Microfluidics
Dr. Ashis Kumar Sen
Department of Mechanical Engineering
Indian Institute of Technology - Madras

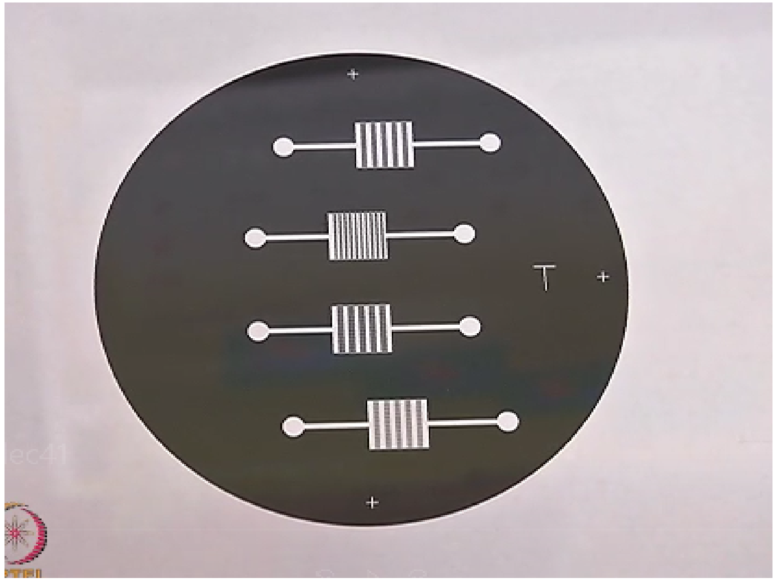
Lecture - 41
Lab Demo

Okay so as part of the microfluidics course we have looked at the theory and so I thought it could be beneficial to show you around lab the microfluidics lab that we have in the department of mechanical engineering at IIT Madras. So, we thought it would be beneficial to so what we do in the lab relating to the theory that we have studied in the microfluidics course. So, here we do you know theoretical microfluidics a look at that theory of different aspects of microfluidics.

We also look at simulations numerical simulations of different microfluidics phenomena and we also do experiments okay. So, what we will show you today is 2 things 1 is to show you how we can make microfluidic devices you know the first thing that we do is look at the theoretical aspects of certain phenomena that we want to investigate and we also perform numerical simulations.

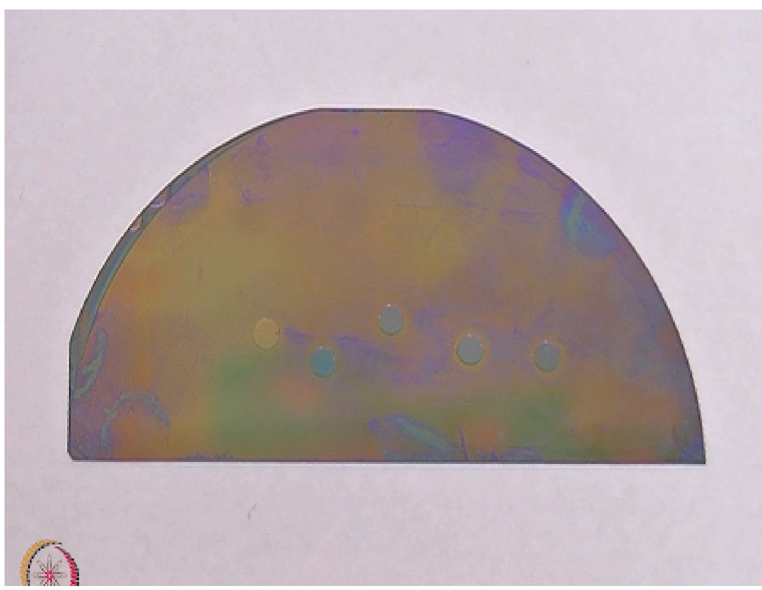
So based on our preliminary studies and our simulation results we come up with a cad design that we use to fabricate you know the mask for the design of the micro chip that we are going to fabricate and so we will show you the procedure that we adopt to fabricate microfluidic devices and then we will also take you through how we perform experiments okay.

(Refer Slide Time: 01:43)



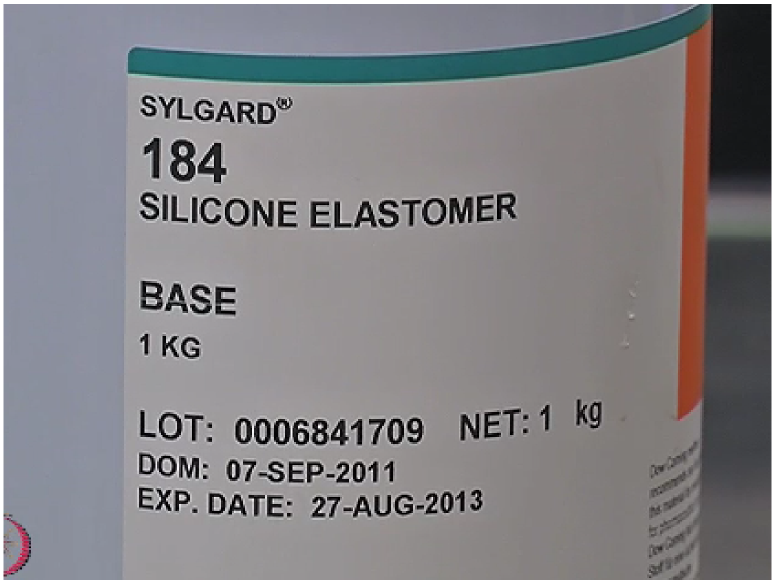
As I was telling you the first you know study the device structure that we want to fabricate and then we come up with the mask layout and we get the mask printed that you can see here okay and this mask is used to follow the photolithography process to make a master which you will be using to make the PDMS based microfluidic device.

(Refer Slide Time: 02:06)



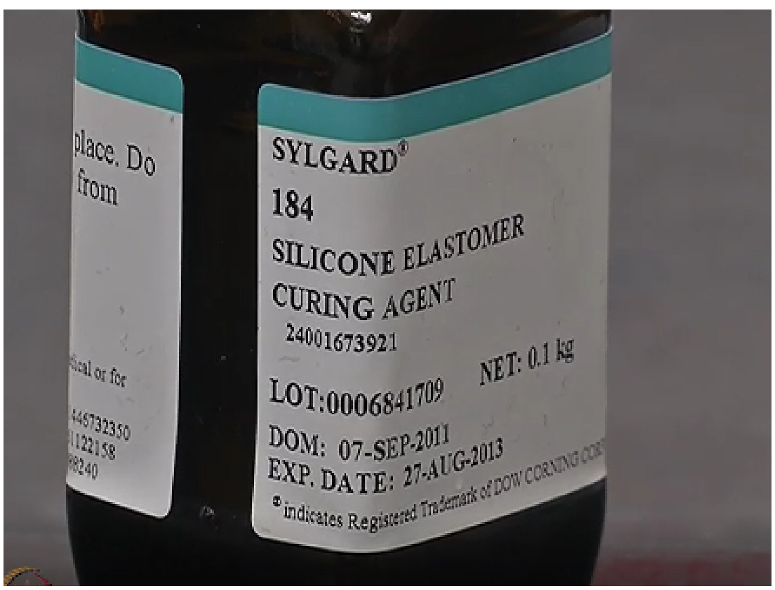
After we do the photolithography so this is the master that we have fabricated using the photolithography process so it is basically an estimate pattern and to the silicon wafer which is an issue is a negative photoresist. So it is patterned on to this silicon wafer using photolithography.

(Refer Slide Time: 02:26)



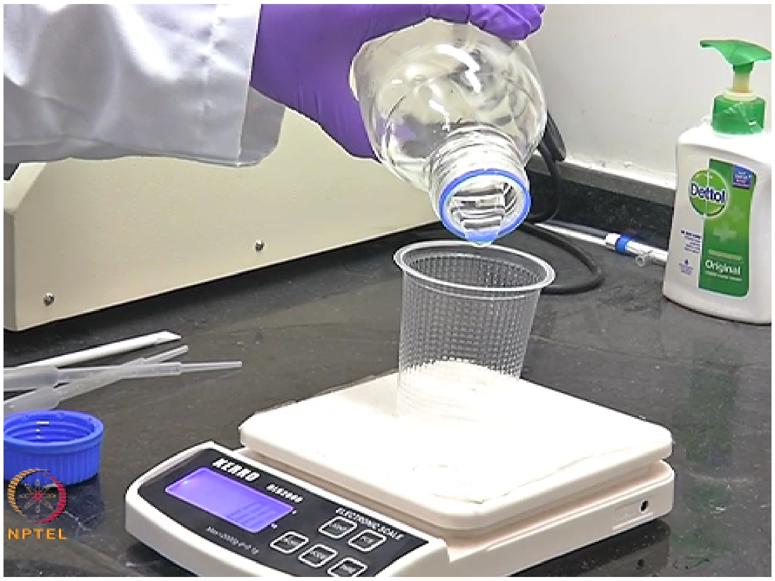
So, this is the you know we have using the silicon master to make PDMS microfluidic device so to make PDMS microfluidic device there are 2 components 1 is the base which is the silicone elastomer which you see it here.

(Refer Slide Time: 02:43)



This is the second component the curing agent.

(Refer Slide Time: 02:46)

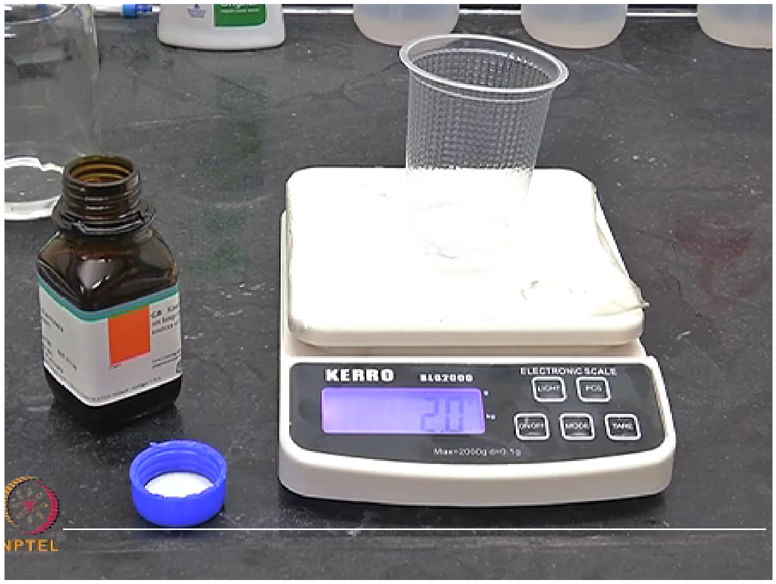


So, we poured this is the basis which we discuss and we use 10 parts of the base and mix it with 1 part of the curing agent. So, this is 10 part of the base that we just poured on to the glass we can use a plastic disposable plastic glass.

(Refer Slide Time: 03:09)

So we have 20 grams of the base.

(Refer Slide Time: 03:14)



We are mixing it with 2 grams of the curing agent, so we have the base and the curing agent 10:1 ratio.

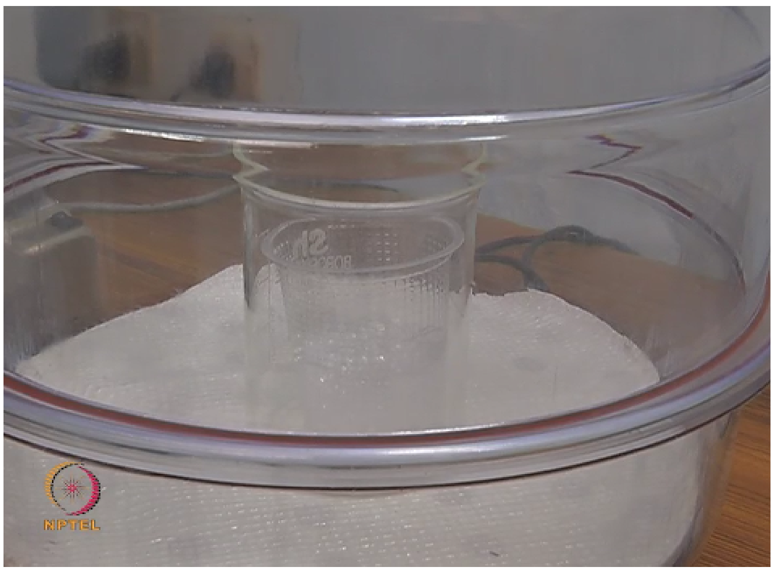
(Refer Slide Time: 03:22)

So, then we make the base and curing agent we basically stir it.

(Refer Slide Time: 03:31)

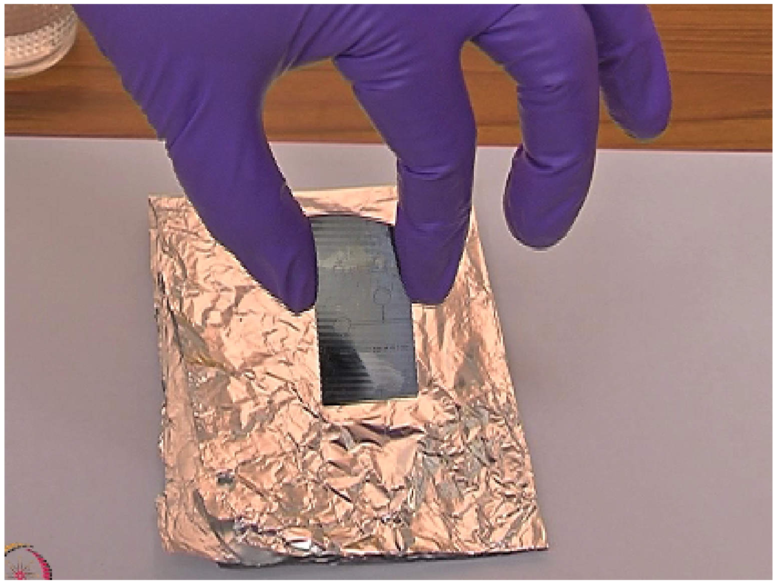
So, that is how it looks after the base and curing agent are mixed thoroughly there are only a lot of bubbles that you can see that trapped so it now we are going to do the degassing to remove these bubbles.

(Refer Slide Time: 03:40)



So, this is the vacuum desiccator which is connected to the vacuum pump and we are going to do that the degassing of the mixed base and the curing agent that we had seen earlier after all the bubbles are removed from the make sure this is how it is going to look like is a transparent solution with no bubbles present okay.

(Refer Slide Time: 04:35)

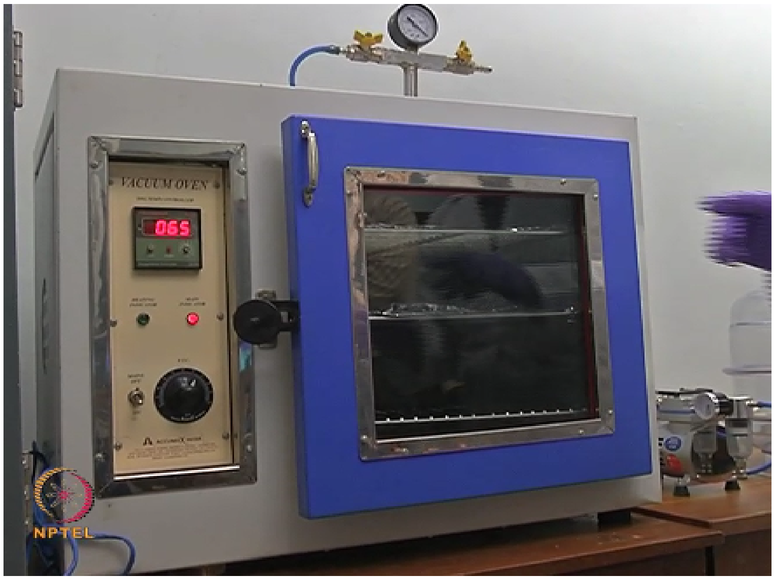


So, this is the master that we have so it is a part of the master cut out so many times we have many different chips on a single wafer. So, this is part of the way for it as one single chip and we are going to pour the PDMS mixture that we have prepared onto this master.

(Refer Slide Time: 04:58)

So, we have prepared and aluminum boat and inside that you can see the master and now we are going to pour the PDMS onto this master. So, the thickness of the chip would depend on the quantity of the PDMS that we pour on the master you can see some bubbles getting trapped during the pouring process which is be removed during the baking that you do in a vacuum oven.

(Refer Slide Time: 05:33)

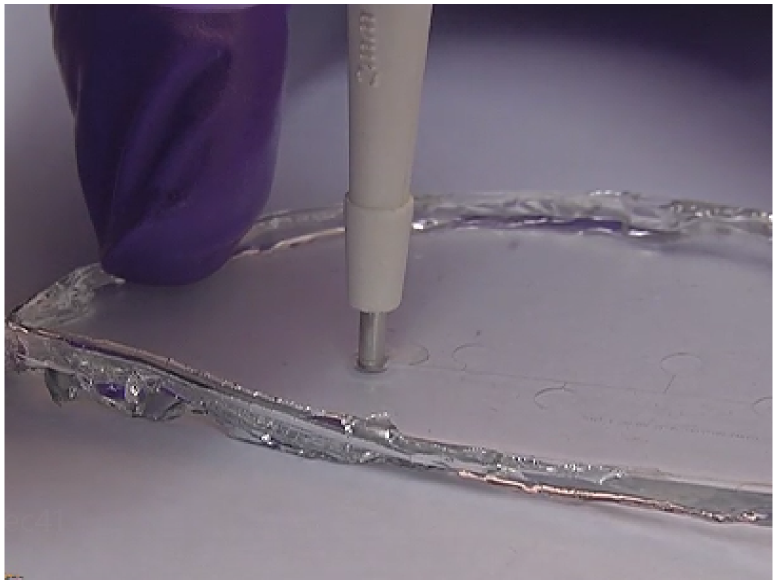


Okay so after pouring the PDMS onto the silicon master to remove the air bubbles and to cure the PDMS we are putting whole setup into the vacuum oven. So, the temperature is 65 degrees C which is used for the curing of the PDMS. So, once the PDMS is cured for a duration of 3 hours at 65 degree C we take out from the oven.

(Refer Slide Time: 06:09)

One such PDMS setup which has been cured for last 3 hours you can see it here that is solidified. Now we are going to peel the PDMS off from the silicon master. So. we can see that it has solidified and now were going to peel the PDMS from the silicon wafer peeling has to be done from 1 end and it has to be very gently pulled out. So you can see that the pattern that was on the master has been printed onto the PDMS.

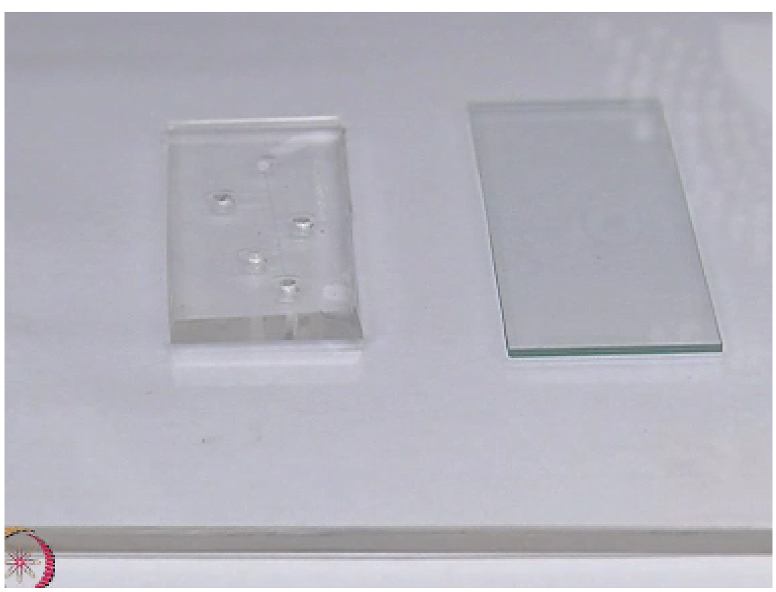
(Refer Slide Time: 06:48)



Okay so the projection that was on the master has been formed by the channel on the PDMS. We are going to bond with the glass to seal the channels and you know to enable interconnection between the external fluid supply typically syringe pump and the channels in the microfluidic chip. We are punching the interconnection holes you can see the punch which we are putting it through the PDMS layer to create the interconnection.

So these are the punch holes where the tubing will be glued to supply the fluid from the pump to the device.

(Refer Slide Time: 07:25)



Okay so after punching the holes we are going to bond the chip with a glass slide you can see that after punching the holes the PDMS has been trimmed off to the shape of the chip. And it is going to be bonded with the glass slide as you can see here and for that were going to treat both the surface of the PDMS and the glass using oxygen plasma.

(Refer Slide Time: 07:51)

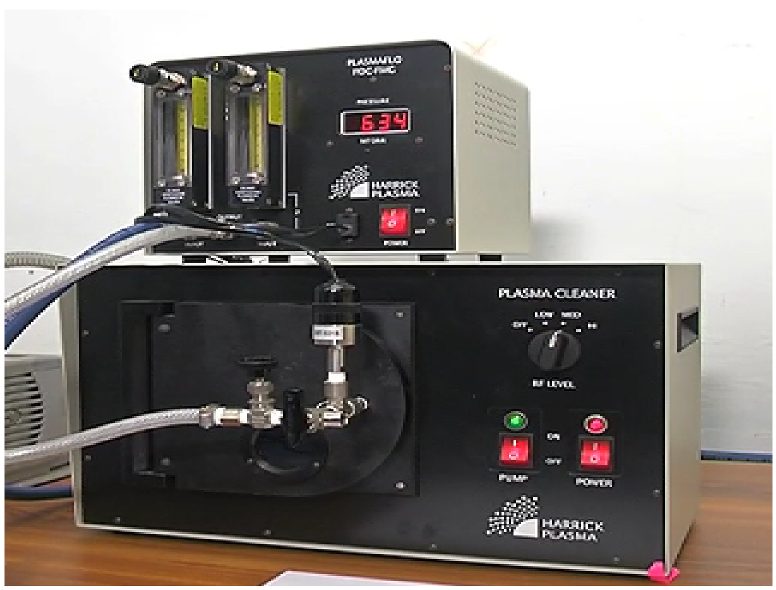
So, this is the plasma system that were using it has basically 3 different parts, this is the main component this is the plasma chamber inside which you will have electrodes and you know the top one that you see there is a pressure gauge it also has a flow meter. And on the left you would see a vacuum pump it is a special vacuum pump it should be noted that since were dealing with the oxygen plasma.

We need a special vacuum pump to do that create the vacuum okay because for ordinary vacuum pump when we deal with oxygen it may mix with the oil that we use in the vacuum pumps which acts as explosive. So, there is a special oil free vacuum pump that is required in this case.

(Refer Slide Time: 08:41)

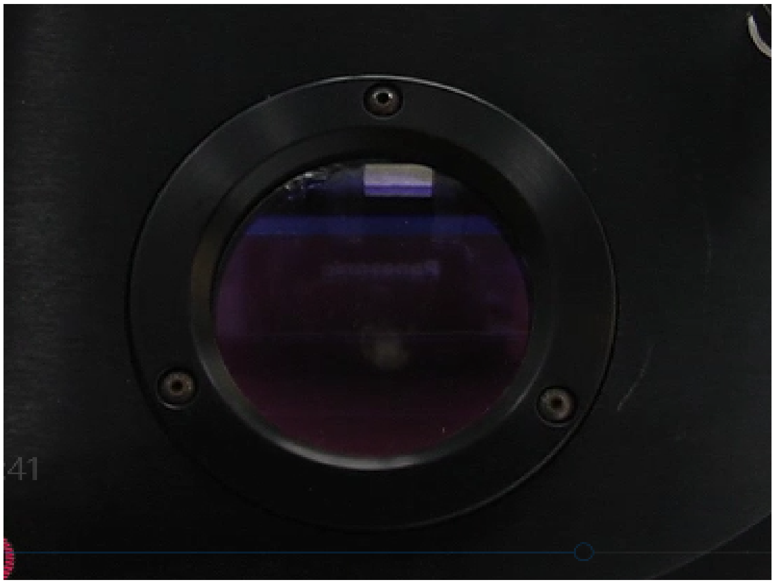
So, were going to bond the glass slide with the PDMS, so they have put in a quad surface and put inside the plasma cleaner.

(Refer Slide Time: 09:13)



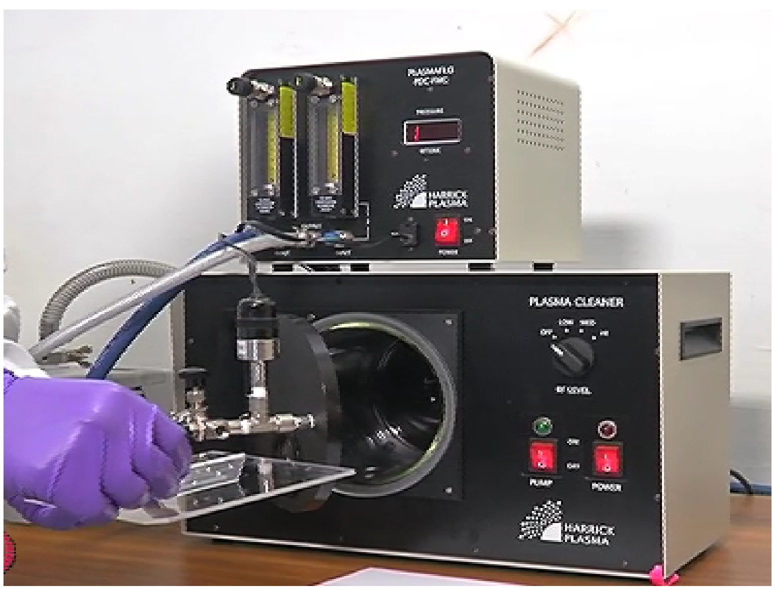
So ,after the pressure required pressure is reached plasma power is switched on and the setting is at the medium level with slight adjustment of entrance of the oxygen into the chamber we can create the plasma.

(Refer Slide Time: 09:40)



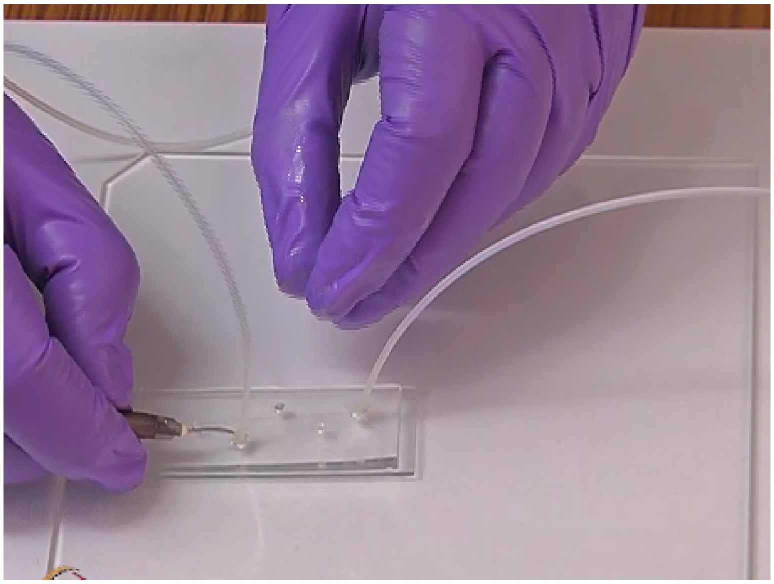
So were going to treat the PDMS and the glass slide surface with the oxygen plasma for about a minute and you can see the oxygen plasma the correlation is light blue color that you see okay.So, once the treatment is over we take out of the plasma chamber and bond them okay after the glass and PDMS are treated.

(Refer Slide Time: 10:06)



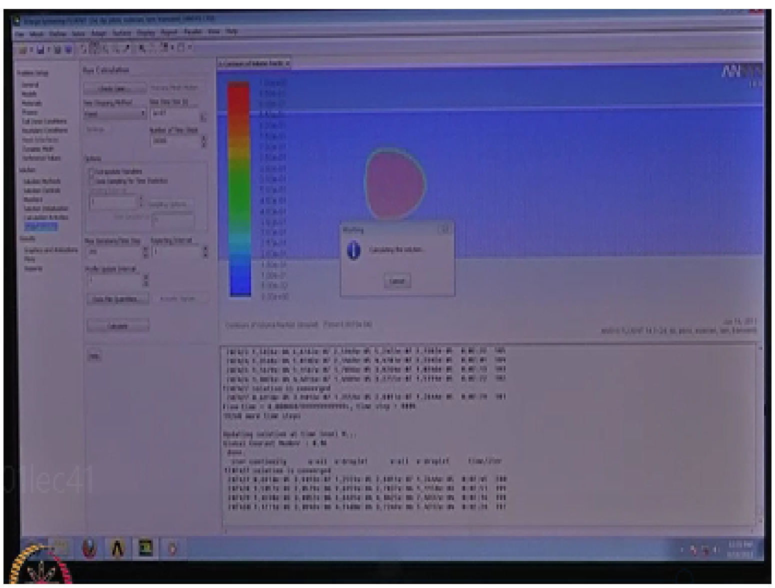
We take it out of the chamber and put the PDMS is on the surface facing down on the glass slide.

(Refer Slide Time: 10:21)



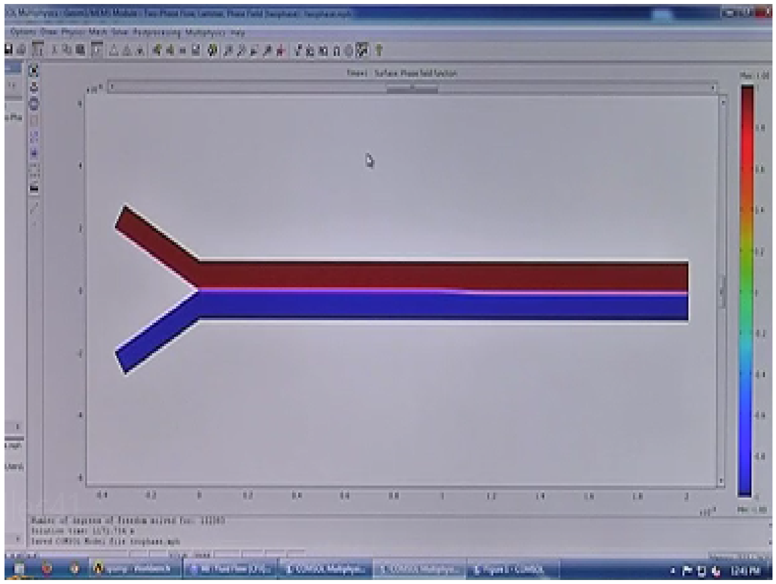
And we apply gentle pressure so it very gentle pressure the bond should be irreversible okay. So the PDMS is irreversible. Now the capillaries will be bonded to the chips on the punch whole areas and so the capillary is inserted into the holes and we glue it around. So, that is how the external fluid is going to be supplied to the chip.

(Refer Slide Time: 10:56)



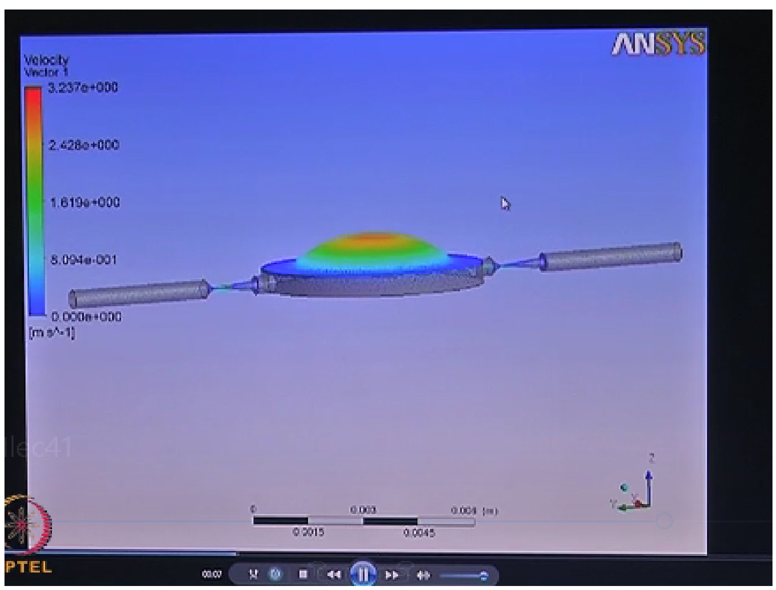
Okay so you know as a as saying we are doing the theoretical analysis and experiments so this is 1 numerical simulations that we are performing.

(Refer Slide Time: 11:09)



Here a 2 fleets of different discuss it is coming into a channel and were trying to predict what the interface location is knowing the viscosity ratio okay.

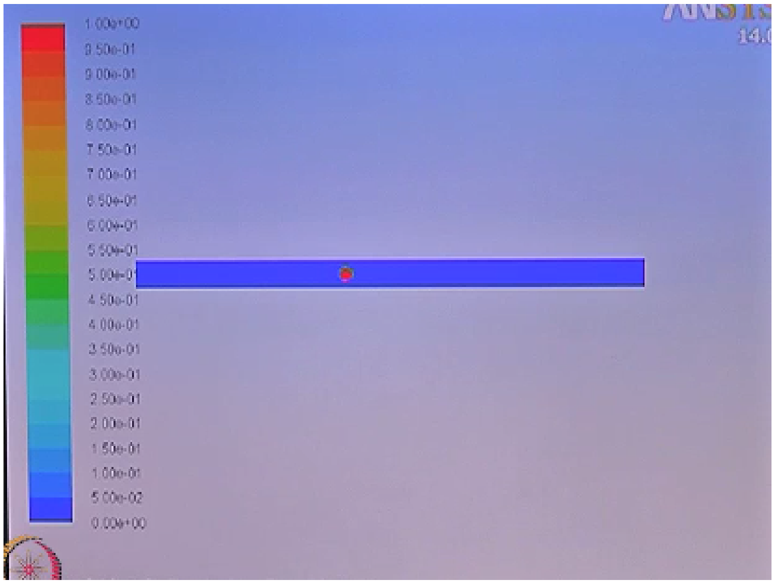
(Refer Slide Time: 11:21)



So, this is a pressure electric actuated valve less micro pump that we are trying to simulate as you can see there in the forward stroke as the membrane moves up the fluid comes into the chamber more as compared what it goes out. And in the reverse stroke when the membrane goes down more fluid goes towards the exit outwards toward the outlet as compared to what goes out through the inlet.

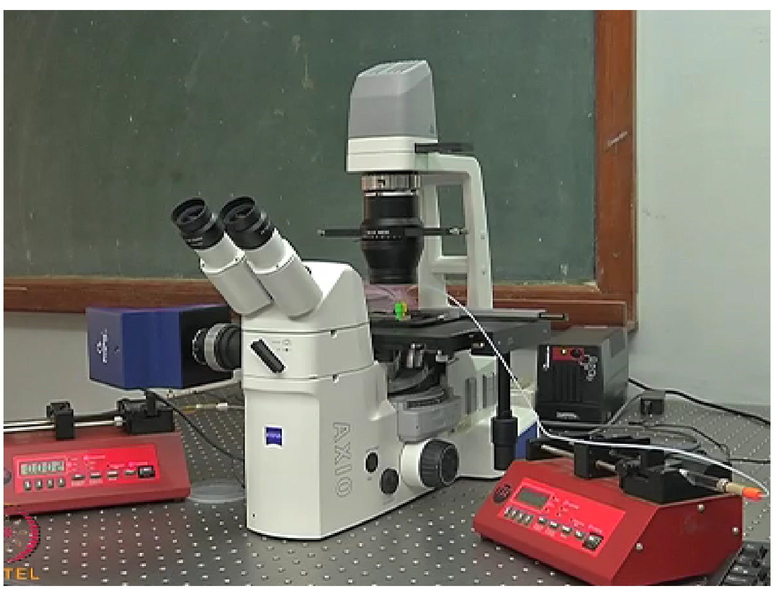
So we have a net flow coming from the inlet to the outlet.

(Refer Slide Time: 11:52)



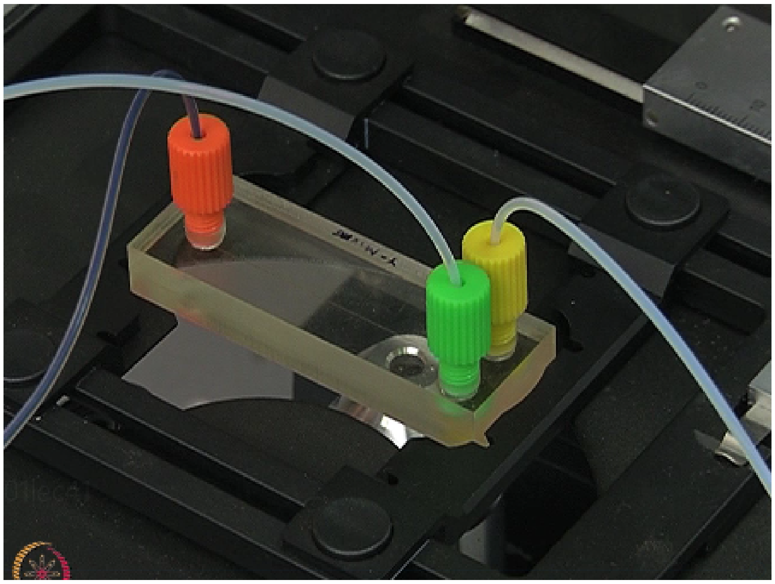
So, this is a simulation of the motion of a droplet in a microchannel that we are trying to do here and were trying to predict the additional pressure drop that we encounter in the presence of a droplet as compared to in a case where we do not have droplet present in a channel okay.

(Refer Slide Time: 12:10)



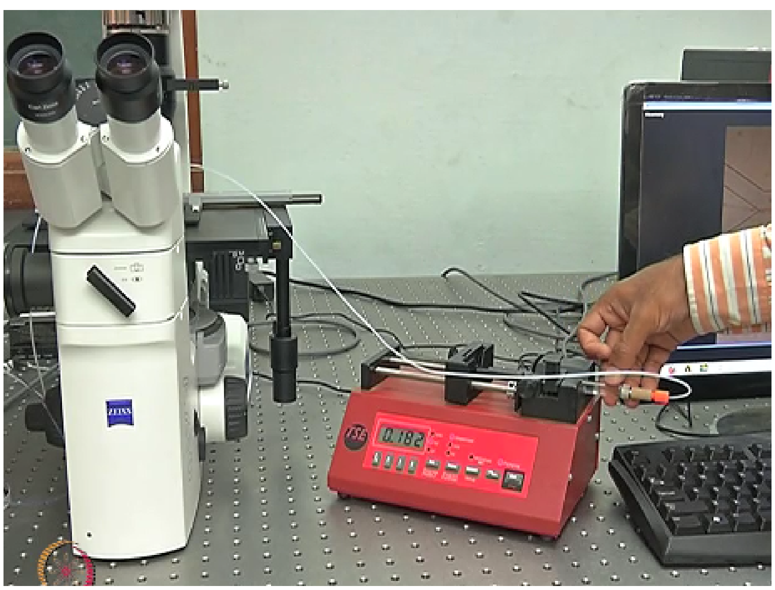
So here you can see you are doing an experiment on mixing mixing 2 fluids in a micro channels as you can see we have 2 syringe pumps driving 2 different fluids equal flow rates and so the 2 fluids still mix going to be a diffusion zone which is going to be developed.

(Refer Slide Time: 12:35)



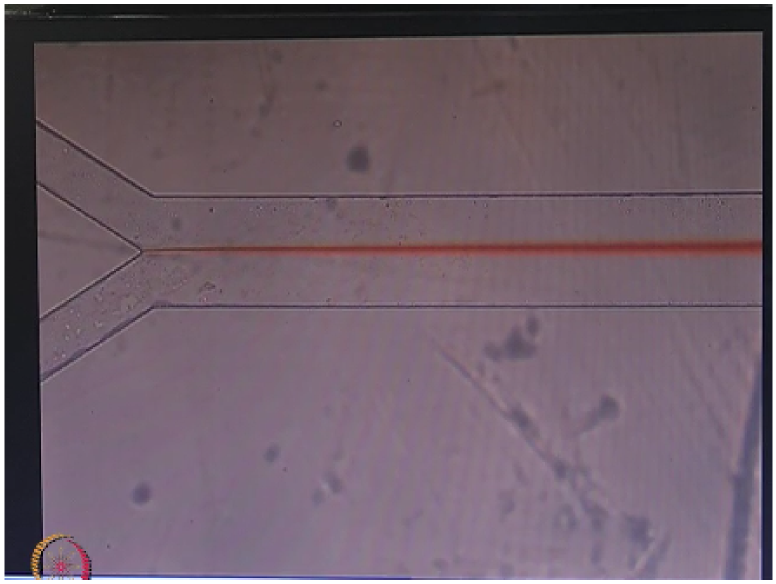
So, here is the microchip that way of using for the experiment and you can see there are 2 inlets and 1 outlet and the inlet fluidic connection is by quarter 28 unit thread and we have these fluidic threads also connected to the capillaries and which are threaded on to the fluidic hole or the connection.

(Refer Slide Time: 13:02)



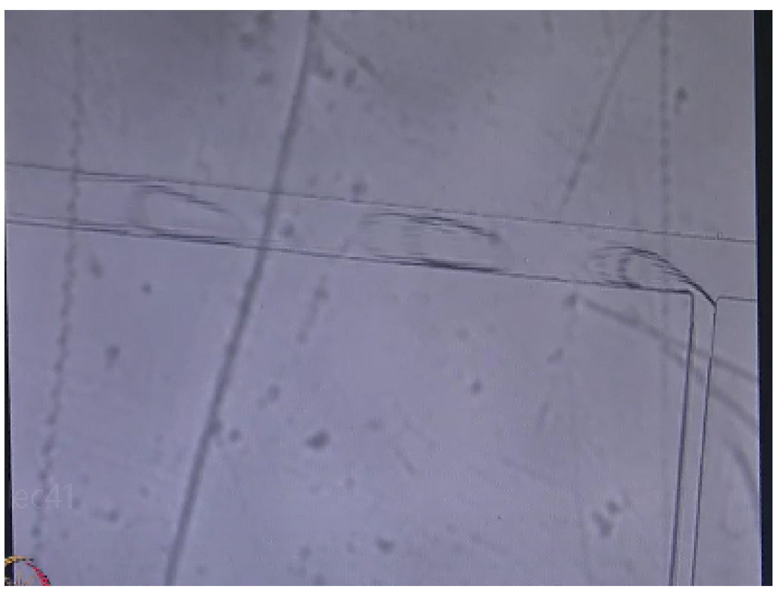
So this is the syringe pump the fluid into the microfluidic chip we have a glass tight syringe and this since pump is going to be driven by the stepper motor and so this fluid is going to be pushed and going to go to the chip using this capillary.

(Refer Slide Time: 13:19)



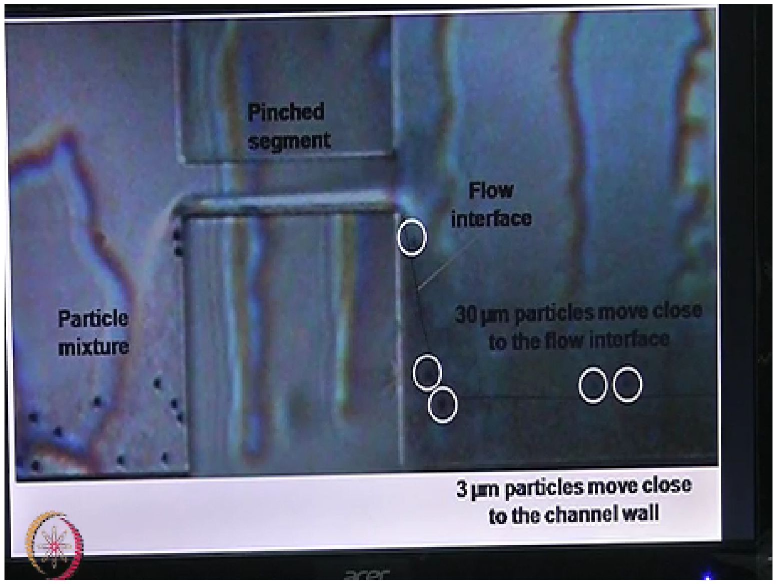
So this was the video that the experiment that we have running where 2 fluids being mixed 2 colorless fluids are being mixed and as they come in contact with each other a diffusion zone is developed and as you can see the width of the diffusion zone increases along the flow direction okay.

(Refer Slide Time: 13:43)



This is an experiment generation of micro droplets in micro channels as you can see the continuous phases trying to shear the discreet face where discreet droplets being formed in micro channels.

(Refer Slide Time: 13:57)



We are also doing experiments the particle setting this is a mechanism called pinch flow fractionation where we use a pinch segment to pinch a particulated sample with pure fluid and based on the principle that particles tend to move along the stream line passing through the center of mask the bigger particles will be closer to the center line. And the smaller particles will move close to the wall. And that is how we will be able to sort particles using pinch flow fractionation.