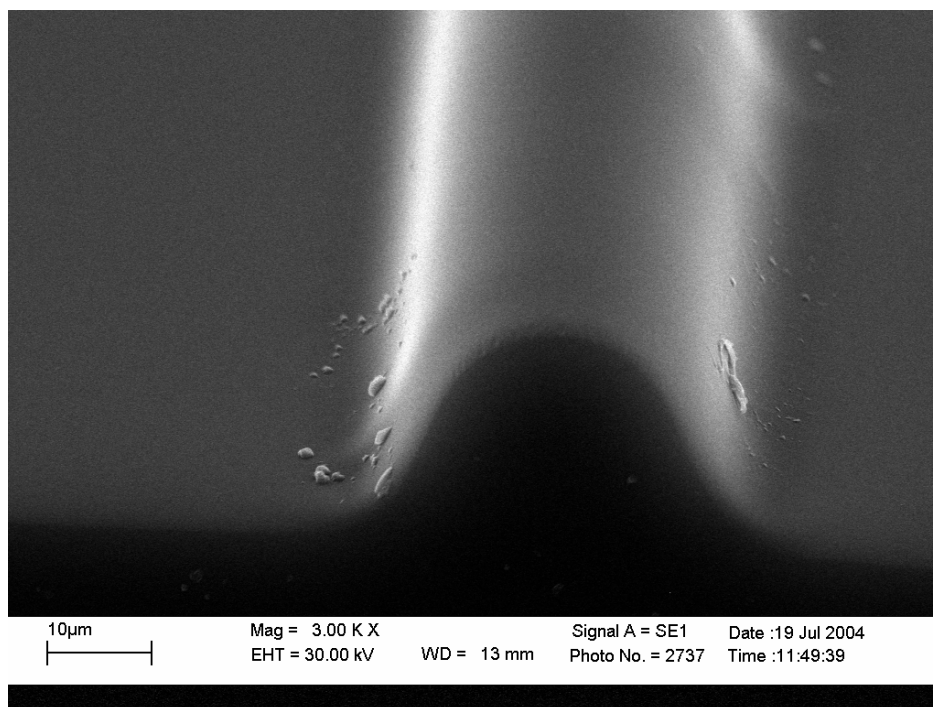
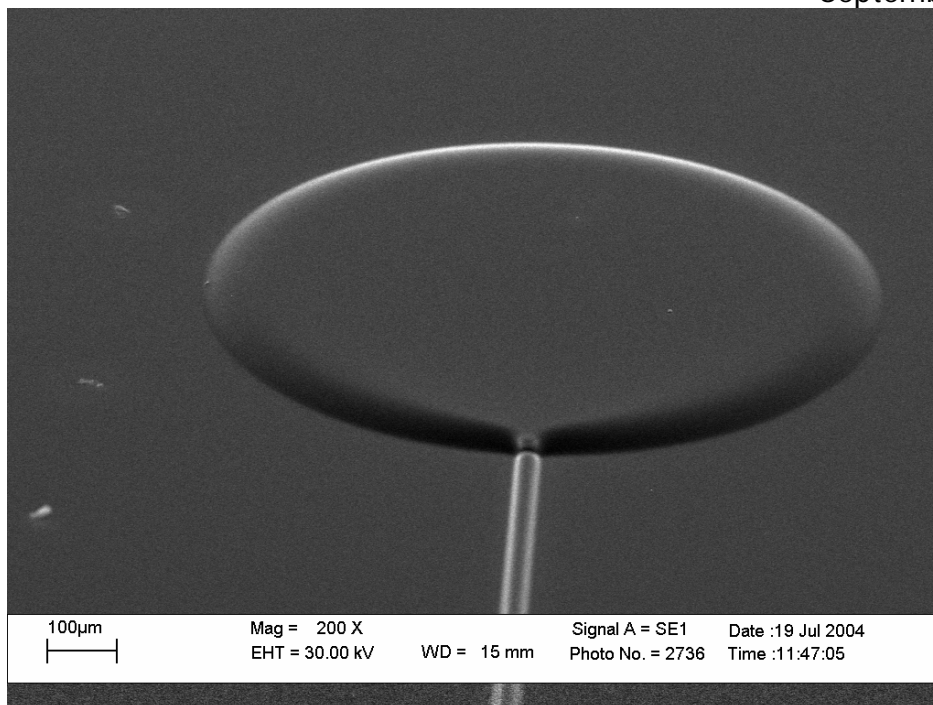


# NanoFab's PDMS Microfluidic Device Fabrication Manual

Aruna Kroetch  
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## Introduction

The use of PDMS in microfabrication, especially microfluidics, packaging, and microcontact printing, is becoming increasingly popular. PDMS has many desirable qualities such as its low cost, simple fabrication procedure, and robust nature. It is optically transparent down to 280 nm, can be reliably demolded numerous times from the same master, and can be reversibly sealed to itself or irreversibly sealed to itself, silicon, or glass after exposure to an oxygen plasma. After completing this fabrication manual, you will have a bonded microfluidic chip and the knowledge to apply to your own process.

## Objective

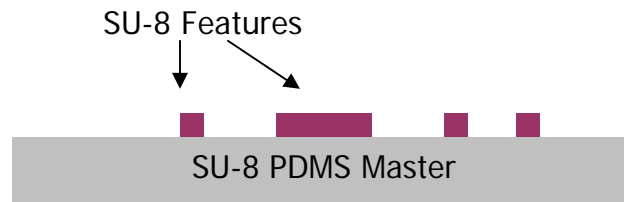
The objective is to become familiar with the typical steps of PDMS micromolding. In one day, a PDMS silicon master and the resultant PDMS mold will be fabricated using standard lithography and PDMS mixing/curing protocols. The resultant PDMS microfluidic device will also be irreversible bonded to a piece of glass. **As you go through this manual with a NanoFab Staff Member, fill out the provided run cards and record any observations that may help you in the future.**

## Fabrication Overview

### PDMS Silicon Master

PDMS silicon masters can be fabricated using either an SU-8 or a deep silicon etch (ICP/RIE) protocol. Due to time restraints, an SU-8 master will be created.

- SU-8 photoresist is spun on a clean wafer, exposed, and developed in a typical optical lithography process.
- Because of the viscosity of SU-8, thick photoresist layers are produced.
- SU-8 is a chemically amplified negative photoresist which must undergo a post-exposure bake
  - When SU-8 is exposed, strong acids are formed in the exposed areas. The post-exposure bake activates the areas that the strong acids initialized, resulting in epoxy cross-linking.



Side view of a SU-8 PDMS master. Because of the difficulty removing PDMS, the photoresist remain on the master and becomes the features. Note: drawing not to scale.

- SU-8 is extremely difficult to remove due to the extreme epoxy cross-linking, so on PDMS masters, the SU-8 remains and becomes features as shown in Fig 1.
- More info at [http://www.microchem.com/products/su\\_eight.htm](http://www.microchem.com/products/su_eight.htm)

### **Silanizing the PDMS Masters**

Silanizing the PDMS master is important as many typical silicon surfaces result in PDMS adhering to the master, making peeling and preserving the PDMS more difficult. A drop of trichloro(1,1,2,2-perfluorocetyl)silane is placed in a vial and placed in a desiccator with the PDMS master. The desiccator is placed under a vacuum causing the silanizing agent to evaporate and form a monolayer on the surface of the master that prevents the PDMS contacting and bonding to the master's surface

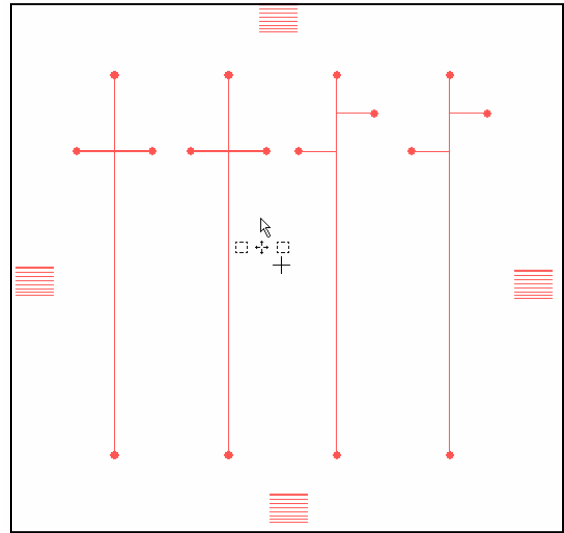
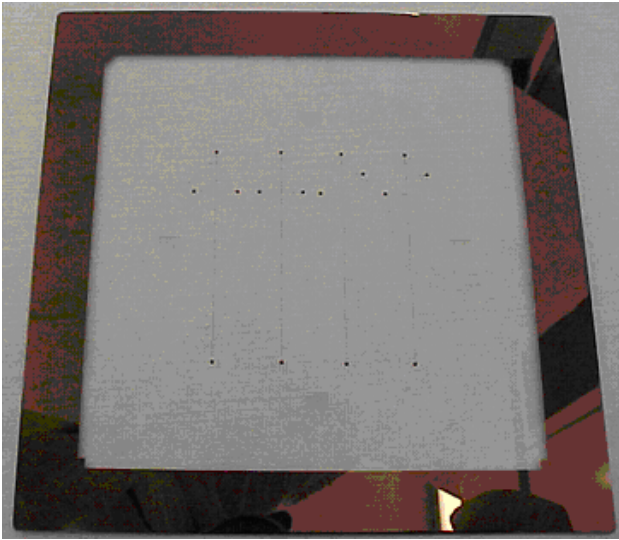
### **Preparing and Curing the PDMS**

Preparing the PDMS is very straightforward. Sylgard 184 silicone base and curing agent are mixed in a 10:1 ratio by weight. Then the mixture is degassed to remove any bubbles and poured over the PDMS master. The PDMS is then baked under vacuum, causing it to cure and ensuring all entrapped gasses are evacuated. After cooling, the PDMS is easily peeled and cut.

### **PDMS Bonding**

PDMS can be successfully bonded to glass, silicon, and itself using a standard oxygen plasma in a reactive ion etcher (RIE). PDMS is quite hydrophobic with an overall non-reactive surface, making it difficult for it to bond with other surfaces. By exposing PDMS to an oxygen plasma, the PDMS surface becomes hydrophilic and reactive, resulting in irreversible bonding when it encounters glass, silicon, or another PDMS piece that was exposed to the same plasma. This contact should be made immediately because the PDMS surface will return to its hydrophobic state after time.

## The Standard Microfluidic Optical Mask



The mask that will be used to fabricate the microfluidic devices was created with the Heidelberg DWL-200 Laser Pattern Generator and L-EDIT V10.01. The microfluidics are designed within a 3.25" diameter so that the master integrates with the master holder. The mask has two standard microfluidic designs with 50um wide channels and windows for alignment with a 4" silicon wafer.

## List of Materials and Supplies

- 4" silicon wafer
- SU-8 2050 Photoresist
- SU-8 Developer
- Disposable graduated dropper
- Glass vial
- Plastic bag
- Trichloro(1,1,2,2-perfluorooctyl)silane
- Disposable plastic beaker
- Sylgard 184 Silicone Elastomer Kit (PDMS)
- Mixing stick
- X-ACTO Knife
- Blue Tape
- Glass Beaker
- Disposable Dropper

# Processing Equipment

## **PDMS Box**

In the PDMS box, you can find disposable droppers, beakers, vials, and plastic bags. This is also where you can find the PDMS Micromolding Instructions and the Master Holder.



## **Wet Deck**

The wet deck provides an area for doing numerous wet chemical processes. Piranha cleaning and SU-8 developing are performed on these decks.



## **Aisle 1 Fumehood**

This fumehood is used to spin PMMA, SU-8, and other chemistries onto substrates while preventing the majority of fumes from entering the main air.



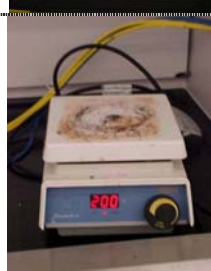
## **HeadWay Resist Spinner**

The HeadWay Resist Spinner is used to manually dispense various photoresists. Because of its location in the Aisle 1 Fumehood, various organic chemistries can be spun.



## **Contact Hot Plate**

The contact hot plate is found in the Aisle 1 Fumehood and is used to perform a soft bake that drives off solvents after the SU-8 photoresist is spun and to perform a post exposure bake to initialize the epoxy cross-linking after the resist has been exposed.



## **ABM Contact Mask Aligner**

The mask aligner exposes and transfers the pattern of your mask onto the SU-8 covered silicon substrate.



### **Aisle 3 Fumehood**

This fumehood is used to mix and prepare the PDMS while preventing the majority of fumes from entering the main air.



### **Desiccator**

The desiccator provides a dry environment that can be placed under vacuum. It is used to degas the PDMS and to silanize the PDMS silicon master.



### **PDMS Holder**

This holder can be leveled during curing, has an O-RING design to prevent PDMS from seeping under the master, and makes demolding PDMS relatively simple.



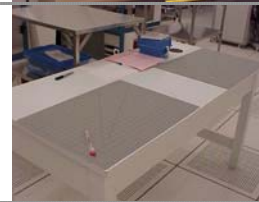
### **PDMS Oven**

This oven can be placed under vacuum and is restricted to PDMS use so that contamination is minimized.



### **PDMS Work Area**

This area should be used during demolding. It has cutting mats to facilitate in device fabrication.



### **Blue Tape Dispenser**

Here tape can be placed on one side of the demolded PDMS to protect it until it is used or bonded..



### **Microetch RIE**

This RIE is used to create a hydrophilic and reactive PDMS surface so PDMS can irreversibly bonded.



# Procedure

## **Creating the SU-8 Master**

- 1) Piranha clean a 4" silicon wafer and the piece of glass.
- 2) Dehydration bake them on a contact hot plate for 5 minutes at 200°C.
- 3) Turn the vacuum on the Headway Resist Spinner found in Fumehood 1. Use the SU-8 spinner containers.
- 4) In Program 3, change rpm1 to 500, rmp1 to 5, and time1 to 10s. Turn rpm2 to 4000, rmp2 to 15s and time2 to 30s. (This gives roughly 30 – 40 um)
- 5) Pour the SU-8 2050 directly onto the wafer. Note: because of the viscosity no beaker is used so that waste is reduced.
- 6) Put on cover and press the start button.
- 7) After it has spun, let the wafer sit for 5 minutes so that entrapped air has a chance to escape.
- 8) Soft bake the substrate for 3 minutes at 65°C and 9 minutes at 95°C on the contact hot plate so that all solvents are driven off.
- 9) Let the wafer cool.
- 10) Expose the design on the wafer for 75s under the mask aligners (wavelength of 356 and 405 nm). Note: use the instructions for the mask aligners.
- 11) Post exposure bake the resist for 1 minute at 65°C and 7 minutes at 95°C.
- 12) Develop in SU-8 developer for 3 – 5 minutes.
- 13) Rinse with IPA, dry with a nitrogen gun, and inspect with a microscope. If a white film occurs during after rinsing, the substrate has been underdeveloped.

## **Silanizing the SU-8 Master**

- 1) Masters are silanized to prevent PDMS adhering to it after curing.
- 2) Using a plastic dropper, place a drop of trichloro(1,1,2,2-perfluorooctyl)silane in a glass vial.
- 3) Place the holder in the glass desiccator. Put the master and the vial containing the silanizing agent in the holder.
- 4) Put the desiccator under a vacuum for 1 – 2 hours. During this time, the silane will evaporate and form a monolayer on the master.
- 5) Vent the desiccator slowly.
- 6) Remove and store the master.
- 7) Put the plastic eyedropper and the vial in a plastic bag and place it in the Organic Waste bin underneath Fumehood 1. Note: The glass and the eyedropper are both contaminated by the silanizing agent.

## Preparation and Curing of PDMS

- 1) Measure about 25 g of the PDMS base and the curing agent in a 10:1 ratio by weight for one master in the plastic petri dishes found in the PDMS box.
- 2) Mix the PDMS smoothly and well.
- 3) Place the mixture in the desiccator under vacuum at about 22 in Hg until there are no bubbles in the mixture. This should take 10-20 minutes.
- 4) Place the master in the PDMS Holder.
- 5) Pour the degassed PDMS on the master slowly to avoid trapping air.
- 6) Place the mold in the PDMS vacuum oven and cure at 80°C for 2 hours under a vacuum of 5 in Hg. This vacuum will aid in evacuating entrapped air, enabling finer features to be produced.
- 7) Carefully peel off the PDMS, blue tape the features to prevent contamination, and cut the PDMS as seen fit.
- 8) Place all the PDMS waste in the Organic Waste underneath Fumehood 1.

## PDMS Bonding

- 1) Following the RIE instructions, do a 10 minute oxygen clean on the uEtch RIE.
- 2) Load in the PDMS piece and the glass piece.
- 3) Follow the following recipe.
  - a. O<sub>2</sub>: 25%
  - b. Pressure: 0.200 torr
  - c. RF: 33.3%
  - d. Time: 30 seconds
- 4) As soon as possible, bring the PDMS and the substrate into contact.
  - a. For best results, place a drop of water between the PDMS and the substrate. This will allow more time for adjustments to be made and will provide a more consistent bond with less bubbles. The water must evaporate before the bonding is complete.
- 5) Ensure that the RIE is shut down.