MAKING A MOLD USING SU-8 PHOTORESIST

All work is done with Saurabh Vyawahare in the Princeton Microfluidics Core facility in 105 Jadwin Hall (Physics Department).
Website: http://www.princeton.edu/microfluidics/

Materials You Should Provide:
Silicon Wafers (3-4", type P, 500um thick, SSP, Resist 1-100, Quality: Test. We get ours from University Wafers).

Photoresist: SU-8 2000 series from MicroChem. I've been using SU-8 2050 exclusively; consult MicroChem's website for other formulations (affects channel depth). Our lab’s bottle of SU-8 2050 is currently in the flammables cabinet in the Microfluidics facility.


TCMS (use in hood; caustic). I've been using the stuff already in the facility; we should probably get our own at some point.

Petri Dishes for holding completed molds(s).

Tweezers for handling wafer (flattened ends).

A 5x5" glass plate(s) for UV exposure.

A. Applying photoresist.

1. Program spin coater. Use the “mode” button to go to programming mode.
   a. Step 0: Nothing here
   b. Step 1: 500 rpm, 10s, 5-10s ramp.
   c. Step 2: x rpm, 30s, 5-10s ramp. *this determines your channel depth.
   d. Step 3: 0 rpm, 15s ramp.

   If you want to change any settings, you must hit “enter” or it won’t be saved.

   The depth of your design is determined by the type of SU-8 and the spin speed at Step 2. SU-8 2050 channel depths I have gotten at different speeds are in the Microfluidics Packet; for other resists consult MicroChem’s website.

2. Do a trial spin with a test wafer to verify your program.
3. Cover the bottom of the spinner with foil. Clean wafer with air gun if necessary. Place your wafer in the middle of the chuck, shiny (polished)
side up. Pour SU-8 to cover ~25-50% of the wafer – try to pour close to the surface of the wafer to help prevent bubbles.

4. Shut the lid (this will pull a vacuum). Start the spinner.

5. When done spinning, you need to do the soft bake. For most depths useful for worms, this is:
   a. 3m at 65°C
   b. 10m at 95°C
   c. While you’re baking, pull up the foil from the spinner and use acetone to wipe off any SU-8 from the sides of the spinner. Dispose of foil and wipes in the Ziploc beside the machine.
   d. Consult the MicroChem manual for specific bake times for your channel thickness; Saurabh recommends adding an extra 1m to the recommended 95°C bake.

General Notes: Keep your wafer covered as much as possible, this prevents dust.

B. UV exposure.

1. Remove your transparency (20,000 dpi, from CAD/Art Services) from the bag it was shipped in (open in a clean room to avoid dust). Turn so that the printed side is facing you, and snip the upper-left corner so you know which side is “up.” Cut out the designs you want.

2. Place a wipe on the table, and place your 5x5 glass on top of it. With the printed side FACING you, tape your design to the glass with Scotch tape.

3. Get the mask holder, carry to table. FLIP THE GLASS (the printed side will now face the table), use screws to fasten into apparatus.

4. Carry to machine, use screws to tighten. Your transparency now faces downwards.

5. Sign up in the notebook, check to see that UV lamp and vacuum is on (under table, separate pieces of equipment). Turn on the vacuum if necessary; If UV is not on, contact Saurabh.

6. Raise mask holder, slide wafer onto wafer holder. Center, turn on vacuum (located to the left of the machine).

7. Lower mask holder. If necessary use XY screws to orient wafer under mask using microscope.

8. Use the “Z” dial to raise the wafer to the glass. You want them to touch, you should see the glass rise slightly.

9. Set UV exposure time. This is unique to each machine and involves some guess-work. If you’re trying a new depth, look through the book to see what others have tried and if it was successful (or ask Saurabh for suggestions). For ~30µm with SU-8 2050, I do 14s.

10. Put on UV glasses and hit “cycle.” The machine will go first bring the microscope attachment over your mask so you can check the alignment (not necessary for single layers). Hit “cycle” again for UV exposure.

11. Remove your mask, turn off the vacuum and place your wafer back in its petri dish. Place your transparency (still attached to the glass plate if you
like) back in the bag it was shipped in, and store in the glass cabinet in the clean.

12. Now its time for the Post-Bake
   a. 3m 65°C
   b. 10m 95°C (same as soft bake).
   * If your exposure was done properly, you should see your design appear on the wafer in the first 15s at 95°C.

C. Developing.

1. Get a flat-bottomed, glass container large enough for your wafer (there should be an inch or so of extra diameter). Wash with water, then acetone, then isopropanol, and wipe dry. Place in hood.
2. Pour SU-8 Developer into vessel (enough to completely cover the bottom). I like to wait a couple of minutes for the wafer to cool after the Post-Bake. When you are ready, use tweezers to place the wafer in the developer.
3. Gently swirl your wafer in the Developer using a circular motion. You will see your features acquire sharper relief as the un-crosslinked resist is dissolved; if your tweezers pull up bits of resist when you pull it out then it needs more time. I usually develop for 3 minutes.
4. Place wafer on clean wipes in hood; use air hose to dry/remove developer.
5. Dispose of developer in organic waste container; clean vessel with acetone and isopropanol.
6. **Optional:** You can apply TCMS, this helps release PDMS from your mold. In the hood in the semi-clean room, place on foil boat in TCMS container (will be marked, stays in fume hood). Using a Pasteur pipette and disposable bulb, get a few drops of TCMS (Caustic!). Balance your wafer on the bottle cap in the TCMS bowl, cover with the provided lid, and leave for 1-3 minutes. I haven’t noticed a difference from skipping this step.
7. Mold goes back in Petri dish. I usually write the pertinent information from the fabrication (date, spin speed, exposure time, bake times, development times) on the lid to keep my molds straight.
Mold fabrication troubleshooting

How do I know how deep my channels are?
There are two routes – using the profilometer in the Microfluidics Facility, or measuring PDMS slices on the Nikon.

Profilometer – scans your mold (silicon wafer) with a fine needle (won’t cause damage). Most precise method, but requires training from Saurabh (easy to use).

PDMS slices – make PDMS chips as detailed in “applying PDMS.” Instead of bonding to glass, bring PDMS chunks back to lab, cut thin slices with a knife or razor blade. Place them on their sides on a microscope slide, such that the underside of the PDMS that has your features on it now faces the right or the left. Take to the Nikon, image at 10X, and measure the channel depth using the “length” feature. This is also helpful for viewing your features (see below).

ALWAYS CHECK YOUR CHANNEL DEPTH; EVERY SPINNER IS DIFFERENT AND I’VE SEEN MAJOR DIFFERENCES IN DEPTH AFTER MOVING OR SERVICING THE SPINNER.

I may have had my transparency upside down when I made my mold. How can I tell?

It is very important to use the printed side of your transparency against the mask during UV exposure – otherwise you will mess up your features and not get fine resolution (see Figure). To easily tell if your mask is upside down, look at it under a microscope. Can you get the features into focus? If not, you’re probably working with transparency upside down. Not sure? Flip it over and see if the other side goes into focus (see Figure).

My wafer sticks to the glass plate when I do the UV exposure.
You need to increase your soft bake time (the time on the heat block prior to UV exposure). This evaporates solvent in the photoresist, ensuring that it will not stick.
Photoresist flakes off of my wafer when I’m developing. You may be underdeveloping your wafers. An easy cure: put back in developer for a few minutes. Otherwise your wafers may be dirty – I dropped my first batch of wafers and had a major problem with flaking. Try cleaning them with the air gun, or ask Saurabh to recommend a solvent. You can also pretreat your wafer with HCMS (as you would use TCMS after developing), but I haven’t tried this.

My chips don’t bond to the glass. Your materials may have dust or oil on them. Always use tape when processing PDMS, you can also wash your PDMS and slides with ETHANOL prior to bonding if this is a major concern. If this doesn’t help, the plasma bonder might be broken or need attention.

I gave my PDMS plenty of time to cure, but it is still sticky. Either you didn’t add enough curing agent, or didn’t mix your PDMS sufficiently. Carefully peel the PDMS off of your mold and start over. There may be regions of PDMS that are solid and can be salvaged, check before you throw it all away.