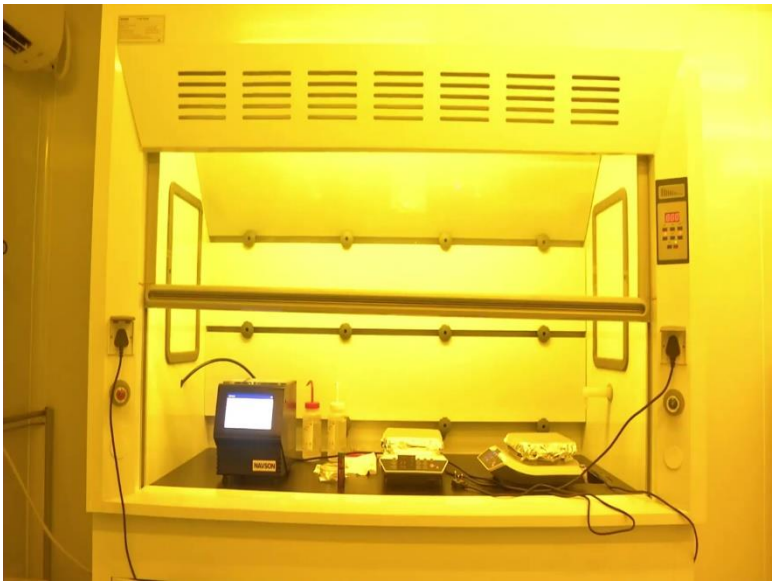
Mathematical Aspects of Biomedical Electronic System Design
Dr.Tushar Sakorikar
Indian Institute of Science, Bengaluru
Lecture 33
Spin Coating Demonstration

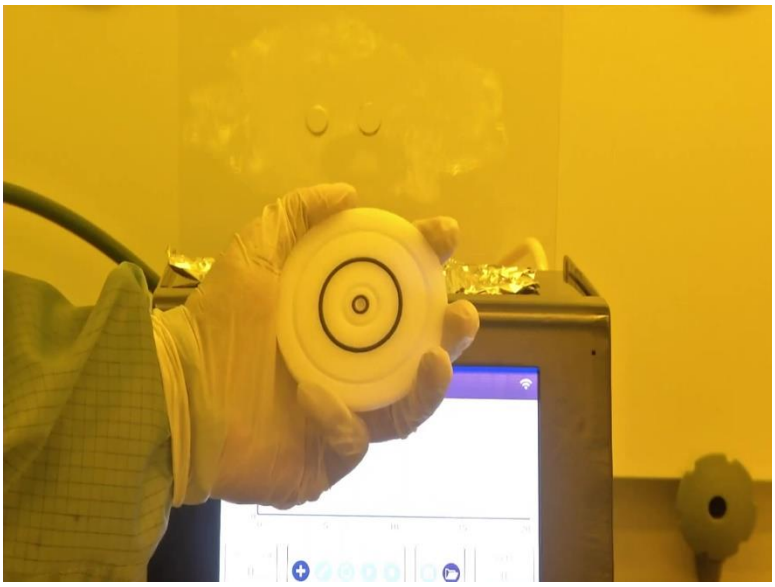
(Refer Slide Time: 0:27)



Hello, everyone. Today we are going to see how we can spin-coat polymers to obtain flexible substrate. What we are going to do is, we are going to use a precursor. It is similar to that what you have seen for a photoresist spin-coating and we will be using a carrier wafer in this case, it is silicon three-inch wafer. We will spin-coat on that, the precursor, the polymer that we want to obtain is a flexible substrate.

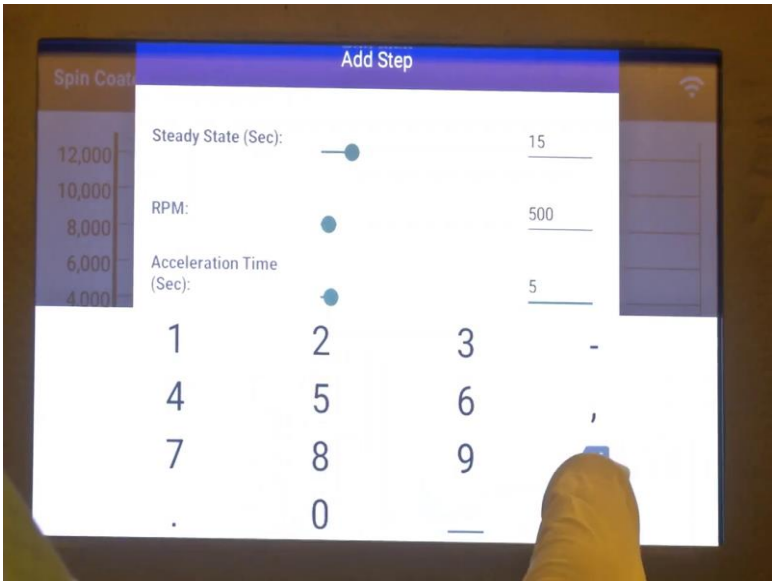
And then we will cure it at two different temperatures. And finally, we will show you how we can get a flexible substrate out of the silicon carrier wafer. So, the first step to spin coat any kind of photoresist or polymer or similar precursor solution is to use a spin coater. Spin coater works on the principle of centrifugal force. You keep the substrate and the substrate is placed on a sample holder, the sample holder holds the sample by virtue of vacuum, which is generated by a dedicated vacuum pump. So, let us now see how the spin coater can be operated.

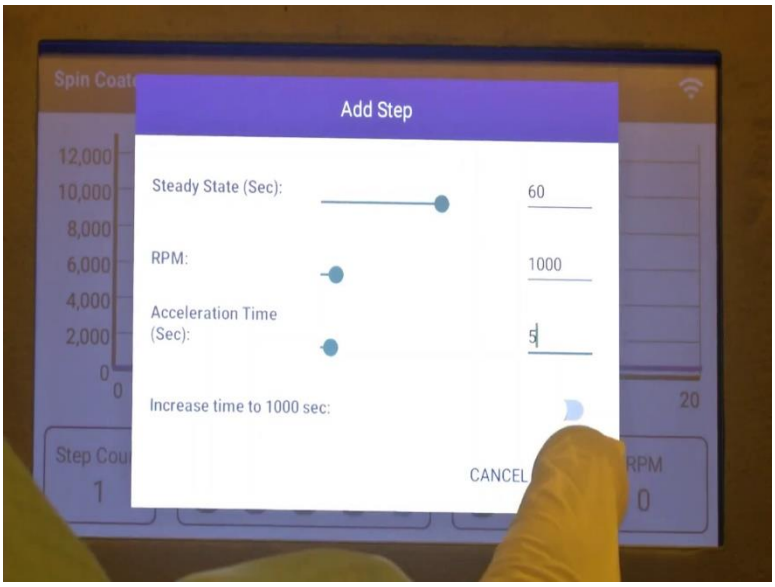
(Refer Slide Time: 1:40)

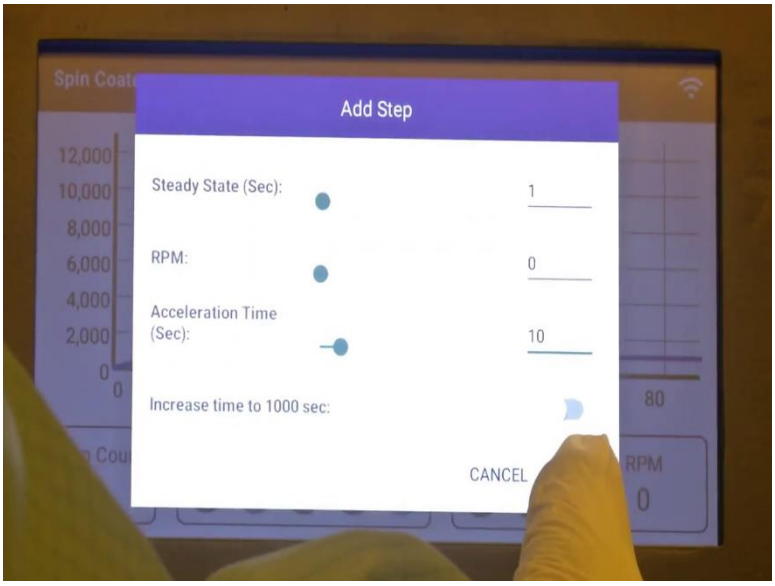


So, now we will see how a substrate holder looks like, so we can open the lid of the Spin coater, and then we take out the substrate holder, so this is how a substrate holder looks like. The black colour ring that you see is the O-ring, the technical name is O-ring, and there are multiple groups depending upon the size of the substrate, the smallest one can be for a small wafer pieces, the middle one can be for a 3-inch silicon wafer, the larger other one can be for 4-inch silicon wafer, depending on the substrate you want to spin coat on, you can put dedicated O-ring. The O-ring should be a put after applying vacuum compatible grease, so that the contact between substrate which is silicon wafer and the O-ring is leak free.

(Refer Slide Time: 2:23)







So, now we will see how we can program a spin coater. By programming, we can have multiple steps for spin coating. Why do we need multiple steps? We will see now, as my colleague will show you. So, generally, when we spin coat polymers or photoresist, we give two speeds. One speed is to spread the solvent along with the precursor and second speed is to dry off the solvent and thin it down, so as we can see as of now, we have given fifteen seconds of rotation at a particular speed, the speed we have decided in the RPM: 500 hundred RPM is the first.

So, what this particular step will do is, it will spread the precursor uniformly on the surface and we can give the acceleration as well. Once that is done, the next step is to give the higher speed step to ensure that the solvent, which is spread uniformly can now be evaporated and thin down.

Generally, for photoresist, we give 4000 RPM and for one for 40 seconds, but in this case, we have optimized to get a flexible substrate, so we are giving it for 60 seconds, and the RPM is around 1000 and acceleration will remain almost the same, which is around 400. As we had discussed, acceleration speed, but in some of the Spin coaters, acceleration time is there, so you can do math and calculate the acceleration time for this, we have calculated to be 5.

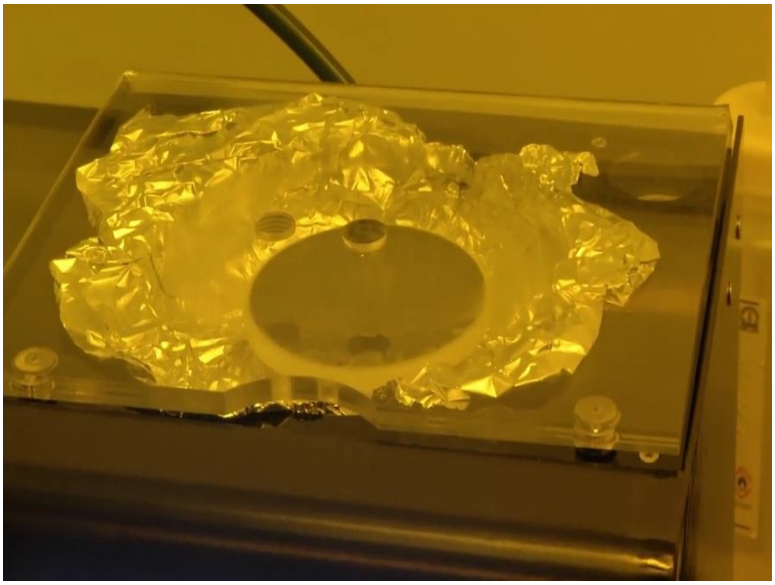
These spin coaters are almost similar in terms of functioning, only the software interface is different. So now, we have given the speed and the time for spin coating first and second step. So, now we are ready to spin coat. Now, there is one more final step, which is called as ramp-down step. This is to ensure that spin coater does not stop abruptly, we can generally give it for 10 to 15 seconds depending upon the speed that we are already in and the RPM can be given as 500, so that it goes down to 0 at a very gradual speed.

Again, this RPM that we are referring to, depends on the spin coater to spin coater. For some cases, it may require us to feed the RPM, but in this case, even if we give one step of steady state ramp-down**,** this will function as a ramp-down.

(Refer Slide Time: 4:50)

See, so as you can see in the graph plotted where Y-axis is the RPM, X-axis is the time in seconds. We can see there is a ramp up speed and then it stays there for some time, then again, there is second ramp up, which is thousand RPM, it stays there for sixty seconds or one minute, and then there is a ramp-down. So, we now have set the spin coating parameters, let us know spin coat.

(Refer Slide Time: 5:17)



So now, we will see a hole, the precursor of the polymer can be spin coated onto a carrier silicon wafer. So, my colleague is showing how to place the silicon wafer, we need to be very careful. We will place the polish surface exposing facing us and non-polish surface, in case of single side polish silicon wafer.

We need to align the vacuum check with silicon wafer to ensure that the centrifugal force acting upon the silicon wafer, which ensures, uniform coating of precursor or any other photoresist matches with the central axis of the vacuum check. Once that is done, now, we are ready to hold or to allow the silicon wafer be folded by the vacuum check for that, we have a dedicated pump. So, as my colleague will switch on the vacuum pump and you will hear a noise coming out of the pump.

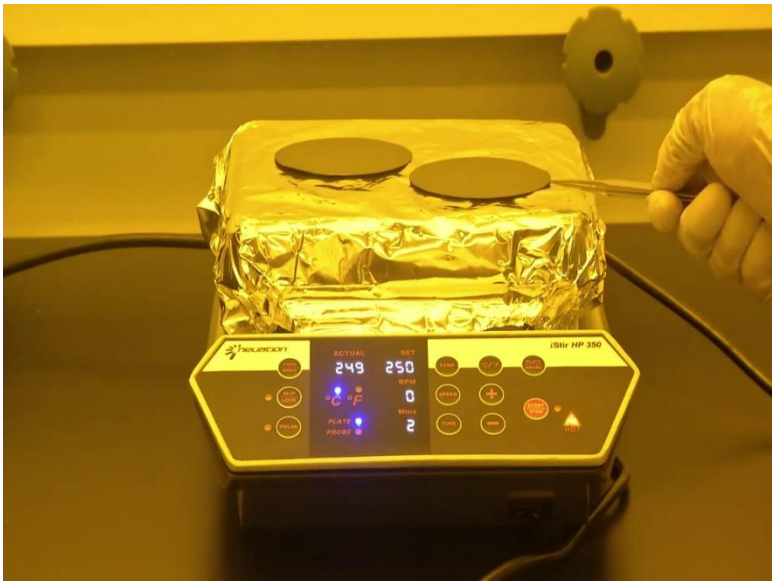
Now, before spin coating, it's always good to make a check by gently moving silicon wafer using tweezer, not moving very fast, just to see at all if silicon wafer is moving from check or not. This is to ensure that once we start the spin coating, the wafer does not break because of loss of vacuum, this check needs to be done very carefully, and very slight towards, just a touch of that should be applied to ensure that it is nicely holding it. Now, we have checked it and we are ready for spin coating.

So now, my colleague will use a dedicated wire for pouring the precursor onto the silicon wafer. Pouring itself requires some amount of practice. We need to ensure that there is no bubble formation. So, we need to be very careful while pouring the polymers precursor. We need to pour it very gradually to ensure that there are no air bubbles form on the silicon wafer.

So, as we can see, he is gradually pouring the polymer precursor on the silicon wafer and now, since it is gradually poured, he will wipe off the excess of polymer from the wire to keep it clean and so there is no contamination next time when we spin coat. And now he will close the lid and press the play button, as we have seen general music player in the similar way, we will press the play button, which will mean we can start the spin coating process.

So, spin coating process, as you can see, has started and the wafer has started rotating. This is the first step, where the polymer, the polymer precursor is spreading. Once this step is over, the next step is where it will increase by ramping up to the speed where it can thin down also evaporating some of the solvent.

(Refer Slide Time: 8:25)



So, now we have spin coated and placed the wafer on a hot plate, which was preheated at the dedicated temperature, which is eighty degree. For the first step, the question arises, why are we going for two different steps of heating? The reason is as follows; the first step ensures that a part of the solvent is evaporated and the substrate is nicely, firmly adhered to the spin coated polymer film. Also, if we do not increase to very high temperature immediately, so that there is no thermal stress built up in the polymer film, which might lead to cracking or a very poor curing of polymer.

So, we will cure it at 80 degrees celsius for one hour, and thereafter we will carry it at a higher temperature for 2 hours, which will complete the overall curing process. So, in the process of curing, as we discussed, there are two steps. So, one step for first step of curing is done now, which was done at 80 degrees celsius. For one hour and now one hour has lapsed. Now, we will keep it for curing at 250 degrees celsius for 2 hours. This will form the second step of curing.

So, now we will gently press, keep the wafer on the hot plate, which is preheated at 250 degrees celsius. This will be kept for 2 hours and this completes the curing cycle. So, now 2 hours are left since we gave it, kept it for second stage of curing, and therefore the wafers can be taken off from the hot plate, and my colleague will do the procedure. So, this is how we can spin coat photoresist or polymers such as polyamide or acute on desired substrate, in this case, it was silicon wafer.