

Microsystem Fabrication with Advanced Manufacturing Techniques
Prof. Shantanu Bhattacharya
Department of Mechanical Engineering
Indian Institute of Technology Kanpur

Replication Part- 1
Lab Session - 8

A very good morning to all of you, this is the same experiment the continuation of the experiment which you are doing in the earlier module in different lab where we were talking about laser etching of p m m a sheets the idea there was to be able to use that as a mold. So, that you could develop a device, and the device could micro (()) operate, and those various testing or calibrations for different process at the microscopic lens scale. So, here in this module (()), I would like to demonstrate today is basically work on the next step of replicating the shape or the feature.

That had been produced by laser etching technique, and the replication would be like a micro casting. So, therefore, you have to use a soft polymeric material in our case will use material called poly dimethyl disiloxane p d m s, and this p d m s is nothing but a silicone rubber which is otherwise commercially available into two different in to two different forms one of the components is actually a curing agent another is a silicone rubber, and you mix both of this components together in a certain ratio to obtain the requisite bond strength, and the curing agent essentially helps the p d m s to develop cross bonding, and eventually it results in a rubber like membrane which comes out. So, if this is poured on a small laser etched surface the surface kind of gets replicated.

(Refer Slide Time: 02:14)



And the negative of that created on to the surface of the p d m s. So, I would just like to recall what we did in the last module where we actually make device like this using c o two laser processes on p m m a, and the etching which happen there in resulted in this kind of a feature being imprinted on this surface of depth about close to fourteen or fifteen microns, and various widths of various dimensions of the different parts that you can see on the central chamber the chambers which are on the sides etcetera. So, I am going to actually take a box were this is commercially available plastic box, and this this is for the purpose of pouring the p d m s, and containing it or confining it over the mold surface. So, whatever you saw here this particular chip that had been formulated am going to first sort of paste this on the top of this box at the centred. So, I make it mobile, and used that as a casting platform as a mold platform for micro casting the p d m s. So, am going to first try to fix this using double sided tape over this box before doing that you ensure that you have another identical box here.

(Refer Slide Time: 03:31)



So, that whatever amount of p d m s is needed on the on the top of this mold box can be calibrated using this other spear box of identically same each other these are very easily commercially available in the market. So, now, what I am going to do is to take a double sided tape like this interestingly double sided tape.

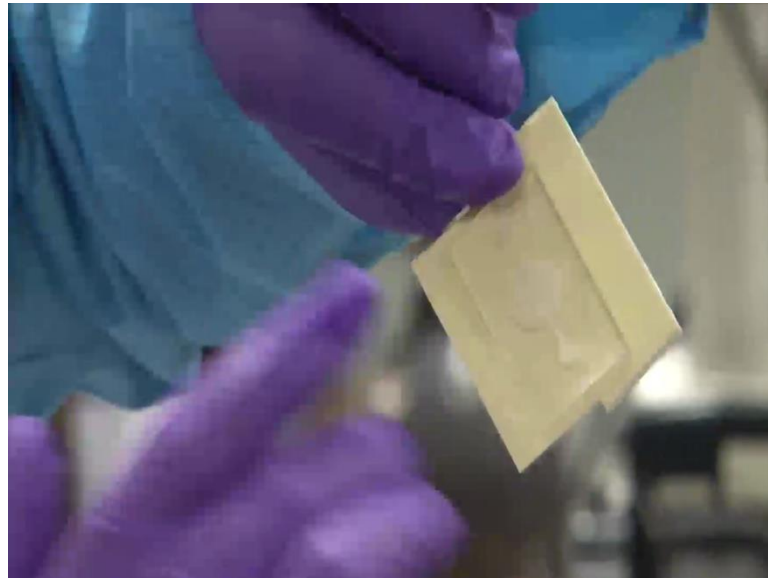
(Refer Slide Time: 04:03)



Commercially available in the market comes in this form where one of the sides as a yellow covering on the top, and other side also adhesive. So, basically the adhesive side is lifted up like this, and you can measure how much you need for completing the or

cover the whole mold surface, and try to fix it. So, using normal shear appliers I want to take small measurement here like this to be able to kind of estimate how much length is needed to cover the whole surface and am going to cut a piece of this length all the way up to here. So, that you can cover half the surface of this feature very well.

(Refer Slide Time: 05:02)



So, I am going to actually now place this feature almost half way through in this particular tape like you can see here. So, the other half can have another piece which I will cut out by doing the same kind of size measurements, and what I am actually going to do is try to cover the whole base of this mold in a similar manner. So, that one thing you have to really ensure is that you make it (()) tightly to the other tapes of... That is one continuity see from the back you can either's no gap between the two tapes that you have put, and then on the tough surface there is some projection which is in a outwardly manner, and I am going to just shear that off. So, that it becomes of the same size as the mold. So, I will do this shearing action.

(()) see roughly now (()) using size, and shape of this double sided tape such that its covering the entire lower portion of the mold box the etching the etched feature is available somewhere on the top surface which you need to micro replicated one has to be really careful about which side you are pasting, because this feature itself is very small only way to feel it is to either rub your nail over it, and see if it produces a scratching sound,, because of the laser etching which is happened at this area or if the features has

to small I am just try to ensure with your hand whether there is a feature of a certain depth, and the planarity of the surface is not uniform that goes in the top side, and the other plane surface or planar surface goes on the bottom side. So, I just need to pull this tape off from the lower surface exposing the other side of the tape like this similarly like this on you left with a dissipate. Now on the lower side which you want go head, and paste on the top of this particular box right about in the centre of the box as this. So, this is how it.

(Refer Slide Time: 08:35)



Now, looks, and you can see,, because of the tape it does not go anywhere, and when you pour something which is liquid in it there is always bawan (()) forces through which the mold might come up unless have been fixed. So, this we did for ensuring that the mold does not flowed up,, because of the bawancy (()) of the liquid in any event.

P d m s is a highly viscous thick liquid you should have to offer more bound forces, and need to somehow be able to hold this mold on to the place. So, that the p d m s can go on the top without making to left the mold (()) bound effects.

(Refer Slide Time: 09:25)



So, I am now going to go ahead and make the p d m s solution as I told you there are two parts of the p d m s in which it normally comes this particular p d m s is from a company called docanik midlim (()), and the brand name is known as sylgard one eighty four. So, you have two components one is a sylgard one eighty four silicone rubber which comes in this tube, and then this curing agent now am going to now sort of go head and mix these two in a manner.

So, that it p d m s comes all the way to the top of the box here. So, it can actually cover what is there on this particular mold surface. So, for that we need a chemical balance like this, and we just try to first measure the amount ratiometrically through weights, and then we just tend to one ten parts of the silicone rubber, and one part of the curing agent, and then mix properly using pepiter (()). So, that it can uniformly disperse the two phases can infinitely disperse throughout. So, (()) doing that (()) the two (()) silver tear the weight of the box machine, and once it has been teared, and you take it out, and put little bit of this phase one.

Here on the surface of this to ensure (()) all the way to the top need to be little careful while handling this, and the other part which is in this particular solution here also curing agent. So, first of all we need to way this, and find out how much. This would be. So, these happens to be about close to thirty grams. So, we need exactly three grams of this other material keep at going and. So, I told you that in the chemical balance here

measures the quantity of the the p d m s that is the silicone rubber part which we have put inside this small box, and then we have to mix the curing agent, but before doing that one has to ensure that whatever mold you are using will release the p d m s after heat curing action etcetera is over. So, the idea here is that I would (()) treat this with some kind of vapours or some kind of chemical which will formulate a mono layer on the surface of this material p d m s otherwise is highly hydrophobic in nature the contact angle is about hundred eighty degrees.

So, one has to have a hydrophobic surface. So, that there is a mutual repel repelling action between the tool, and there are no as such van der's waals forces which develop between the surface, and the p d m s, and there should not be an restriction right particularly when you are pulling it out that is the purpose of a release agent when you talk casting will use powder on the walls of the mold. So, that the material comes off without damaging or breaking the mold in these case the breaking is not possible,, because of the p d m s is soften material, but guess it has to be coated properly. So, that it should not be that the features entrapped a part of the p d m s, and it is broken off that resulting bad finished casting. So, mold releases very very important. So, what we are going to do is to use a vacuum desiccator right about here, and we are going to use something called H m d s which is commercially. Otherwise available in whites, and this material has to be handled very carefully the h m d s is normally coming in a closed while it has to be taken to a feom (()).

(Refer Slide Time: 14:20)



Hood something like this where you can break open the cap of the h m d s, and transport the bottle all the way into the desiccator, and then vacuum air head before doing that you ensure that you put this into the desiccators. So, that the environment given by the vapours sort of dust a preliminary treatment of this surface by giving small coating on the surface. So, as you can see now the processing of the while (()) is done.

(Refer Slide Time: 14:46)



There is a while inside which is broken gap, and the material that you want to (()) that is the mold everything is inside here in this particular desiccators, and there is a pipeline which goes into otherwise a evacuating system. A small mechanical pump, and that takes care of a sort of close to ten to the power of minus one or minus two power vacuum within this particular chamber one reason why the vacuum is also engaged this material h m d s is highly volatile in nature, and the idea is that it should actually come, and evacuate or come,, because of the negative vacuum pressure, and formulating environment over the surface including the plastic box, and mold etcetera which is kept inside for a very long amount of time. So, that there is a small layer in facting see that the layer which is formulated will be visible at the small whitish layer on the top of the surface. So, this process will take about fifteen minutes beyond which we will have to examine whether the mold is fully coded, and then if you feel that (()) fully coded will go head, and stop the process otherwise will have to again recoded.

(Refer Slide Time: 16:20)



So, that the small thin whitish layer can be seen on the (()) surface of the mold. So, this right here is demonstration of all the oven functions there is a controller for this oven where there is a set value which you need to set for heat curing p d m s p d m s as you seen before has you mixed into two different parts component a, and b curing agent, and the silicone rubber, and your heat curing it to a temperature of about eighty five degree Celsius for about forty to forty five minutes. So, this has to be very precisely controlled otherwise of the temperature is higher you know the plastic container it might just work, and it might just deform, and change the shape of the containing mold which is really not desirable. So, what we do is to preset the oven as your seeing here at eighty five degrees, and wait for the oven to achieve a temperature all the way up to the set point value as you can see little bit quick glance here that the temperature is changing quite bit, and basically the temperature once it achieves the eighty five degrees Celsius you have to keep the oven in closed conditions. So, that the temperature is maintained at the particular level now once we are sure that the temperature has been reached the other important aspect is to take out the mold which has been cured priority this or coated priority this using the h m d s or hexa methyl disiloxane layer, and release agent layer. So, what I am going to do is to sort of take out the mold from the vacuater, and see the mold surface clearly it is indicate of that there is a layer on the surface.

So, you pour the ten is to one ratio of the curing agent with the silicone primer from the other box that we had we have taken position for this purpose on to the box containing

the mold and. So, once this is thoroughly poured, and the whole p d m s I transferred it is very viscous substances were seen like molasses, and therefore, it needs to you have to really hold it for some time for the material to be complete the loaded on to the other (()) box containing the mold. So, once this is finished you have to be really check what is the level of the p d m s on the on, and over the mold pasted on the surface of the box,, because mind you the mold item is not changed,, because of the thickness of the double sided tape which is been inserted below the box. So, you have to actually seen a what is the level of the p d m s on the box if you are happy there is another issue about setting up the evacuator again,, because mind you when you are actually trying to do this process of mixing agent curing agent along with this silicon polymer there is a issue of entrapment of bubbles, and dissolved air which comes in. So, that air has to be removed,, because otherwise when it starts heat curing.

And there are conductive currents (()) in the medium there is a tendency of this bubbles to formulate a two phase system, and bubbles in this manner if they get entrapped into the cured silicon matrix would have lot of problems regarding optical visualization of the p d m s matrix. So, we place this p d m s, now on the vacuum desiccators, and wait for few minutes at high pump pressure for the desiccation action sort of pull out all the air which is entrapped in the p d m s matrix.

(Refer Slide Time: 20:46)



In the mean time you also should check the conditions of this gravity fact convection oven which has been sort of now (()) installed about eighty five degrees Celsius, and all the way you normally.

Handle is to actually keep a sort of elevated platform which is already pre balanced, and there could be an issue of proper levelling of the mold box that you are eventually going to place into this oven. So, normally it is pre levelled by using a spirit level such ovens also have the possibility of tilting shelves. So, therefore, you can actually using a spirit level acquits cross manner do both x, and y in the x, and y direction you can check whether they are completely levelled with respect to gravity. So, that the overall p d m s surface can be flat now the it is high time now that this desiccation has already happened for (()), and bubbles must have come out of this solution. So, we are going to the replace.

We are going to just sort of take out the mold box along with the p d m s on the top, and see what is the condition of the mold box you can see here that there are bubbles in a way coming off the surface of the p d m s which actually is a suggestive of that the dissolved air has really come out. So, a few more minutes are needed. So, that you can individually burst this bubbles, and you have to see that over this mold really or there are any bubbles are not in these case over the mold you are relatively a clean layer of p d m s which you can see and. So, the idea is that was resulting (()) formulated you can put this into the oven in the level plate there is a level plate here in the bottom corner as you have seen. So, you just put this over the level plate, and the same can be done with the shelves as illustrated earlier.

So, that the level of the p d m s over this mold is completely flat in the x, and y direction parallel to the gravity, and close the oven, and wait for about forty minutes till the p d m s actually achieves the necessary curing action,, because of the opening of this oven for loading, and of loading there is a certain change in temperature as you can see here it again needs to go all the way to about eighty five to eighty six degree Celsius which does now reached (()) we controlled, and we have to wait for forty five minutes. So, on that we can actually have good cured sample of p d m s which will later separate from the mold which has been formulated I were see here actually the sample has come out after forty five minutes.