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Channel Shape Study Report

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Critical Factors
- When using an SU-8 base layer as a wafer pretreatment, the base layer must undergo a post-exposure bake or else the fabricated channels will take on a rounded characteristic.
- The rounded channels seem to be unique to using a base layer of resist under the feature layer by skipping the post-exposure bake step for the base layer.

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Goal
Test various wafer pretreatment conditions' effect on exposed and developed channel shape.

Materials
- SU-8 2005 (produced by thinning SU-8 2050)
- SU-8 2025 (produced by thinning SU-8 2050)
- SU-8 thinner
- SU-8 developer
- 3 inch diameter silicon wafers
- Line photomask (transparency film)
  - 10 µm channels, 50 µm troughs ("10x50")
  - 25 µm channels, 50 µm troughs ("25x50")
- Isopropyl alcohol (IPA)
- Acetone
- Buffered oxide etchant (BOE) in HF hood. **You must be HF hood trained before working with BOE. Speak with Eric Johnston or Kyle Keenan to arrange training.**
- PDMS/PDMS Curing Agent

Equipment
- Laurell Spinner
- Hot Plate
- ABM Mask Aligner
- Vacuum Chamber
- Optical microscope
Protocol
Preparation of SU-8 2005/2025 equivalent from SU-8 2050 stock
1. Weighed out SU8-2050
2. Calculated weight of thinner to add via:
   a. \( W_{\text{thinner}} = \frac{\text{(% solids initial / % solids final)}}{1} \times W_{\text{resist}} \)
3. Mixed with glass stirring rod in beaker for ~ 10 min until homogeneous
4. Aliquoted using Teflon funnel into resist bottles
5. Allowed bottles to degas by resting at RT overnight
6. Long-term storage of bottles in resist cabinet

Wafer pretreatments tested
1. 2 min BOE wash + 2 min rinse in overflow bath + nitrogen blow-dry + minimum 10 min dehydration 200 ºC
2. Dehydration for at least 10 minutes at 200 ºC + spinning and blanket exposing a 5 µm base layer of SU-8 of various thicknesses underneath the feature layer
   a. No post-exposure bake after exposing base layer and spinning feature layer
   b. With post-exposure bake after exposing base layer and spinning feature layer

SU-8 spinning (27 µm)
1. Set spin parameters:
   a. Vacuum = “req”
   b. Step 1 of 2: 500 rpm, accel = “100”, 30 sec
   c. Step 2 of 2: 3000 rpm, accel = “300”, 30 sec
      i. F40 Filmetrics measurement indicates these settings result in an approximately 27 um thick layer of resist
2. Mounted wafer and ensured that it is centered
3. Poured SU-8 2025 photoresist without air entrapment to ~ 50 mm diameter
4. Spun the wafer
5. Transferred spun wafer to 95 ºC hot plate for 5 min soft bake
6. If performing multiple spins, wiped spinner hood between wafers to prevent excess SU8 from dripping onto samples

SU-8 spinning (5 µm)
1. Set spin parameters:
   a. Vacuum = “req”
   b. Step 1 of 2: 500 rpm, accel = “100”, 30 sec
   c. Step 2 of 2: 3000 rpm, accel = “300”, 30 sec
2. Mounted wafer and ensured that it is centered
3. Poured SU-8 2005 photoresist without air entrapment
4. Spun the wafer
5. Transferred spun wafer to 95 ºC hot plate for 2 min soft bake
6. If performing multiple spins, wiped spinner hood between wafers to prevent excess SU8 from dripping onto samples
Resist exposure and development

**Pretreatments 1**
1. Started the ABM UV lamp (channel A) and allowed at least 20 min for warm-up
2. Computed required exposure time based on exposure energy values given on SU-8 data sheets
   a. ABM power output can be measured with the power meter or a recent value can be found in the log located in the ABM Operating Procedure binder
   b. \[Exposure\,\,time = \frac{Exposure\,\,energy\,\,needed}{ABM\,\,power\,\,output}\]
3. Mounted wafer and photomask
4. Contacted to Omega optical filter with leveling
5. Exposed lines for calculated exposure time
6. Post-exposure bake:
   a. 1 min at 65 °C
   b. 5 min at 95 °C
7. Developed in bath of SU-8 developer for 5 min with periodic agitation
8. Rinsed in acetone followed by IPA and nitrogen blow-dried

**Pretreatment 2**
1. Started the ABM UV lamp (channel A) and allowed at least 20 min for warm-up
2. Computed required exposure time based on exposure energy values given on SU-8 data sheets
   a. ABM power output can be measured with the power meter or a recent value can be found in the log located in the ABM Operating Procedure binder
   b. \[Exposure\,\,time = \frac{Exposure\,\,energy\,\,needed}{ABM\,\,power\,\,output}\]
3. For base layer:
   a. Mounted wafer
   b. Exposed wafer for calculated exposure time
   c. Post-exposure bake:
      i. None for Pretreatment 3a (no PEB)
      ii. 3 min at 95 °C for Pretreatment 3b
4. For feature layer:
   a. Mounted wafer and photomask
   b. Contacted to Omega optical filter with leveling
   c. Exposed lines for calculated exposure time
   d. Post-exposure bake:
      i. 1 min at 65 °C
      ii. 5 min at 95 °C
   e. Developed in bath of SU-8 developer for 5 min with periodic agitation
   f. Rinsed in acetone followed by IPA and nitrogen blow-dried
Figure 1: Schematic of wafer exposure for all pretreatments.

**PDMS Casting and Peeling**
- Placed wafers in aluminum foil dishes of appropriate depth
- Mixed ~50 g of PDMS at 10:1 base:cure by weight ratio per wafer and degassed under vacuum until clear (~45 min)
- Poured PDMS to a depth of 7 mm over each wafer on a level aluminum block
- Transferred block to preheated 100 °C convection oven
- Cured PDMS for 70 min
- Allowed wafers to cool to RT
- Using a new razor blade manually excised PDMS above the SU8 mastered lines and peeled
- Inspected wafer and peeled PDMS for evidence of resist delamination

**PDMS Cross-section Imaging**
- Each block of PDMS had a cross-section cut approximately 1 cm in length
- Cross-sections were placed sideways on top of a clean room sticky note (for contrast purposes) such that the cross-section of the molded channels could be visualized
- Images were taken of the focused views
Results

Pretreatment 1

Figure 2: Cross-sectional images of PDMS casts of SU-8 masters fabricated with a BOE wash wafer pretreatment. At left is the image of the "10x50" channels and at right is the image of the "25x50" channels.

Pretreatment 2a

Figure 3: Cross-sectional images of PDMS casts of SU-8 masters fabricated with a 5 µm base layer of SU-8 without post-exposure bake as a wafer pretreatment. At left is the image of the "10x50" channels and at right is the image of the "25x50" channels.
Figure 4: Cross-sectional images of PDMS casts of SU-8 masters fabricated with a 5 µm base layer of SU-8 with post-exposure bake as a wafer pretreatment. At left is the image of the "10x50" channels and at right is the image of the "25x50" channels.