if you have standard 4 inch wafer, then it is very easy to load using these clamps and here we have 3 inches the clamp can fit it, but we usually prefer using captain tapes. So you can see this is the captain tape basically this is a polyimide material.

So the same polyimide material that is here, it is similar but thickness will be different and this is commercially available, so, we prefer to use polyimide tapes or captain tapes.

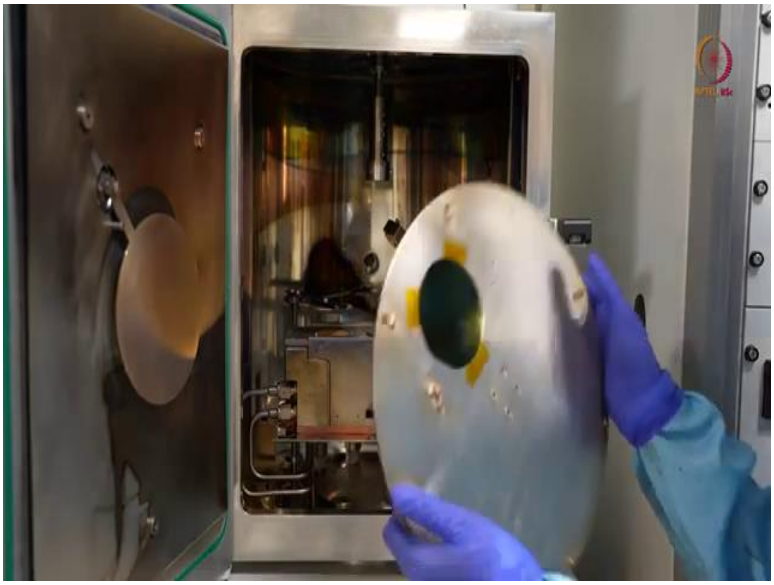
So, here if we see, so here, we want to load it something like this. So here if we load it, here you can see top material is also polyimide and here if we put some captain tape on this, and there is a sticky material that is our gum, so it can peel the whole layer so we have to fix this polyimide layer first on the backside and based on that we have to load the things so we will take some time to load it after that we will come back again and show you how it was how it is fixed on this.

So, here you can see we already pasted the sample using this captain tapes usually two or three like this will be enough and we tried to avoid attaching tapes on the front surface. So that this thing will not come out on this polyimide film will not peel, that other thing the, these things are there now what is the status of this sample we can just recall the things again.

So, silicon wafer is kind of I mean is the supporting material, then the substrate is this polyimide film that we have deposited or we can we have prepared the film the other day, on top of it we have done lithography, so, whatever patterns you are seeing these are basically photo resist patterns. So, there is no metal as of now, we are going now to deposit the metals, let us load this in our chamber.

So, whenever you leave the tool or the chamber for some time, better you close it all the time, because the more time you will keep it open, it will accumulate more amount of contamination inside from this air only, and it will take more time to evacuate so that is why I just closed the chamber and went there for loading.

(Refer Slide Time: 51:34)



Here, let us open the chamber, so, the shaft is there to hold the chuck will load it like this. This is fixed, now this shaft can rotate so that this whole thing, this chuck will be rotated. So here we will show you today first the stationary deposition, and then the deposition in rotation in some vacuum level only. So first, we will just, let us just as I told already that I will be showing stationary, so, for stationary deposition always it should be exactly above that, so, that the deposition will be maximum.

If it is in rotation, then you do not have to worry because the whole chuck will be rotated and in rotation always uniformity is better, so we prefer deposition in rotation always, so, you have to remember that when you are optimizing any tool. But in other case, if you want some or if you deposits if you want to deposit some material like gold or platinum, some precious material, then you can prefer stationary mode, depending on your sample size and if there is only one way for something like that, and you do not want to waste material all over the chuck only if you want to deposit here then you can go for it.

That is your choice, you have to optimize your recipe in that way but we will deposit in rotation only. So here is the first thing and as I have already mentioned about this hole like rectangular hole, how this will come to that and it will be deposited there is the cover here is that and we have our substrate here.

So, now we are good to go and you just check by mistake, you should not keep any loose object inside like, let us like tweezer let us see like all of the screws, you just checked that and as there is nothing just let us close the chamber and then we will go to the process. So, let us close the chamber this is done. Now, here is our tool so now let us see what is the tool condition? If you see here, safety interlock is off, as I already mentioned, that safety interlock corresponds to the doors like whether all the doors are closed and whether there is some amount of vacuum there in the chamber as it is under atmospheric pressure, so, by default the safety interlock is off.

(Refer Slide Time: 54:25)

Now, I request to focus this area like this and this so that we will just show what is the status, so, as a closer look we can see that see one more thing here in most of the tools whatever is allowed that will be either in glowing condition or these or some color differences will be there like what are allowed things and what are all not allowed.

So here similarly we can see that we can go for start or we can go for vent, vent already we have tried vent is for painting the chamber and open the chamber. Now here is the start, so start it will start the pumps basically and so let us try that. Here you can see that chamber pressure by pirani gauge measure by pirani is at atmospheric pressure, let us start.

As I pressed see, so, first start the backing pump. So, after this backing pump, let us see and after this backing pump, it will start turbo molecular pump and then see after backing pump started it started backing process, so, backing processes, there are two lines basically that you can see from here, system view and mini diagram. So, here you can see this is the rotary pump this is acting as a backing pump now, how? See here there are two lines one is roughing line one is backing line, backing line is through this, so, here as you can see, this is our chamber so through that we are getting, we are taking the connection here.

So, backing valve is open as it is glowing as I already told, a backing valve is open and roughing valve is closed. So, through this line, we are creating the vacuum now, why backing line because before starting this turbo molecular pump, it wants to make some sort of vacuum, here is the reason, so, this P1, P2, P3 these are the gauges. So, P1 is the pirani gauge, P2 is also another pirani gauge and this is P3 is spinning gauge. What is pirani gauge and spinning gauge? These are already covered in theory session, we will discuss it again but before that, so, as you can see here turbo pump is on it is going.

So, let us go back to the system control and see what is the case? See it is showing turbo acceleration, so, as turbo pump was off, it was having some 0 RPM as rotation. So, here it will increase to 13,000 RPM on its rated speed that will take some time. So, that is why we are seeing status as turbo acceleration it will be turbo ready. So, when turbo pump will be ready we can go for vacuum cycles. So, let us wait for some time as long as turbo acceleration is going on.

So, now, as we can see after waiting for some time turbo pump ready, so, now we have these many options like stop, we can stop the tool. So, stop means it will basically decelerate the turbo

pump and it will prepare the tool shutdown step cycle is like vacuum cycle we can vent at any moment till now, and process so we can start deposition but as we know that deposition is supposed to be at 10^{-6} millibar pressure or that much a vacuum so we cannot go for process now.

So, we have to go for vacuum cycle and vacuum cycle is automated here that we will see here how it works? As the turbo pump is ready, let us press cycle and then explain the things for them, cycle.

So, first, it will start with cycle sequence wrapping. So, first roughing cycle we will start that we can see here let us go to that diagram. So, here you can see now backing valve is off, so one second now backing valve is off. So, this backing line is completely detached. So, this is not creating vacuum through this line it is and see here roughing valve is on. So, it is creating vacuum from this chamber to this line and by this time you could probably notice that the safety interlock is on, so, this requires at least ten power one millibar pressure.

So, it should be two times I mean almost like 100 times less than the environment pressure like atmospheric pressure, then only this environment is a little safer for the user to go for deposition or other things. So, that is ensured by this, here you can see only P1 and P2 is active, so, it is here this is giving almost like Pirani gauge connected near to this line and the other one is here in between roughing and backing line almost nearby this roughing pump these two are giving the values now.

So, you can see here some volt is coming, so, that much voltage that is that since the voltage so that voltage is converted to pressure and from there we are getting these values these some millibar.

So here you can see safety interlock is on this is also on this is ready basically and this also on now, let us go to system control because we can do everything from there only, so we will be there now. So, here if you can see it is e power minus 1, we will wait till it goes to the high vacuum or high vacuum valve opens, and it goes for fine pumping through I mean using turbo molecular pump through the backing line till that much we will wait we will show in video after that will again come back when it will reach minus 6 pressure.

So, let us wait for that much time, like few minutes, maybe it will come. So, here you can see it is going down, it is minus 2 now. So, we will wait for some more time it will start fine pumping till now it is pumping through the now it started through the backing line we can show it. See, now, this is high vacuum valve this is on, so, it is through this backing line now and this roughing line is closed.

So, and this P3 that the pending line is activated now. Now we will wait till we can see that fine pumping starts, but this will be the configuration for that next, let us say it will take one hour, one and a half hours, so, this will be the configuration for that through this pumping through this line and it is already at least minus 4.

So, go to system control and see minus 4 to the m gauge and here you can see system status as fine pumping this will continue till minus six range let it go there as it is and let us come, let us focus on little bit details about the gauges also. So, gauges means, there are usually two types of gauges that we are using for this vacuum tools. So, one is Pirani gauge and other one is penning gauge.

So, Pirani gauge is something that is good for measuring higher pressures like a higher pressure means from atmospheric pressure to e^{-3} or e^{-4} millibar that much it can measure and spinning gauge is good for measuring from e^{-2} to e^{-6} or e-^{7}. It can measure e^{-7} millibar pressure. So, as for these two will be we have this atmospheric pressure range as well as when it will be under vacuum we need to measure e power minus six or e power minus six seven millibar range, so, we have both the things.

However, we cannot show you the Pirani gauges and penning gauges as of now, because then we have to actually open this whole thing. So, we do not want to open the setup as of now. So, here these are the two types of gauges as you can see here already aim or the penning gauge took over the things as it was minus 4 that time and still this time it is minus 4 millibar range. So let us wait till it reaches e-6 pressure or actually we prefer 3 e-6 pressure or 4 e-6 pressure before starting our process.