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Trainer: Ali Ghaffari
Location: Clean room, Watson 173

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Optical Lithography: From the mask to the mold
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Notes before you begin

- This protocol was written for normal geometry chips (i.e. push down configuration where the control layer will end up being at the top of the flow layer in the final chip)
- You need to have permission to enter the Clean Room (training is required). Before entering, make sure you are appropriately dressed and sign in.
- You should only bring the mask (transparency) and the chem.-glasses with you in the clean room. Nothing else should be brought in, not even paper (you can find paper and pens in the Clean Room, if you want to take notes).

Making molds

1. Right after coming in: Turn the hotplates, located at the back corner of the room on by pressing the Power Button. Set one to 105°, by pressing 105 and then Enter. Similarly, set the other hotplate to 125°. They take about 15min to heat up to the designated temperature.
   Important note: The temperatures and the baking time (discussed later) will determine the height of the channels. The aforementioned temperatures were used in the case of designs where the channel widths were 100μm. Check the attached graphs for more details on how the channel height depends on the soft bake temperature and the soft bake time. Different channel widths require different channel heights (width to height ratio should be about 8:1) so the baking temperatures and times are important in order for the final chip to function properly. It is always a good advice to ask before you decide on these parameters.
2. Notice that next to the door of the clean room, on the right, there is a working bench with shelves and drawers that contain all the equipment (scissors, razor blades, etc) that might be needed. On one of the shelves there is a basket that contains bags needed for putting the chem.-glass in while working.
3. Clean the chem-glass basis with Ni and acetone. Check with light to see if they are clean. Use Q-tips with acetone if needed or just plain paper with acetone.
4. Make sure the mask (the transparency that has the channels) is face up (i.e. ink is always up).

5. Center the mask on the chem.-glass and stick it using tape. Put the chem.-glass with the mask on in a sandwich bag

Si wafer and photoresist

1. Take the Si wafer. Always use the tongue and grab from the flat part of the wafer (the reference point).
2. In order to enhance the stickiness of the photoresist on the wafer, put the wafer in HMDS vapor for 2 min. Open the chamber that has HMDS written on (located in fume hood 2) pour a few drops of HMDS in the orange cup (it is in the chamber) and place the wafer such that it is either leaning against the walls of the chamber (recommended if working on more than one wafers at a time) or is flat at the center. Set the timer for 2 min.
3. In order to spin the photoresist on the wafer, work with the chamber in fume hood 1. Turn on the switch for the vacuum pump and the switch for Duplex 1 (located at the top of the hood).
4. Use the display located next to the photoresist chamber to find the right program (use the program button) or to create your own (use F1 for that purpose). **Important note:** The program you choose depends on what you want the channel height to be. The rpm's, the acceleration, and the spinning time, just like the soft bake temperature and time, will determine the thickness of the photoresist on the wafer and, thus, the height of the channels. Check the attached graph for important information on how the channel height depends on the spincoat rpm. Also, remember that you want the channel width to height ratio to be about 8:1
5. Put the wafer in the chamber and center. Rotate by 90° and center again. Keep rotating until it is perfectly centered
6. Press the vacuum button. The wafer should now be stuck on the base of the chamber.
7. Close lid and press the Run button. If the wafer wobbles, press Stop and then Vacuum (so as to release the vacuum). Repeat 5, 6 and 7 as necessary.
8. Put the photoresist on the wafer (2/3 of the wafer area should be covered). The photoresist to use is PHOTORESIST 5740. You can find small bottles with photoresist in the cabinet below the working bench, right next to the door. The Rob Phillips's group can use Corinne's bottle that has a green label with her name on it.
9. Close the lid and press Run.
10. After done with the photoresist chamber, clean it well using paper and acetone.
11. After spinning the photoresist, if there are shades in the middle of the wafer, it means that the wafer was not really centered. So let the wafer sit for 5min before soft baking. (In the case of channels with widths of 100μm, the soft bake temperature is 105° and the baking time is 90sec. See the important note on the first page.) Be consistent with the wafers (place at the same spot on the hotplate, etc).

Optical Lithography

1. Turn on the vacuum pump (switch is located next to the machine, close to the wall)
2. Put the chem-glass bases with the mask on the mask holder (a square with a square hole the size of the chem.-glass in the center). Make sure that the pattern is facing you (the ink is up).
3. Center the chem-glass on the mask holder.
4. Flip the vacuum switch located on the switch box (the word "mask" is written on top of the switch) up.
5. The separation handle (located at the side of the machine) should be close to the wall.
6. Mount the mask holder on the machine. (Flip and rotate the holder to mount). Turn the knobs to tighten (finger tight)
7. Mount the wafer on the sliding tray. Slide the tray in and center using the knobs. There are three knobs used for this purpose. One will move the tray right and left, the other back and forth and the last will rotate the wafer.
8. Make sure there is no gap between the wafer and the mask (the bottom (smallest) knob should be used in order to remove the gap between the wafer and the mask) and then push the other handle (located above the separation handle) all the way back. While you push the handle back, the wafer will be moving closer to the mask. Therefore, push the handle back gently and stop if the wafer comes too close to the mask because that might cause the wafer to break. If you notice that the wafer is getting too close to the mask while you are still moving the handle, return the handle to its initial position, use the knob to lower the wafer, and then try pushing the handle back again. The handle is all the way back only after you hear it click.
9. Set the timer by moving the dial (about 45sec of actual exposure in the case of channel widths of 100μm. Exposure times also depend on the chip design). Note that for the timer, the big circle sets the dial and small knob sets the units (min, sec, etc.). The indicator for the small knob is located on the display and is a small black arrow on the left of the knob. The big black and red arrows turn with the big circle and set the exposure time. The time that is set on the dial is different from the actual time that the process takes. Check the chart located next to the machine!!
10. Press the green ("exposure") button.
11. After done, pull the handle back to the front. Take the wafer and the mask out. For the mask, remember to release the vacuum by turning the switch down.
12. Turn off the vacuum switch.

<u>Developing the wafer</u>

1. Use Developer <u>2401</u> in proportion with water. (1:5 ratio, i.e. 20ml developer and 100ml water are used in the case of 100μm channel widths. These proportions might be different, depending on the chip design). Use the water labeled 18 Ohm. Put solution in a small glass container.
2. In a different (bigger) container, put water for rinsing.
3. Put wafer in the developer solution and move wafer up and down with the tongue while rotating the container.
4. This process should not take more than 2min (this time depends on the developer to water ratio, but it is still small). DO NOT LEAVE FOR LONGER THAN

NECESSARY! The channels will be destroyed! The wafer is ready when from cloudy becomes shiny.

5. Rinse the wafer in the water.
6. Dry the front of the wafer holding the gun (the Ni) vertically above the wafer's center. Do not hold the wafer-let it rest on the paper towel.
7. Dry the back holding the gun at an angle (the gun should be almost parallel to the wafer). Hold the wafer with the tongue. Remember to hold from the flat part!
8. Look at the wafer on the microscope. To turn the microscope on, turn the power on on the big box and flip the switch to EPI on the small box. Use the joystick as a mouse to see the design. If there are black spots (photoresist remnants) on the wafer, repeat steps 3-7 as necessary. Remember not to leave the wafer in the solution for too long. The pattern (channels) will be destroyed!
9. Pour the used developer in the big bottle which is located in the hood (it has a funnel on it).
10. Hard bake (for the 100μm channel widths, you can hard bake at 125° for 20min). Again, different channel heights require different baking times and temperatures. ONLY THE WAFER WITH THE FLOW CHANNELS NEEDS BAKING! You do not need to hard bake the wafer with the control channels.