SU-8 Photoresist Processing

Standard Operating Procedure

Faculty Supervisor: Prof. Robert White, Mechanical Engineering (x72210)
Safety Office: Peter Nowak x73246 (Just dial this directly on any campus phone.)
(617)627-3246 (From off-campus or from a cell phone)
Tufts Emergency Medical Services are at x66911.

Revised: January 19, 2012

Goal:
Follow standard SU-8 processing on 4" wafer to fabricate mold for PDMS.

Warning:
SU-8 is very hard to remove and outgases. Thus, it can contaminate glassware, hotplates, ovens, and tools (such as tweezers). Once it gets onto something it can be very difficult to get it off. For this reason, it is very important that you only use the SU-8 ovens, SU-8 hotplates, and SU-8 tweezers. The goal is to try to keep SU-8 from getting onto everything and contaminating processes which do not use SU-8.

1. Material Requirements:

1.1 Equipment and tools: Spin processor, SU-8 oven, SU-8 hotplates, aluminum foil, cleanroom wipes, SU-8 tweezers, glass Petri dish, .

1.2 Chemicals: SU-8 photoresist, isopropanol (IPA), SU-8 Developer (PM Acetate)

1.2.1 Hazards associated with chemicals:

1.2.1.1 SU-8 is an epoxy based photoresist. It contains Gamma Butyrolactone (CAS: 96-48-0); 22-60%, Mixed Triarylsulfonium/ Hexafluoroantimonate Salt;(CAS: 89452-37-9)/(CAS: 71449-78-0), Propylene Carbonate (CAS: 108-32-7); 1-5%, and Epoxy Resin (CAS: 28906-96-9); 35-75%. It is not a major health hazard, but may cause irritation if it contacts the skin, may release irritating vapors, and can combust, although it is not highly flammable. Conduct spin processing and baking steps in the fume hood.

1.2.1.2 Isopropanol is a volatile, flammable solvent. Avoid heat sources. Do not breath fumes. Conduct processing in the fume hood.

1.2.1.3 SU-8 Developer is mainly PM Acetate (1-Methoxy-2-propanol acetate), a volatile solvent. It is not a skin irritant and will not burn your skin. It is flammable, but not nearly as flammable as acetone. It is volatile, and prolonged exposure to fumes my cause dizziness.

1.3 Engineering Controls: Conduct procedures in the fume hood. Dispose of chemicals as described at the end of this document.

1.4 Personal Protective Equipment: Nitrile gloves and eye protection required for all procedures. When working in the fume hood, also wear trionic gloves, apron, and chemical goggles.

2.0 Procedure:

2.1 Wafer should be clean prior to starting processing. A Piranha clean (see Piranha clean SOP) is suggested.

2.2 Dehydration bake your wafers at 200 ^{o}C.

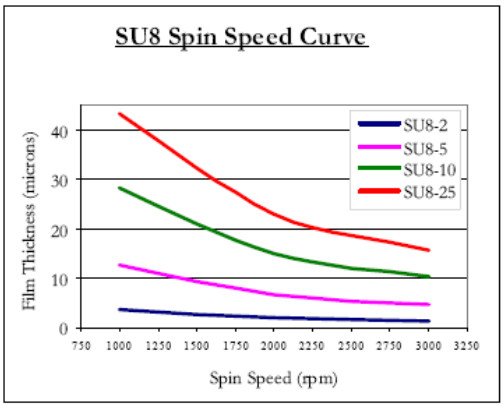
2.2.1 Perform dehydration bake on an aluminum foil topped SU-8 hotplate (5 min) or in the SU-8 convection oven (30 min).

2.3 Spin on SU-8. (SU-8 Spinner: See Spinner SOP for instructions on using the spinner.)
Note: Make sure you line the bowl of the spinner with cleanroom wipes, and the lid with tinfoil. Make every effort to keep SU-8 from getting onto the bowl, chuck, or any other part of the tool. Clean up carefully after spinning. Dispose of SU-8 cleanroom wipes in the "solvents and photoresist" trash. Use fab wipes, acetone, and a dummy wafer on the chuck when cleaning.

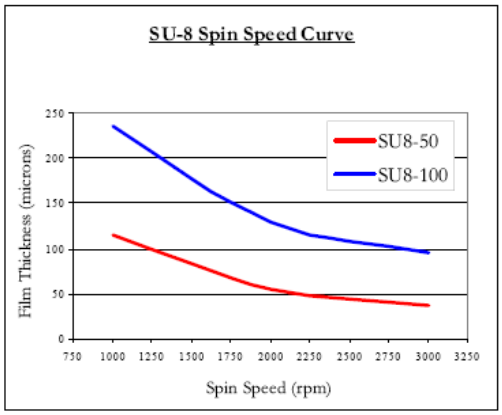
2.3.1 Spread at 500 rpm for 30 sec

2.3.2 Spin for 60 sec. Spin rate (RPM) needs to be determined based on which SU-8 viscosity you have purchased, and what final thickness you require. Spin speed curves are available for each SU-8 resist from the manufacturer. Examples appear below.

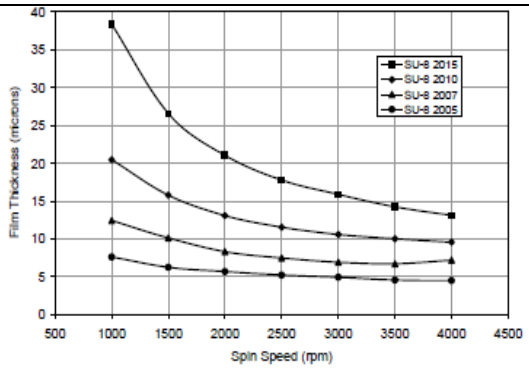
2.3.3 Use about 4ml of SU-8 for a 4" wafer (1ml/in).

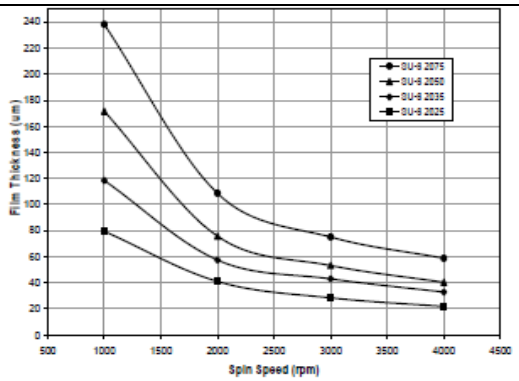


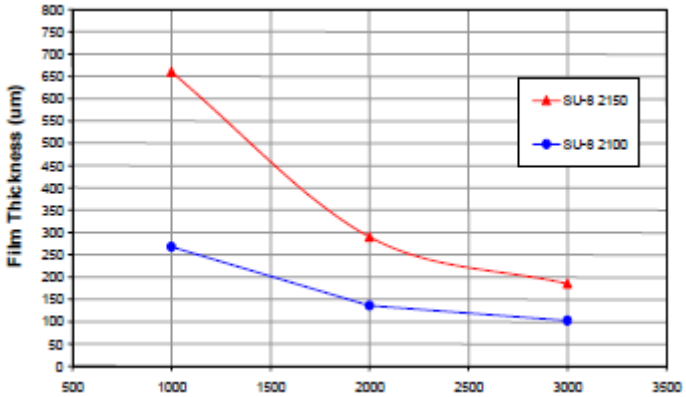
Note: SU8-2 is the bottom curve. SU8-25 is the top curve. The others are in order



Note: SU8-50 is the bottom curve.







2.4 Remove the wafer from the spinner using dedicated SU-8 tweezers. The tweezers will get SU-8 on them!! Don't use them for anything you don't want SU-8 on in the future. Try to clean them as best as you can with wipes and acetone/IPA after you are finished.

2.5 Pre-bake (should be conducted with the hotplates in the chemical hood or under the snorkel):

Note: Pre-bake times vary from one SU-8 formulation to another, and from one thickness to another. Consult the datasheets for your particular SU-8 formulation (available from the manufacturer). Some examples are given below.

2.5.1 SU-8 hotplates topped with aluminum foil (75 ^{o}C and 105 ^{o}C setting on the hotpate) **(Top of the aluminum foil is ~ 10 ^{o}C lower than the hotplate; actual temperature of wafers should be 65 ^{o}C and 95 ^{o}C)**

2.5.1.1 75 ^{o}C for desired time (see tables below).

2.5.1.2 105 ^{o}C for desired time (see tables below).

Product Name	Thickness (µms)	Pre-bake @ 65° C	Softbake @ 95° C
	1.5	1	1
SU-8 2	2	1	3
	5	1	3
	5	1	3
SU-8 5	7	2	5
	15	2	5
	10	2	5
SU-8 10	15	2	5
	30	3	7
	15	2	5
SU-8 25	25	3	7
	40	5	15

Product Name	Thickness (µms)	Pre-bake @ 65° C	Softbake @ 95° C
	40	5	15
SU-8 50	50	6	20
	100	10	30
	100	10	30
SU-8 100	150	20	50
	250	30	90

THICKNESS microns	SOFT BAKE TIME minutes @ 95°C
0.5 - 2	1
3 - 5	2
6 - 15	2 - 3
16 - 25	3 - 4
26 - 40	4 - 5

Softbake times for SU82000.5-15

THICKNESS microns	SOFT BAKE TIMES (65°C) minutes	(95°C) minutes
25 -40	0 - 3	5 - 6
45 - 80	0 - 3	6 - 9
85 - 110	5	10 - 20
115 - 150	5	20 - 30
160 - 225	7	30 - 45

Softbake times for SU82025-2075

THICKNESS microns	SOFT BAKE TIMES (65°C)* minutes	(95°C) minutes
100 - 150	5	20 - 30
160 - 225	5 - 7	30 - 45
230 - 270	7	45 - 60
280 - 550	7 - 10	60 - 120

Softbake times for SU82100-2150

2.6 Expose (OAI 204 Aligner). See SOP for the OAI Model 204 aligner.

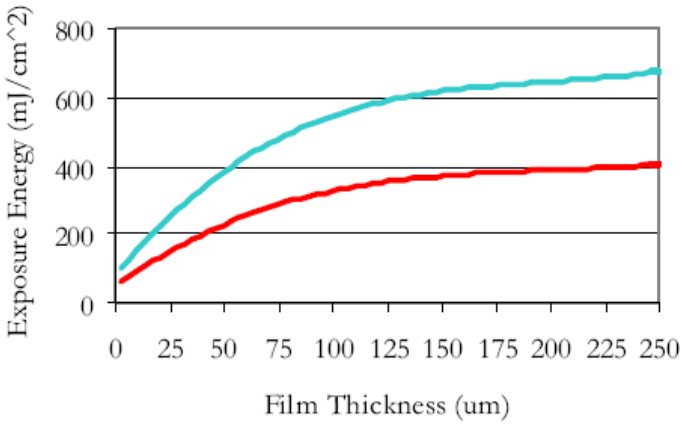
Note: Correct exposure dose is strongly dependent on substrate (verified by Microchem). The following exposure is optimized for a Si substrate. Also, exposure dose will vary for different thicknesses and SU-8 formulations. Consult the manufacturer datasheets.

2.6.1 Use a transparency or soda-lime glass mask. With the transparency mask, cut it out to 5" square and lay it on a blank soda-lime glass mask. The mask frame clamps work very well to hold the transparency mask in place (see Aligner SOP).

2.6.2 Expose for the total desired dose. See chart below. The two curves represent minimum and maximum exposure dose. So, for example, if you spun on 100 micron thick SU-8, you want approximately 350-550 mJ/cm^2. This will required 17.5 to 27.5 seconds exposure at 20 mW/cm^2, which is the intensity setting for the aligner.

	RELATIVE DOSE
Silicon	1X
Glass	1.5X
Pyrex	1.5X
Indium Tin Oxide	1.5X
Silicon Nitride	1.5 - 2X
Gold	1.5 - 2X
Aluminum	1.5 - 2X
Nickel Iron	1.5 - 2X
Copper	1.5 - 2X
Nickel	1.5 - 2X
Titanium	1.5 - 2X

Multiply dose by these numbers depending on substrate type.



Note: Top curve is max recommended dose, bottom curve is minimum recommended dose.

THICKNESS microns	EXPOSURE ENERGY mJ/cm^2
0.5 - 2	60 - 80
3 - 5	90 - 105
6 - 15	110 - 140
16 - 25	140 - 150
26 - 40	150 - 160

Exposure Dose for SU82000.5-2015

THICKNESS microns	EXPOSURE ENERGY mJ/cm^2
25 - 40	150 - 160
45 - 80	150 - 215
85 - 110	215 - 240
115 - 150	240 - 260
160 - 225	260 - 350

Exposure Dose for SU82025-2075

THICKNESS microns	EXPOSURE ENERGY mJ/cm^2
100 - 150	240 - 260
160 - 225	260 - 350
230 - 270	350 - 370
280 - 550	370 - 600

Exposure Dose for SU82100-2150

2.7 Post-exposure-bake (should be conducted with the hotplates in the chemical hood or under the snorkel). Bake times will vary, see charts below or consult manufacturer datasheets.

2.7.1 SU-8 hot plates coated with aluminum foil.

2.7.1.1 Put it on the 75 °C hotplate for desired time. (actual wafer temperature will be 65 °C).

2.7.1.2 Transfer immediately to the 105 °C for desired time (actual wafer temperature will be 95 °C). Turn the hotplate off and let it cool. Leave the wafer on the hotplate until it has cooled to at least 75 °C.

Product Name	Thickness (µms)	PEB 1 @65°C	PEB 2 @95°C
	1.5	1	1
SU-8 2	2	1	1
	5	1	1
	5	1	1
SU-8 5	7	1	1
	15	1	2
	10	1	2
SU-8 10	15	1	2
	30	1	3
	15	1	2
SU-8 25	25	1	3
	40	1	4

Product Name	Thickness (µms)	PEB 1 @65°C	PEB 2 @95°C
	40	1	4
SU-8 50	50	1	5
	100	1	10
	100	1	10
SU-8 100	150	1	12
	250	1	20

THICKNESS microns	POST EXPOSURE BAKE TIME minutes @ 95°C
0.5 - 2	1 - 2
3 - 5	2 - 3
6 - 15	3 - 4
16 - 25	4 - 5
26 - 40	5 - 6

PEB times for SU82000.5-2015

THICKNESS microns	PEB TIME (65°C)* minutes	PEB TIME (95°C) minutes
25 -40	1	5 - 6
45 - 80	1 - 2	6 - 7
85 - 110	2 - 5	8 - 10
115 - 150	5	10 - 12
160 - 225	5	12 - 15

PEB times for SU82025-2075
*Optional step for stress reduction

THICKNESS microns	PEB TIME (65°C)* minutes	PEB TIME (95°C) minutes
100 - 150	5	10 - 12
160 - 225	5	12 - 15
230 - 270	5	15 - 20
280 - 550	5	20 - 30

PEB times for SU82100-2150
*Optional step for stress reduction

2.8 Develop (chemistry hood)

2.8.1 PM-acetate (SU-8 developer) in Pyrex beaker labeled "SU-8 Developer" or in glass Petri dish labeled "SU-8 Developer"

2.8.2 Agitate wafer in container for desired develop time (see below).

Product Name	Thickness (µms)	Development (minutes)
	1.5	1
SU-8 2	2	1
	5	1
	5	1
SU-8 5	7	1
	15	3
	10	2
SU-8 10	15	3
	30	5
	15	3
SU-8 25	25	4
	40	6

Product Name	Thickness (µms)	Development (minutes)
	40	6
SU-8 50	50	6
	100	10
	100	10
SU-8 100	150	15
	250	20

THICKNESS microns	DEVELOPMENT TIME minutes
0.5 - 2	1
3 - 5	1
6 - 15	2 - 3
16 - 25	3 - 4
26 - 40	4 - 5

Development times for SU82000.5-2015

THICKNESS microns	DEVELOPMENT TIME minutes
25 - 40	4 - 5
45 - 75	5 - 7
80 - 110	7 - 10
115 - 150	10 - 15
160 -225	15 - 17

Development times for SU82025-2075

THICKNESS microns	DEVELOPMENT TIME minutes
100 - 150	10 - 15
160 - 225	15 - 17
230 - 270	17 - 20
280 - 550	20 - 30

Development times for SU82100-2150

Note: An ultrasonic bath may be useful in developing small pitch structures

2.8.3 Lift wafer out with tweezers and rinse with isopropanol squirt bottle into another glass beaker (labeled SU-8 IPA).

2.8.3.1 If undeveloped SU-8 remains, it will turn the IPA milky. If this occurs, put the wafer back in for a longer develop time.

2.8.4 When you are happy with the develop and rinse, blow the wafer dry with the nitrogen gun in the hood. Examine under the microscope.

2.9 Hard Bake (optional). From the SU-8 datasheets (Microchem):

> *SU-8 has good mechanical properties, therefore hard bakes are normally not required. For applications where the imaged resist is to be left as part of the final device, the resist may be ramp/step hard baked between 150-200°C on a hot plate or in a convection oven to further cross link the material. Bake times vary based on type of bake process and film thickness.*

2.10 Cleanup:

- **2.10.1** Turn off the hotplates. Throw away the tinfoil in the solvent/photoresist trash.
- **2.10.2** Remove the hotplates from the hood.
- **2.10.3** Make sure the spinner has been cleaned according to the procedures in the Spinner SOP.
- **2.10.4** Dump IPA waste from the beaker into the solvent waste bottle. Rinse the beaker twice with DI water from the squirt bottle and dump into the solvent waste. Return the IPA beaker to the shelves.
- **2.10.5** Dump used SU-8 developer into the solvents waste. Rinse the beaker or Petri dish twice with DI water and dump into the solvent waste. Return to storage.

3.0 Storage:

- **3.1** Isopropanol should be stored in the solvent cabinet.
- **3.2** SU-8 and SU-8 developer should be stored in the photoresist cabinet.

4.0 Waste Disposal:

- **4.1** Isopropanol, SU-8 and SU-8 developer waste:
  - **4.1.1** Solid waste should go in the solvent/photoresist trash.
  - **4.1.2** Liquid waste should go in the solvent/photoresist liquid waste bottle.

5.0 Accident Procedures:

- **5.1** Contact: Read MSDS prior to working with any chemical to familiarize yourself with the symptoms of exposure and recommendations for treatment.
  - **5.1.1** There are solvent fumes from IPA, SU-8, and SU-8 developer. If you breath these fumes, you may feel dizzy. If this occurs, turn off the hotplates and leave everything in the hood. Leave the room and get some fresh air. If symptoms persist, contact Tufts health services and inform the lab directory and Tufts health and safety office.
  - **5.1.2** Skin contact from IPA, SU-8, and SU-8 developer is not critically dangerous. Exit the lab and rinse with water in the bathroom.
  - **5.1.3** There is a fire hazard associated with IPA. It is highly flammable. Do not put it on or near the hotplates. If a fire starts, remove any solvents from near the fire if it is safe to do so, and exit the lab. Do not try to fight the fire. Immediately contact Tufts emergency services once you are outside the lab.
- **5.2** Spill:
  - **5.2.1** If a small, contained spill of isopropanol or SU-8 developer occurs, such as inside the hood, wipe it up with chemical wipes and dispose of in the solvent trash container.
  - **5.2.2** If a large spill occurs that you are not comfortable cleaning up, evacuate the lab and contact Tufts emergency services (x66911). Also notify the faculty advisor.
- **5.3 Fire:**
  - **5.3.1** If a fire starts, use the fire extinguisher to put it out. Evacuate the lab and contact the faculty supervisor.
  - **5.3.2** If you are not able to quickly extinguish the fire using the fire extinguisher, immediately evacuate the lab and call **Tufts Emergency Services at x66911.**

If at any time you feel a situation is dangerous, do not hesitate to call the safety office (x73246, Peter Nowak) or the faculty supervisor (x72210, Robert White).

Report all accidents (injuries, major spills, fires) to the safety office at x73246 (Peter Nowak) and the faculty supervisor at x72210 (Robert White). For emergencies, call Tufts Emergency Services at x66911.