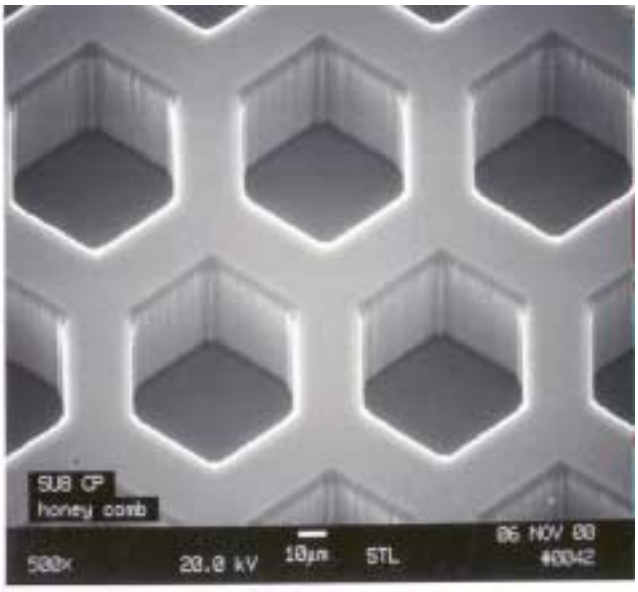
MICRO • CHEM

NANO™ SU-8
Negative Tone Photoresists Formulations 50 & 100

- **Highaspect ratio imaging with near vertical side walls**
- **Near UV (350-400nm) processing**
- **Film thicknesses from 1 to >200µm with single spin coat processes**
- **Superb chemical and temperature resistance**



Honey comb structure in thick SU-8 resist

SU-8 is a chemically amplified, high contrast, epoxy based photoresist designed for micromachining and other microelectronic applications. SU-8 is a negative tone photoresist. The exposed and subsequently cross-linked portions of the film are rendered insoluble to liquid developers. SU-8 has very high optical transparency, which makes it ideally suited for imaging near vertical sidewalls in very thick films. SU-8 is best suited for permanent applications where it is imaged, cured and left in place.

Process Guidelines

SU-8 is most commonly processed with conventional near UV (300-400nm) radiation, although it may be imaged with e-beam or x-ray. i-line(365nm) is recommended. Upon exposure, cross-linking proceeds in two-steps (1) formation of a strong acid during the exposure process, followed by (2) acid-initiated, thermally driven epoxy cross-linking during the post exposure bake (PEB) step.

A normal process is: spin coat, soft bake, expose, post expose bake (PEB) and develop. A controlled hard bake is recommended to further cross-link the imaged SU-8 structures when they it will remain as part of the device. The entire process should be optimized for the specific application. A baseline process is given here to be used as a starting point.

Substrate Pretreat

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Coat

↓

Soft Bake

↓

Expose

↓

Post Expose Bake (PEB)

↓

Develop

↓

Rinse & Dry

↓

Hard Bake ***(optional)***

↓

Imaged Material

↓

Remove ***(optional)***

Substrate Pretreatment

To obtain maximum process reliability, substrates should be clean and dry prior to applying the SU-8 resist. Start with a solvent cleaning, or a rinse with dilute acid, followed by a DI water rinse. Piranha Etch of the substrates is highly recommended. To dehydrate the surface, bake at 200 °C for 5 minutes on a contact hot plate or 30 minutes in a convection oven. Adhesion promoters are typically not required.

Coat

SU-8 resists are designed to produce low defect coatings over a very broad range of film thickness using a variety of spin coat conditions. The film thickness versus spin speed data and plots displayed in Table 1. and Figure 1. provide the information required to select the appropriate SU-8 resist and spin conditions, based upon the desired film thickness.

Recommended spin coat conditions:

(1) Dispense approximately 1ml of resist per inch of substrate diameter.
(2) Spread Cycle: Ramp to 500 rpm at 100rpm/second acceleration and hold for a total of 10 seconds. That is, 5 seconds getting to 500 rpm plus another 5 seconds at 500 rpm. This is necessary since the viscosity of the material is so high.
(3) Spin Cycle: Ramp to final spin speed, based on film thickness desired, at an acceleration of 300 rpm/sec and hold for a total of 30 seconds.

Product	Viscosity**	Thickness	Spin Speed
	cst @ 25°C	µm	rpm
SU-8 50	12250	40	3000
		50	2000
		100	1000
SU-8 100	51500	100	3000
		150	2000
		250	1000

Table 1. Thickness vs. spin speed data for selected SU-8 resists

*** Approximate*

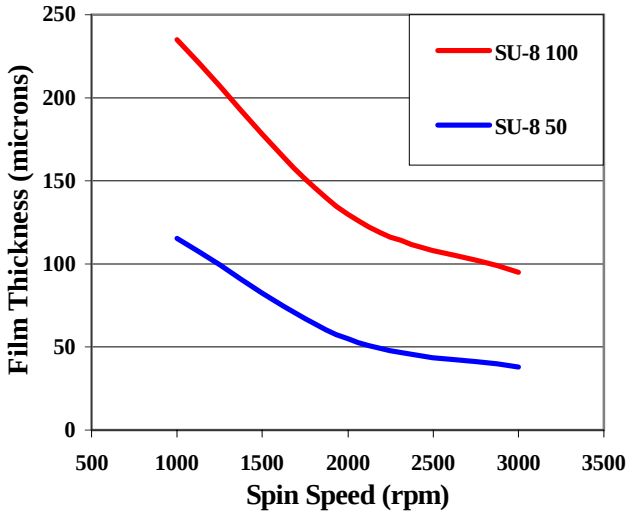

Figure 1. Film thickness vs. spin speed.

Soft Bake

After the resist has been applied to the substrate, it must be soft baked to evaporate the solvent and densify the film. SU-8 is normally baked on a hot plate, although convection ovens may be used. The following bake times are based on contact hot plate processes. Bake times should be optimized for proximity and convection oven bake processes since solvent evaporation rate is influenced by rate of heat transfer and ventilation.

For best results, ramping or stepping the soft bake temperature is recommended. Lower initial bake temperatures allow the solvent to evaporate out of the film at a more controlled rate, which results in better coating fidelity, reduced edge beads and better resist to substrate adhesion. Refer to Table 2. for recommendations for TWO STEP contact hot plate processes

Product	Thickness	Soft Bake Time (minutes)	
	µm	STEP 1 65°C	STEP 2 95°C
SU-8 50	40	5	15
	50	6	20
	100	10	30
SU-8 100	100	10	30
	150	20	50
	250	30	90

Table 2. Recommended soft bake processes.

Expose

SU-8 is optimized for near UV (350-400nm) exposure. It is virtually transparent and insensitive above 400nm and is highly absorbent and reactive to energy below 350nm. This can be seen in Figure 2. Excessive dose below 350nm may result in over exposure of the top portion of the resist film, resulting in exaggerated negative sidewall profiles or T-topping. The optimal exposure dose will depend on film thickness (thicker films require higher dosage) and process parameters. The exposure dose range recommendations in Table 3. are based on exposure source intensity measurements taken with an i-line (365nm) radiometer and probe.

Expose tip: When using a broad spectral output source, for best imaging results, i.e. straightest sidewalls, filter out excessive energy below 350nm.

Catastrophic adhesion failure, severely negative sidewalls and excessive cracking are often indications of an under cross-linking condition. To correct the problem, increase your exposure dose and or increase your post exposure bake (PEB) time.

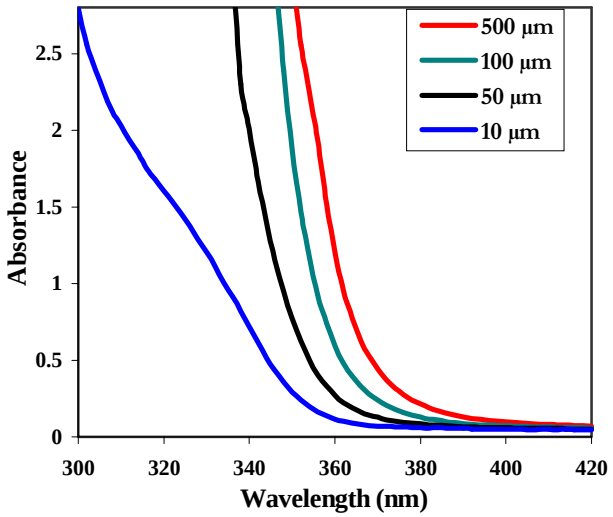

Figure 2. SU-8 absorbance vs. film thickness

Product	Thickness	Expose Dose
	µm	mJ/cm^2
SU-8 50	40	250-300
	50	400-500
	100	500-650
SU-8 100	100	500-650
	150	600-675
	250	625-700

Table 3. Recommended expose dose processes.

Post Expose Bake

Following exposure, a post exposure bake (PEB) must be performed to selectively cross-link the exposed portions of the film. SU-8 can be post exposure baked (PEB) either on a hot plate or in a convection oven. Optimum cross-link density is realized through careful adjustments of the exposure and PEB process conditions. The bake recommendations below are based on results obtained on a contact hot plate.

PEB Tip: SU-8 is readily cross-linked and can result in a highly stressed film. To minimize stress, wafer bowing and resist cracking, a slow ramp or TWO STEP contact hot plate process, as shown in Table 4., is recommended. Avoid rapid cooling after PEB.

Product	Thickness	P E B Time (minutes)	
	µm	STEP 1 65°C	STEP 2 95°C
SU-8 50	40	2	4
	50	2	5
	100	3	10
SU-8 100	100	3	10
	150	12	15
	250	15	25

Table 4. Recommended PEB processes.

Develop

SU-8 resists have been optimized for use with MicroChem's SU-8 Developer. Immersion, spray or spray- puddle processes can be used. Other solvent developers such as ethyl lactate and diacetone alcohol may also be used. Strong agitation is recommended for high aspect ratio and/or thick film structures. Recommended develop times are given in Table 5. for immersion processes. These proposed develop times are approximate, since actual dissolution rates can vary widely as a function of agitation rate, temperature and resist processing parameters.

Product	Thickness	Development
	µm	minutes
SU-8 50	40	6
	50	6
	100	10
SU-8 100	100	10
	150	15
	250	25

Table 5. Recommenended develop processes.

Rinse and Dry

Following development, the substrate should be rinsed briefly with isopropyl alcohol (IPA), then dried with a gentle stream of air or nitrogen.

Rinse tip: If a white film is produced during rinse, this is an indication that the substrate has been under developed. Simply immerse or spray the substrate with SU-8 developer to remove the film and complete the development process. Repeat the rinse step.

Hard Bake (cure)

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.

Remove

SU-8, after expose and PEB, is a highly cross-linked epoxy, which makes it extremely difficult to remove with conventional solvent based resist strippers. MicroChem's Remover PG will swell and lift off minimally cross-linked SU-8. It will not remove fully cured or hard baked SU-8. Alternate removal processes include immersion in oxidizing acids such as piranha etch/clean, RIE, laser ablation and pyrolosis.

To remove minimally cross-linked SU-8 with Remover PG, heat the bath to 50-80^{o} C and immerse the substrates for 30-90 minutes. Actual strip time will depend on resist thickness and cross-link density

Storage

Store SU-8 resists upright in tightly closed containers in a cool dry environment away from direct sunlight at a temperature of 40-70°F (4-21°C). Store away from light, acids, heat and sources of ignition. Shelf life is twelve months from date of manufacture.

Disposal

SU-8 resist may be included with other waste containing similar organic solvents to be discarded for destruction or reclaim in accordance with local state and federal regulations. It is the responsibility of the customer to ensure the disposal of SU-8 resists and residues made in observance all federal, state, and local environmental regulations.

Environmental, Health and Safety

Consult product Material Safety Data Sheet before working with SU-8 resists. Handle with care. Wear chemical goggles, chemical gloves and suitable protective clothing when handling SU-8 resist. Do not get into eyes, or onto skin or clothing. Use with adequate ventilation to avoid breathing vapors or mist. In case of contact with skin, wash affected area with soap and water. In case of contact with eyes, rinse immediately with water and flush for 15 minutes lifting eyelids frequently. Get emergency medical assistance.

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