

Sub-Protocol: Etch Mask Lithography

Description: This document details the protocol for the photolithography used to produce the etch mask used to define the pattern in (deep) reactive ion etching steps in the PIE Foundry MEA microfabrication process. This protocol is tailored for use on Parylene C coated silicon wafers.

MATERIALS

AZ 12XT-20PL-15Photoresist
726 MIF Developer
5 mL Polypropylene Syringe (per wafer)

EQUIPMENT

OAI Model 200 Contact Mask Aligner and UV Source
Electronic Micro Systems 1000-1 Hot plate
YES CV200RFS Plasma Asher
Laurell Technologies Photoresist Spinner Model WS-400B-6NPP Lite
Vacuum oven with N₂
UV intensity meter
IR temperature sensor
Wafer centering tool
HDPE trays for developer and water baths
Wafer dipper/holding tool

PARAMETERS

Spinner Recipe Program T
1st Spin Speed: 500 RPM
1st Spin Time: 10 seconds
1st Spin Acceleration: acceleration level 8 (1088 RPM)
2nd Spin Speed: 2000 RPM
2nd Spin Time: 45 seconds
2nd Spin Acceleration: acceleration level 8 (1088 RPM)

Soft-Bake
Temperature: 110 °C
Time: 180 seconds

Exposure
Dose: 185 mJ/cm²
Time: 14.8 seconds
Intensity: 12.5 mW/cm²

Post-Exposure Bake
Temperature: 90 °C
Time: 60 seconds

Develop
Concentration: 726 MIF developer as bottled
Time: 75 seconds (approximate)

PROCESS

1. DESCUM

- 1.1. Descum (clean/roughen) wafers in the asher using the following recipe:
125 mT, 100 W, 30 sccm O₂, 300 seconds

2. PREPARE DEVELOPER AND WATER BATHS

Note: perform in chemical fume hood

- 2.1. Prepare a shallow HDPE tray full of DI water, and another with 726 MIF developer.
 - a. ~250 mL of 726 MIF developer should be sufficient for 6 wafers.

3. DRY-BAKE

Note: this step should be performed immediately before photoresist deposition

- 3.1. Bake wafers at 60 °C in an oven under light vacuum (35-40 cmHg) and N-2 flow (15-20 sccm) for >15 minutes

4. SPIN PHOTORESIST

Note: Before coating wafers run 3 “dummy spins” using spare wafers to ensure spinner chamber environment is saturated with solvent from photoresist. This will prevent differences in resist thickness between first and last wafers in a run.

- 4.1. Line sidewalls of spinner with aluminum foil to reduce mess.
- 4.2. Center wafer on spinner vacuum chuck using spinner centering tool and engage chuck vacuum.
 - a. Spinner requires supply of clean dry air for vacuum to engage.
- 4.3. Deposit 3 mL of AZ 12XT-20PL-15 photoresist from preprepared syringe onto center of wafer.
 - a. Ensure there are no air bubbles in resist
- 4.4. Close lid and run program
 - a. Spin on 500 RPM for 10 seconds
 - b. Spin 2000 RPM for 45 seconds

5. EDGE BEAD REMOVAL

1. Remove photoresist edge bead to improve lithographic alignment. See Parylene C Coating Subprotocol.

6. SOFT-BAKE

- 6.1. Bake the wafer on hotplate for 3 minutes at 110 °C. Calibrate temperature to IR gun and do not rely on hotplate reading.
- 6.2. Wafer should be placed in the center of the hot plate with flat facing forward. Use heat shield around hot plate.
- 6.3. After baking, store the wafer in black wafer storage box for at least 3 minutes.

7. ALIGN, CONTACT, AND EXPOSURE

- 7.1. Set the UV lamp to desired intensity and duration. Targeted dose is 185 mJ/cm². Typical intensity is 12.5 mW/cm² (measured at i-line 365 nm) for 14.8 seconds but can be adjusted depending on current lamp intensity.
- 7.2. Clean mask aligner vacuum chuck and mask holder of any particles. Remove vacuum O-ring around vacuum chuck if present.
- 7.3. Place photomask feature (chrome) side down (facing vacuum chuck). Secure with mask holder vacuum and screw clamps.
- 7.4. Place wafer face up and centered on vacuum chuck. Turn on substrate vacuum.
- 7.5. Blow mask surface and wafer surface clean of particles with N₂ gun.
- 7.6. Engage N₂ purge.
- 7.7. Lower mask holder.
- 7.8. Raise wafer using Z-axis knob until mask is flush with mask. Engage ball lock.
- 7.9. Reduce Z-axis control sensitivity. While looking through aligner microscope on lowest magnification, lower wafer until it just barely disengages with mask. Confirm that wafer is now able to move freely using fine X/Y/θ controls.
- 7.10. Moving back and forth between left and right alignment marks, align the angle (theta) of the mask and wafer.
- 7.11. Once wafer and mask are aligned in theta, ensure X and Y coordinates are aligned.
- 7.12. Increase magnification to higher objective lens then repeat 5.10-5.12.
- 7.13. Once satisfied, raise the wafer to contact, confirm alignment has not drifted. Disengage N₂ purge.
- 7.14. Expose the wafer by carefully sliding the aligner assembly under the UV lamp. Wait for exposure, then carefully slide the assembly back to starting position.
- 7.15. Re-engage N₂ purge. Gently lower the wafer. If the wafer does not move freely, pause, and wait before trying again.
- 7.16. Once the wafer moves freely, return Z-axis sensitivity to starting level and lower the wafer completely clear of the mask. Raise the mask holder. Dis-engage substrate vacuum and N₂ purge. Remove wafer.

8. POST-EXPOSURE-BAKE

- 8.1. Bake the wafer on hotplate for 1 minute at 90 °C. Calibrate temperature to IR gun and do not rely on hotplate reading.
- 8.2. Wafer should be placed in the center of the hot plate with flat facing forward. Use heat shield around hot plate.
- 8.3. Allow wafer to cool to room temperature before development.

9. DEVELOP

- 9.1. Develop wafer in shallow bath of 726 MIF developer for approximately 75 seconds.
 - a. Development time is dependent on area of exposed features and will vary between mask-sets.
- 9.2. Immediately rinse in DI water bath and rinse 3× in water.
- 9.3. Blow dry with N₂.

10. INSPECT

- 10.1. Inspect under compound microscope with yellow light filter.