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SU-8 Delamination Resistance Study Report

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Critical Factors

- Best treatments to prevent SU-8 photoresist delamination during development and PDMS casting and peeling:
  - BOE + Dehydration
  - BOE + SRD (Spin Rinse Dryer) + Dehydration
  - SRD + YES Oven (HMDS Priming)
- Flood exposing a 5um base layer of SU-8 underneath the desired SU-8 feature layer prevents delamination

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Goal

To test SU-8 resistance to delamination induced by PDMS casting and peeling under various wafer pretreatment conditions

Results

Wafer Treatment	Result	Image
No Treatment	Delamination	No Image
5um SU-8 Base Layer	Pass	No Image
Piranha + SRD + YES	Partial Delamination	Figures 1 & 2
Piranha + SRD + Dehydration	Delamination	Figure 3
BOE + SRD + YES	Partial Delamination	Figure 4
BOE + SRD + Dehydration	Pass	Figure 5
BOE + YES	Delamination	Figures 7 & 8
BOE + Dehydration	Pass	Figures 9 & 10
SRD + YES	Pass	Figure 6
Surpass + IPA	Delamination	Figures 11 & 12
Acetone + IPA + Dehydration	Delamination	No Image
MCC 80/20	Partial Delamination	No Image

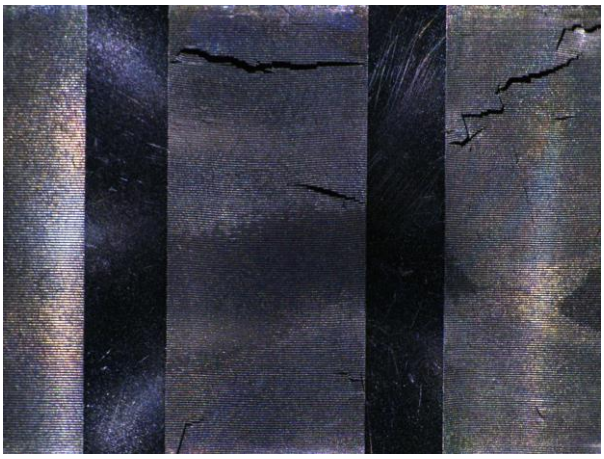

Figure 2: Partial delamination of Piranha + SRD + YES treated wafer, with 10um x 20um features and 40um height.

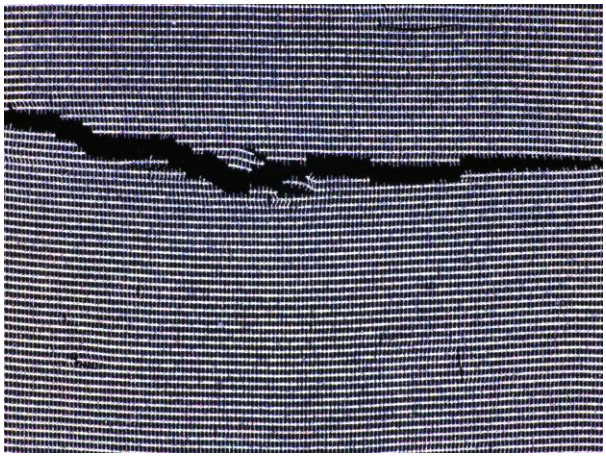

Figure 1: Piranha + SRD + YES treated wafer, 10um x 20um features and 40um height, 40x zoom.

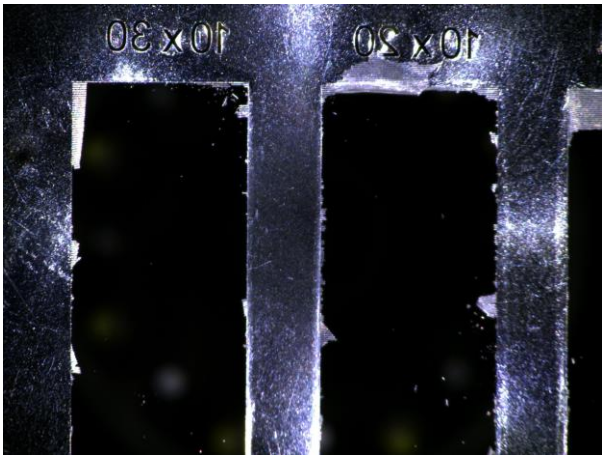

Figure 4: Delamination of Piranha + SRD + Dehydration treated wafer with 10x30um and 10x20um features and 40um height.

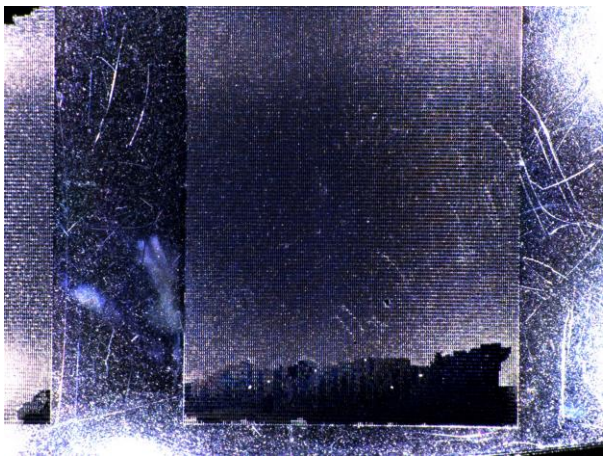

Figure 3: Partial delamination of BOE + SRD + YES treated wafer, with 10um x 15um features and 40um height, 20x zoom.

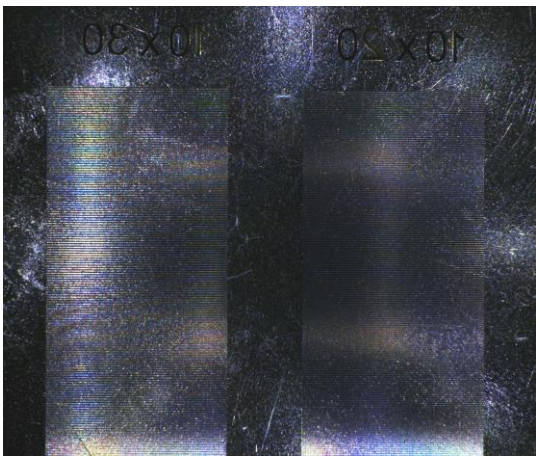

Figure 6: BOE + SRD + Dehydration treated wafer with 10x30um and 10x20um features and 40um height.

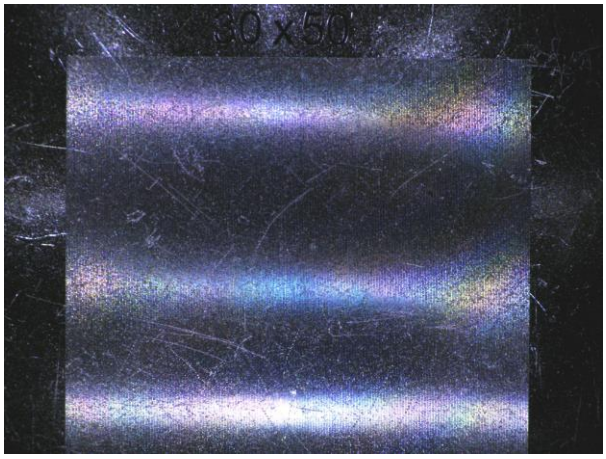

Figure 5: SRD + YES Oven treated wafer with 30x50um features and 40um height.

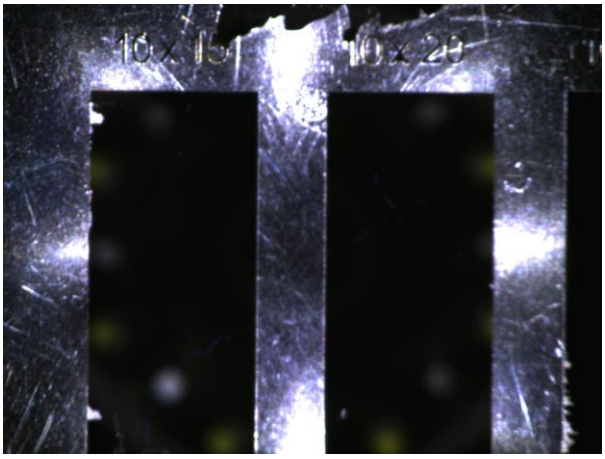

Figure 7: Delamination of BOE + YES oven treated wafer with 10x15um and 10x20um features and 40um height.

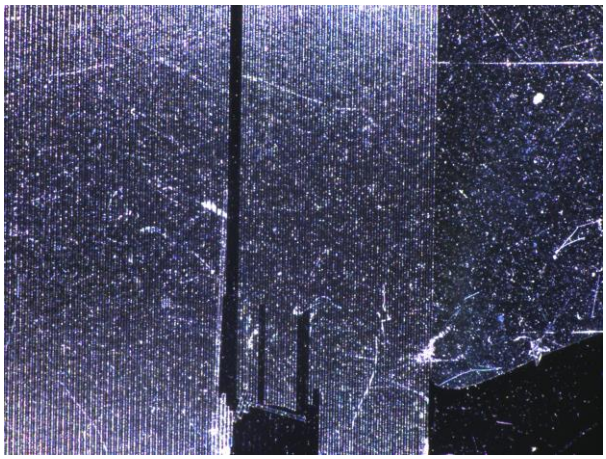

Figure 8: Partial delamination of BOE + YES oven treated wafer with 30x50um features and 40um height.

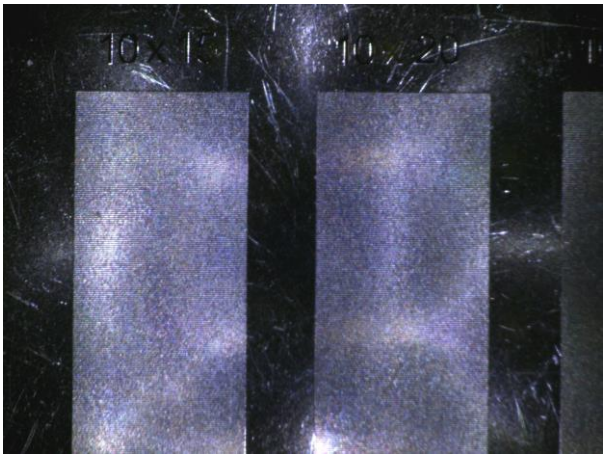

Figure 9: BOE + Dehydration treated wafer with 10x15um and 10x20um features and 40um height.

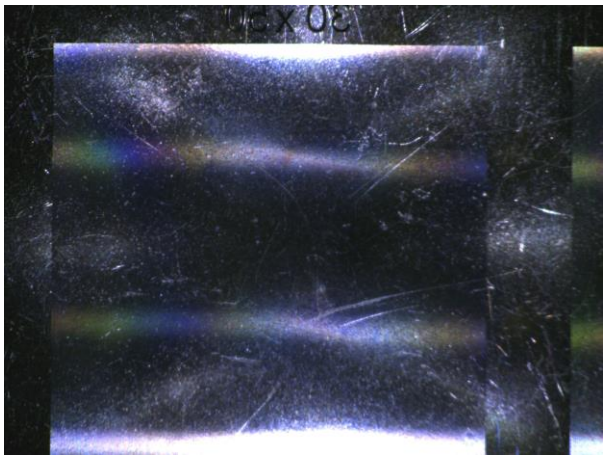

Figure 10: BOE + Dehydration treated wafer with 30x50um features and 40um height.

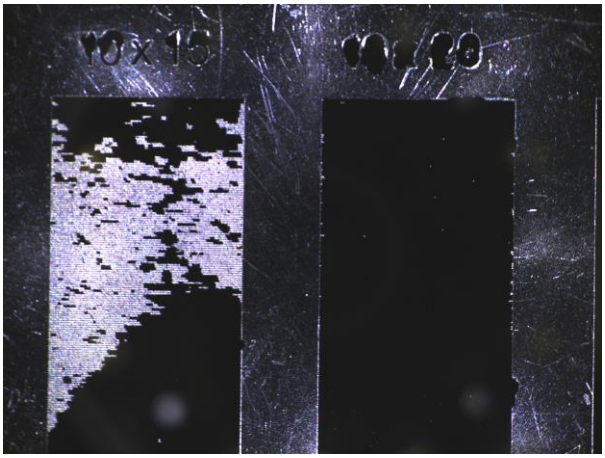

Figure 11: Delamination of Surpass + IPA treated wafer with 10x15um and 10x20um features and 40um height.

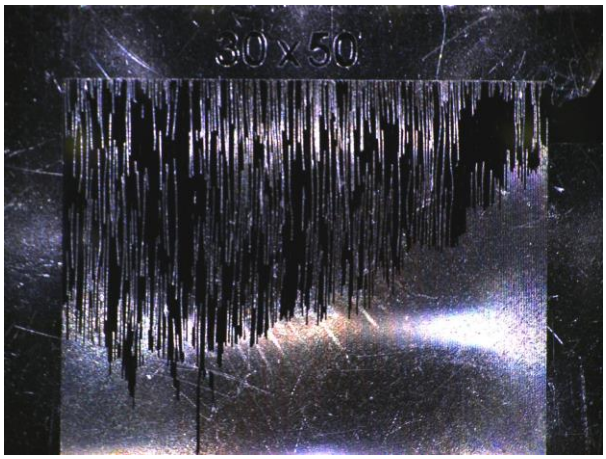

Figure 12: Delamination of Surpass + IPA treated wafer with 30x50um features and 40um height.

Materials

- SU-8 2005 (produced by thinning SU-8 2050)
- SU-8 2010 (produced by thinning SU-8 2050)
- SU-8 2025 (produced by thinning SU-8 2050)
- SU-8 thinner
- 3 inch diameter silicon wafers
- 4 inch diameter silicon wafers
- Line photomask (transparency film)
- Isopropyl alcohol (IPA)
- Acetone
- MCC 80/20
- Buffered oxide etchant (BOE) in HF hood
- Surpass
- PDMS/PDMS Curing Agent

Equipment

- Laurell spinner
- Hotplate
- YES Oven
- Spin Rinse Dryer (SRD)
- ABM mask aligner
- Vacuum Chamber

Protocol

a. Preparation of SU-8 2005/2010/2025 equivalent from SU-8 2050 stock

1. Weigh out SU8-2050
2. Calculate weight of thinner to add via:
    a. $W_{thinner} = [(\%\ solids\ initial / \%\ solids\ final) - 1]*W_{resist}$
3. Mix with glass stirring rod in beaker for ~ 10 min until homogeneous
4. Aliquot using Teflon funnel into resist bottles
5. Allow bottles to degas by resting at room temperature overnight
6. Long-term storage of bottles in resist cabinet

b. Wafer pretreatments tested

1. No treatment (including dehydration)
2. Dehydration for at least 10 minutes at 200 ºC
3. Acetone wash + IPA wash + nitrogen blow-dry + minimum 10 min dehydration 200 ºC
4. 2 min BOE wash + 2 min rinse in overflow bath + nitrogen gun-dry + minimum 10 min dehydration 200 ºC
5. Dehydration for at least 10 minutes at 200 ºC + spinning and flood exposing a base layer of SU-8 of 5µm
6. Dehydration for at least 10 minutes at 200 ºC + spinning a layer of MCC 80/20 primer (commercially available from MicroChem consisting of 20% HMDS and 80% PM Acetate)

c. MCC 80/20 spinning

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 MCC 80/20 primer to cover the entire wafer
4. Allowed the primer to sit for 10-15 seconds
5. Spun the wafer
6. Transferred spun wafer to 110 ºC hot plate for 2 min bake

d. Resist exposure and development

1. Start the ABM UV lamp (channel A). After suitable warm-up period, measured bulb exposure power:
    a. Using power meter set to channel A, measure power through transparency, glass blank, and Omega Optical filter: 14.2 mW/cm^2
    b. Compute required exposure time: 155 mJ/cm^2 / 14.2 mW/cm^2 = 10.9 sec
2. Mount wafer, photomask and filter
3. Contact to glass blank with leveling
4. Post-exposure bake:
    a. 1 min at 65 ºC
    b. 5 min at 95 ºC
5. Develop in bath of SU-8 developer for 5-10 min with periodic agitation
6. Rinse with IPA and acetone and nitrogen blow-dry

e. PDMS Casting and Peeling

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

	Plateau Length	Trough Length	Exposure Length		
Wafer Treatment	um	um	8.9 s	10.9 s	12.9 s
No Treatment	25	50	Delamination	Delamination	Pass
	10	50	Delamination	Delamination	Delamination
Dehydration	25	50	Delamination	Delamination	Delamination
	10	50	Delamination	Delamination	Delamination
Acetone+IPA+Dehydration	25	50	Pass	Pass	Pass
	10	50	Delamination	Delamination	Partial Delamination
BOE + Dehydration	25	50	Pass	Pass	Pass
	10	50	Delamination	Partial Delamination	*Partial Delamination

Table 1: 02/10/2014 results of delamination study performed on 1/31/2014 SU8 masters. Study was conducted by casting 10:1 (base:cure by weight) PDMS slabs to a depth of 7 mm and curing at 100 C for 70 min. After wafers cooled to RT, PDMS slabs were manually peeled from the master. Post-peel masters were inspected under an optical microscope for evidence of SU8 delamination. Out of all conditions tested, the BOE pre-treated wafer was the most robust in withstanding PDMS casting.
***Delamination likely due to edge bead and not wafer pretreatment at this location.**

	Plateau Length	Trough Length	Delamination Test
Base Layer Thickness	µm	µm	
5 µm	25	50	Pass
	10	50	Pass
10 µm	25	50	Pass
	10	50	Pass
27 µm	25	50	Pass
	10	50	Pass
Pretreatment			
MCC 80/20	25	50	Partial Delamination
	10	50	Partial Delamination

Table 2: Results of delamination study performed on 4/4/2015 and 4/26/2015 SU8 masters. Study was conducted by casting 10:1 (base:cure by weight) PDMS slabs to a depth of 7 mm and curing at 100 C for 70 min. After wafers cooled to RT, PDMS slabs were manually peeled from the master. Post-peel masters were inspected under an optical microscope for evidence of SU8 delamination.