CALIFORNIA INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

ME 96
Microfluidic Chip Fab Manual

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1. Notes before you begin

- This protocol was written for:
  - Normal geometry chips (push down configuration where the control layer will end up being on top of flow layer)
  - Sylgard silicone elastomer
- DO NOT use gloves except for the step involving TMCS
- Always copiously clean the mixing cups. DO NOT use solvent and avoid using Kimwipes as much as possible.
- Make sure no dust is on your pattern.
- The wafers are silicon lattices, thus they have a tendency to break if manhandled.
- Rob Phillips' group can use the boxes (located in Watson 173) that have his name written on them. The white/clear box contains tools while the brown box contains Part A and Part B bottles for the preparation of PDMS.

2. Making chips

- Clean both the flow and control cups, if they contain solidified PDMS. Use only forceps and your hands, do not wear gloves. (This step need not be done if the cups are already clean. See the last step of the "Prepare the Flow Layer" section.)

- Clean both the flow and control molds:
  - Remove the thin flow layer from the flow mold using forceps. Remove small dust particles using N_2 stream. Never touch any part of the photoresist pattern. Do not use any liquids.
  - Remove aluminum foil containing control mold from Petri dish. Remove aluminum foil and residual PDMS from wafer. Blow clean with N_2 stream.

- Prepare PDMS:

Notes: Part A refers to the big bottle with the label 184 Si elastomer base. Part B refers to the small bottle that also has the word "curing" written on the label.

- For the Control Layer: The proportions for Part A to Part B are 5:1, i.e., 25g Part A and 5g Part B (usually a little bit more than that). Put the control cup on the scale and adjust the scale so that is shows zero on the display, even though the cup is on it. That way you will know the exact weight of the liquid you are pouring. Pour the liquids in the control cup. Close the cup and put it in the hybrid mixer located at the corner of the room, next to the ovens. Adjust the weight balancer to 175 by turning the silver knob (the weight should be more if the contents of your cup weight more than 30g. There should be a chart located on the wall next to the hybrid mixer. Consult the chart for the exact adjustment of the weight balancer). Mix using program number 2 (i.e. mixing time of 1min and defoaming time of 2min).
- For the Flow Layer: The proportions for Part A to Part B are 20:1, i.e., 15g Part A to 0.75g Part B (usually a little bit more than that). Put the flow cup on the scale and adjust the scale as before. Pour the liquids in the flow cup, close the cup and put it in the hybrid mixer. Adjust the weight balancer to 160 (or higher, depending on the weight of the mixture. Again, consult the chart next to the hybrid mixer). Mix using program number 2.
- Switch the hybrid mixer off.

- TMCS treat molds:
  Notes: For this part of the process, except for the molds, everything else needed should be located in the hood.
  - Only use the plastic container labeled "TMCS" (acronym stands for Chlorotrimethylsilane).
  - Pour about 0.5ml of TMCS in the small black container.
  - Remove the Petri dish cover containing the molds and put the molds in the plastic container. There are some stands in the plactic container so the molds can be placed on top of them.
  - Close the lid and incubate for 1-2 minutes.

- Prepare the Control Layer:
  - Clean the control mold with N_2 stream.
  - Cover the inside of a Petri dish with aluminum foil and put the control mold in it.
  - Pour the control layer PDMS mix into the Petri dish, using most of the content (2/3 of the wafer's area should be covered). When you pour the mixture, do it from a short distance and quite fast so as to prevent bubbles from forming.

- Using wooden applicators, press the mold to the bottom of the dish in order to make sure that the thickness of the PDMS is uniform on top of the wafer.
- Put the dish in the vacuum chamber to de-gas (remove all the bubbles) for about 10 minutes. To do that, connect the black wire to the lid of the vacuum chamber, put the lid on the chamber and turn the red knob of the lid as shown on it. If the red knob is turned properly, then you can hear the pump working.
- Take the mold out of the vacuum chamber.
- Remove any air bubbles of top of the pattern using small wooden applicators (use the wooden side, not the cotton one). Also, as before, press the mold to the bottom of the dish to make sure that the thickness of the mix is uniform on top of the mold.

- Prepare the Flow Layer:
  - Clean the flow mold with N_2 stream.
  - Switch the spin coater on (located at the other side of the corner where the hybrid mixer is)
    1. Open the air line (right line to the right side of the leftmost oven) by turning the black knob.
    2. Switch the vacuum pump on. The red switch is located on the wire.
    3. Switch the spin coater on. The switch is located at the back of the spin coater.
  - Put the mold in the spin coater and center on the large jug.
  - Pour the flow layer PDMS mixture onto the mold (2/3 of the wafer's area should be covered).
  - Use program number 4. Hit "CHG PRE" button. If the display shows that the Recipe is not 4, then:
    1. Hit "Enter".
    2. Using lift/right arrows and +/- buttons change Recipe to 4.
    3. Hit "Enter".
  - Check whether spin RPM1 reads the desired rpm value (in the case of the 100μm channel widths, this was 2500rpm). If yes, hit "MSG". If not, then:
    1. Use "+" button until spin speed is in the topmost row.
    2. Hit "Enter".
    3. Change RPM1 to the desired rpm using left/right arrows and +/- buttons.
    4. Hit "Enter".
    5. Hit "MSG".
  - Close the lid and push the "Start" button (as soon as you press the button, the mold will stick to the jug due to the vacuum pump).
  - When finished, take the mold out of the spin coater and put it back into the Petri dish.

    - Switch off the spin coater and the vacuum pump and close the air line.
    - Clean the flow and control cups using paper towels (in order to remove the residual PDMS mixture that was not used), isopropanol and N_2 stream. That way the first step of Section 2 (Making Chips), will not have to be done next time.

- Put both molds into the right oven at 80°C and incubate for **30 minutes**.

- Take both molds out of the oven and cut out the chips from the control mold using the number 12 (curved) scalpel blade.

- Put the chips in a Petri dish with the bottom of the chip facing you (the channels were touching the mold. So, when the chip is flipped, the channels are facing you).

- Punch holes for the control ports on the chips. Put a finger under the dish where the hole is being punched and press and twist until the point of the needle goes all the way through. Using forceps to remove the part of the chip that comes out on the other side before trying to get the needle out of the chip.

- Trim the chips using the chip guillotine and then wash them with Ethanol and blow dry them with N_2 stream.

- Put the control layer on the flow layer making sure that the control channels are touching the wafer and align the control layer to the flow layer. It helps to roughly align all control layers to the corresponding flow layers in order to avoid dust accumulation. Use the stereoscope in the FAB lab if necessary.

- Incubate at 80°C for 1.5 hours.

- Take the mold out of the oven and cut out the flow layer (the chips) using the number 11 (straight) scalpel blade. Peel the chips of the wafer and punch holes for the flow ports. When punching the holes, the flow lines should be facing up.

- Wash the cover slips and the chips with Ethanol and dry with N_2 stream.

- Put the chips onto the glass making sure that the flow layer is down and remove any air bubbles.

- Incubate overnight at 80°C.