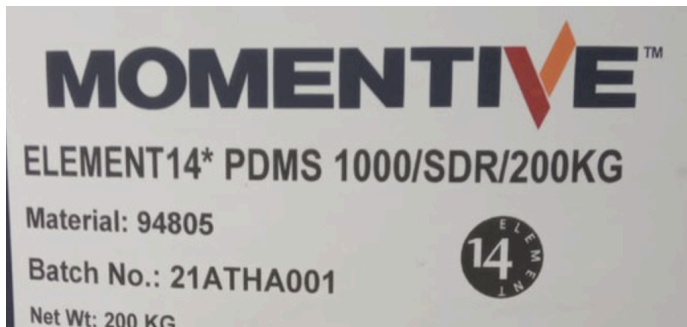


### PART 3: PUSH DOWN DEVICES (e.g. MITOMI)

#### Required Materials:

- RTV 615 (under sink in clean room, small bottle = crosslinker (component “B”), large bottle = base (component “A”)) – \*this is a type of PDMS, a soft polymer used for devices.
  - Mixing Momentive and Sylgard leads to bad results! **ONLY** use Momentive
  - If out of Momentive and Sylgard is the only option, check out Sebastian Maerkl’s groups methods if needing to only use Sylgard.
  - **DO NOT USE DIFFERENT LOT #s OF PART A + B**



Read the **Batch No.** and make sure this is the same for Part A + B!

- Mixer Cups (in plastic box on bottom shelf of table in clean room and under sink)
- Aluminum foil
- PFOS treated wafer
- Scalpel and cutting board (in cabinet above hole punching drill in clean room)

#### Protocol

##### Thick (control) layer

Each wafer requires ~ 52 g of material. This procedure is for 2 wafers. Adjust as needed.

##### *Weigh out PDMS*

3. Blow cup with clean air to get rid of dust.
4. Weigh out **18 g Part B** (crosslinker) and **90 g Part A** (base) (1:5 ratio, **keep total volume below 110 g to minimize` spillage in THINKY**). Add Part B first and then Part A. Wipe RTV 615 bottles with TekWipes after each pour.
  - a. Use different wipes for Part A and B to avoid cross-contamination of crosslinker.
  - b. Add a THINKY “hat” (plastic bag) and secure with a rubber band. Cutting “slits” on the bag can help with attaching the bag. (Rubber band helps prevent the bag from coming off).

##### *Mix PDMS*

4. Turn on THINKY mixer, open lid, and remove the cup holder adapter to weigh it. Insert mixing cup with unmixed PDMS and weigh assembly. Adjust balance with scissors to correct weight. Normally 225 g will work well for this recipe.
5. Put this whole assembly inside the THINKY mixer. Set the THINKY mixer to mix 3 minutes at 2000 rpm ~~and then defoam 3 minutes at 2200 rpm~~. If no setting for rpm is available, use these times as values are already set.
6. While THINKY is mixing PDMS, get Petri dishes ready for control layer. Make foil wafer holders using either the black and white ‘pie tin’ foil tools in the cleanroom or by carefully placing a wafer on top

of a 5" square of Al foil. If the latter, roll the sides of the foil up around the wafer while carefully holding the wafer down (gently!). Make sure the wafer is airtight with the bottom and the bottom of the foil tin is sitting flat.

#### *Degas PDMS*

5. Pour ~ 50-55 g of mixed PDMS on top of each wafer.
6. Degas 45 minutes. To do this, remove lids from Petri dishes containing wafers and PDMS and place the dishes on shelves within the vacuum chamber. Turn the stopcock to close the vacuum chamber, and turn on the pump (located on the shelf underneath the table). If the PDMS starts to bubble over, spin the vacuum chamber valve to let in a little bit of air and deflate the bubbles. You have to really watch this here – if the PDMS bubbles over too much, it can make it really hard to peel the PDMS off of the wafer without cracking it.
  - a. You can speed up de-gassing (~20-25 minutes) when the bubbles are large enough and on the surface of the PDMS by removing the wafers, and **gently** popping them with the air gun by the fume hood. **Be careful during this step to avoid spraying PDMS, and wear eye glasses if you choose to do this!**
  - b. You also don't need to wait for *every* bubble to pop; you can use a pipette tip to push stray bubbles off of the features before baking.
7. Remove the wafers from the vacuum chamber. Push out remaining air and PDMS underneath wafer using Teflon sticks (push on each side of wafer with 1 Teflon stick) GENTLY.
8. See baking instructions below before proceeding. The thick layer must be placed in the oven 25 min before the thin layer.

#### **Thin (flow) layer**

##### *Weigh out PDMS*

3. Blow out mixer cup with clean air to get rid of dust.
4. Weigh out **5 g Part B** (crosslinker) and **100 g Part A** (base) (**1:20 ratio**) into cup.

##### *Mix PDMS*

4. Insert cup with PDMS into THINKY cup adapter, weigh entire assembly, and adjust balance within THINKY mixer.
5. Put this whole assembly inside the THINKY mixer. Set the THINKY mixer to mix 3 minutes at 2000 rpm and then defoam 3 minutes at 2200 rpm.
6. While THINKY is mixing PDMS, get Petri dishes ready for flow layer. Spread a foil sheet over the bottom of the Petri dish – use your gloved hands to make this as nice and flat as possible and fold the edges over the sides. Place wafers in foil-lined Petri dishes.

##### *Spin PDMS*

1. Turn on spin coater by flipping toggle switch that controls **air** (the middle valve on the wall in the inner part of the clean room) and the **vacuum**.
2. Set the spin program to go through the following 2 steps:
3. Step 1 (spread): 500 rpm, ramp = 133x, time = 10 s
4. Step 2 (spin): 1775-1825 rpm (*default 1800 rpm*), ramp = 266x, time = 75 s

#### **What do spin times impact? What might an incorrect spin time result in, in terms of device operation?**

spin times determine the height of the flow layer and in turn the thickness of the PDMS that needs to be deflected to close valves. This means spin time will be related to what control pressure you

need to run the device at (faster spin → marginally thinner flow layer → lower PSI required to actuate valves).

5. Place a wafer on the spin chuck (center the wafer!).
  - a. Hit the vacuum button to pull a vacuum. **Gently** tug on the wafer to make sure it is immobilized.
6. Pour some (around a 1.5" diameter circle) of PDMS onto the wafer and start the program. Make sure that the cup is near the surface of the wafer when you pour (but not touching) to avoid bubbles.
7. Remove wafer from spin chuck and replace in Petri dish.
  - a. If you've been spinning a lot, there may be PDMS coating the side of the spin coater that could drip onto your wafer. As you open the spin coater top, you can use the top of a petri dish to protect your wafer from any stray dripping PDMS.
8. Relax PDMS-spun wafers for at least 5 minutes. Relaxation can help remove "bumps" or "waviness." Can relax for longer if needed. MGH relaxes wafers up to 1 hr.
9. *Optional: Degas Thin (Flow) Layer*
  - a. After spinning, place in vacuum chamber and degas ~5min or until bubbles are free (see Degas - step 2)
  - b. **Relax** flow layer before baking. Bubbles escaping during this step could disturb the surface of the PDMS and interfere with alignment downstream

### **Baking and alignment**

1. Bake thick layer at 80C for 60 minutes in convection oven.
2. Bake thin layer at 80C for 40 min in the convection oven.
  - a. This size shouldn't change too much with additional baking. RH has done up to 50 minutes without problems.
  - b. Place this wafer in about 25 min after beginning the thick layer to allow time for hole punching.

### **What do bake times impact?**

If you bake the control layer for **not long enough**, the features won't shrink enough and you will struggle to align. This is less of an issue for the flow layer, since it is adhered to the wafer.

If you bake either layer **too long**, you risk cross-linking each layer too much, so there's not enough cross-linker to diffuse between the layers. This could result in delamination between the control and flow layers.

3. Peel control layer off of wafer. To do this, run scalpel along edge of wafer (carefully to avoid scratching wafer with scalpel) and then *carefully* peel off the thick layer of PDMS.
4. Use guillotine to cut out individual devices from thick layer using the cutter. If you like, you can also align the whole wafer. Remember, the thin layer should be in the oven still with about 5-10 min left.
5. Punch holes using drill press, being careful to remove all PDMS plugs – it's best to check the height of the drill bit before using. To visualize where to punch, remove the lens cap from the camera (it should already be on) and start the camera program (on the computer desktop).
  - a. Tape tape tape!!!
  - b. When punching holes, hold the device up to the light to look for blockages. You can use a syringe tip (light blue) to remove any remaining plugs.

6. Use hole punch to punch control layer holes. Be sure to punch holes all the way through the device and then lift the hole punch arm all the way up to release the device.
7. Align control layer to flow layer using dissection microscope (in inner clean room area) to visualize layers. I usually tape the wafer to the glass square before starting to align. Before aligning, clean off both the area of the flow mold you'll be using and the bottom of the control mold well with tape. Start at one corner and then roughly align other 3 corners. Release strain and do fine alignment starting in middle of device and working your way out.
  - a. Blow with N2 first!!
8. Bake both layers at 80C together for 50 minutes.
9. Cut devices off of flow wafer using a scalpel. Punch flow holes as before. For MITOMI devices, be careful here – there is an outlet hole on the other side of the device from all of the other flow and control inlets – don't forget it!

Pour leftover 1:20 PDMS mix onto thin layer molds – you need at least 10 g of the mixture to coat the wafer. Bake 40 minutes to overnight. Peel PDMS layer off of molds and store.

**Tip:** if you are ever struggling to punch holes or cut devices with the guillotine, you can replace these!  
**In the future, take some videos on how to replace these + where the reagents are, then put them on the drive.**