Experiment #6
Photolithography: Microprocessing Technology
Fabrication of the microstructures with SPR photoresist

The Steps involved in Fabrication:

Substrate Pretreat

Coat

Soft Bake

Expose

Post Expose Bake (PEB)

Develop

Rinse & Dry

Hard Bake (optional)

Imaged Material

Remove (optional)

The experiment will cover making of the structures with high aspect ratios using the parameters like temperature of the soft bake, exposure time of the substrate.

Cavity Micro resonator made at BMNL.

Students will fabricate microstructures on the surface of aluminized silicon wafer by photolithography using SPR-220 photoresist. Having been introduced to Prolith, a series of pre-fabrication simulations with Prolith should be performed. The optimized condition for each step in the simulation will be used in the actual patterning. A spin coater was used to coat the photoresist on the Al-silicon substrate. Photolithography was performed with the projection aligner. Developing of the resist and etching of the exposed aluminium was performed via chemical means. The final micro-pattern will be imaged using SEM.
**Photolithography Procedure**

Silicon wafers were coated with aluminum using microwave plasma chemical vapor deposition techniques. These wafers were then cleaned with IPA (isopropyl alcohol) and water, then air-dried. The aluminum-coated silicon was then spin coated using SPR 220-7 at 2000 rpm for 1 minute. The pre-exposure bake was conducted at 115 degree Celsius for ninety seconds. The photoresist was exposed using 11.5 mJ/cm² for sixty seconds. The mask produced a given pattern on the wafer was selected by the TA. The soluble portion of the photoresist was removed using 0.02 M NaOH solution for 30 seconds. The wafer was then post-exposure baked for 90 seconds at 115 degrees Celsius. And then developed in 0.22 M NaOH solution at 40 degrees Celsius for 20 seconds to etch the image into the aluminum coating. The substrate was then washed with water to stop the development any farther, and the SEM was used to determine the angles of the substrate.

**Experiment 4: Photolithography**

**Operating procedures**

A. Starting up the cleanroom
   1. Turn the switch on the wall near the gas tanks.
   2. Turn O₂ flow (make sure the pressure gauge indicates pressure of at least 500 psi).
      Do not adjust O₂ flow rate (it is pre-adjusted).
   3. Go to the central room:
      i. Turn the air compressor on
      ii. Make sure the pressure gauge indicates about 70psi (and no more)
      iii. Turn the vacuum pump on by:
         - plugging the electrical connector on the wall (it will fit only the receptacle cable vacuum power)
         - turn on the power strip behind the vacuum pump
         - flip the vacuum start switch “up”
      iv. open the air and vacuum valves on the wall
   4. Go back to the main room and behind the cleanroom.
      i. Open air, DI and vacuum valve to the wet bench and aligner
   5. make sure all the black curtains are secured to prevent any ambient light into the cleanroom
   6. Gown up and enter the cleanroom.

Inside the Cleanroom:

Wet bench
   7. turn the wet bench on by pressing the start button on the top left corner of the bench
   8. verify the air flow through air gun by squeezing the trigger
   9. verify water flow by pressing the foot peddle. Small amount of water will flow through ¼ inch tubing
10. put a dummy wafer on the spin coater and press the vacuum switch on the spin coater. It should indicate vacuum of about 19-22 inches of mercury.
B. Cleaning substrate with plasma Asher  
1. Plug the asher and vacuum pump power cord into the strip beside the aligner  
2. Load wafers in the asher by opening the front door. Carefully remove the inner glass cylinder chamber. Lightly greased the rubber O-ring. Place wafer into the inner cylinder chamber then gently insert the chamber back into the asher.  

Turning “On” plasma  
3. Turn on the asher power then the vacuum pump switch (to the plasma asher)  
4. Close the front door  
5. Follow instructions for turning the plasma asher.  
6. Make sure the plasma does not enter the vacuum outlet  
7. After plasma has been generated leave samples for 2-5 minutes.  

Turning “Off” plasma  
8. Turn off the RF switch (flip up)  
9. Turn off the vacuum (flip up)  
10. Open the door and remove the samples from the plasma chamber  
11. Before leaving cleanroom remember to unplug the asher and vacuum pump power from the strip.

C. Spin Coater (read the notes on spin coating)  
1. Make sure vacuum is on (19-22)  
2. Make sure excess fluid outlet drains into a tin container  
3. Note: vacuum indicator would be flashing if vacuum is not routed to substrate holding chuck  
4. Open lid and place your clean substrate in the center of the chuck. Press vacuum button on the control pad and not the vacuum (enter in the lab notebook)  
5. Set desire spinning rate on the control pad entry program  
6. Put small few drops (10-12 drops) of resist on the center of the wafer substrate  
7. Let it spread till it reach ¾ of the way to the edge of the wafer  
8. Close the lid and run the spin coater program  
9. Note: use a wafer tweezer or vacuum wafer “wand” to place or remove the sample on or from the chuck. Do not use finger.  
10. Once the program is finished move the resist coated wafer to PEB hot plate station.

D. Hot plate operation  
1. Start hot plate. One is marked “pre exposure bake” and the other “post exposure bake (PEB)”  
2. Measure the surface temperature using thermocouple  
3. Adjust to desire pre and post exposure bake temperature on corresponding hot plate.  

For PEB:  
4. Start the timer  
5. Place the wafer on the appropriate hot plates  
6. As soon as timer beeps remove the wafer from surface
E. Aligner
1. turn on the aligner by flipping 30 Amp circuit break from the outside
2. aligner fan should start operating (you’ll hear it)
   (IMPORTANT: The Power Supply (Tamarack Model H-1000) to the Hg lamp (bottom) should be turn on first)
3. Turn the Power Supply (Tamarack Model H-1000) illuminator Power “on” (flip the farthest right toggle up) by flpping the relay on the Hg lamp power supply (bottom unit)
4. Wait 5 min to warm up the power supplies
5. Momentarily turn on the “Start” button by toggle it
6. Hg lamp should light
7. Check power meter, should read about 700 watts
8. Volts and amp meter should read about 80V and 15amps
9. Wait 5-10min for lamp to stabilize
10. Turn on the power to control unit (Model-162). (IMPORTANT: make sure shutter switch is on “Auto” position
11. Place clean mask on the top chuck (facing the chrome side down). Turn on “Mask hold” and “Mask position lock” vacuum.
12. On table three lights should be deilluminate:
   i. scope in – when lit filters prevent UV from exposing the sample
   ii. expose – operate only in “auto” mode to control the exposure
   iii. substrate hold – substrate hold turns on and off
13. Press “scope in” to insert the filters (the “scope in button” should be illuminated)
14. Flip the toggle switch on the control unit to “shutter open”. You should see green light with the projected mask patterns coming through the filters
15. Place substrate on the bottom chuck and align the substrate wafer with projected image from the mask then press “substrate hold” button on table (the “substrate hold” button should be illuminated). The vacuum will create a suction to secure the substrate wafer. (Note: you can move both substrate chuck or mask so that the holes on the mask holder align with the three pins on the chuck)
16. Check vacuum and air flow on the mask and substrate region
17. Make sure the mask image is focused on the wafer surface
18. Once the image is in focused on the surface flip the toggle switch on the control unit to “Auto”. This will close the shutter. Press “scope in” on the table to withdraw the filter (button should now be deilluminated).

To expose sample after alignment: Either Auto or Manual exposure
For Auto exposure
19. Set desire exposure time on time counter (on control unit) by using the rotary knob; OR set desire exposure energy by the rotary wheel.
20. Press “expose” button on table (the “expose” button should now be illuminated).
   IMPT: Do not look into the lenses at this point. At this time the digital display on the time counter should start counting up. Once the digital counter display reached the set time the shutter will automatically shut off to prevent further UV exposure.
21. When auto exposure is complete press “substrate hold” button and remove your exposed substrate wafer from the chuck.
22. Remove the sample by holding substrate with tweezers.
23. Repeat procedure 19 to 23 for next exposure.
24. Move to the wet bench and perform post exposure bake using the hot plate.

For Manual Exposure
25. Flip the toggle switch on the controller unit to “Shutter Open”. Begin timing immediately. This will begin the exposure procedure.
26. Once desire exposure time has reached, flip the toggle switch back to “Auto” to shut the shutter.
27. Press “scope in” on the table to insert the filter (button should now be illuminated).
28. Repeat procedure 25 to 27 for next exposure.
29. Move to the wet bench and perform post exposure bake using the hot plate.

Turning down the aligner
30. Turn off the Controller (Model-162) power first before the Lamp power supply (Model-1000). To turn off the Lamp power, just flip the Power toggle down.
31. Turn off the 300 Amp current supply from the circuit breaker outside

F. Developing
1. Remove the wafer from the hot plate and allow it to cool to room temperature
2. Pour enough developer solution in a clean petri dish enough to submerge the entire wafer into the developer solution.
3. Start timer place wafer in developer solution.
4. Immediately rinse the wafer in DI water after developing
5. dry the wafer using air gun
6. Place in light-proof container in wafer rack. Premark indicate processing condition
7. After leaving the cleanroom bake the wafer in the oven at 150°C in the middle room.

G. Etching
1. Etching of exposed or unprotected aluminium surface can be etch by using diluted NaOH (0.07 M) at 40-45°C.
2. To stop the etching, remove the substrate from the NaOH and rinse with D-H₂O.

H. Stripping
1. Remaining photoresist, after etching Al, can be removed by rinsing with acetone or IPA.