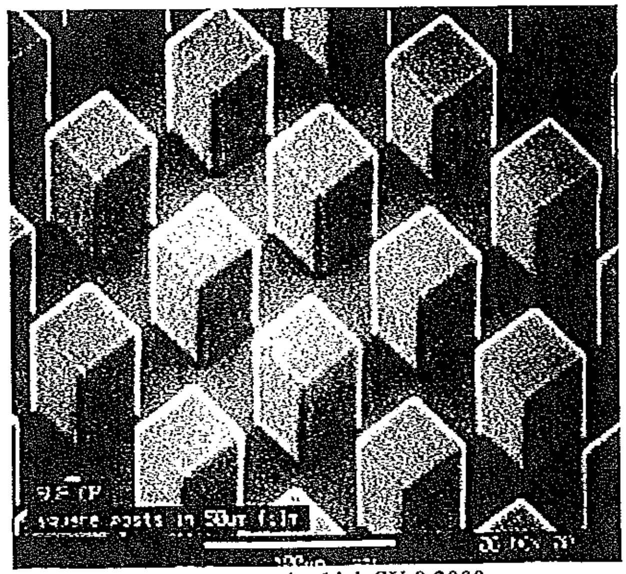
NANO™ SU-8 2000

Negative Tone Photoresists

Formulations 25 - 75



Square posts in thick SU-8 2000

- **High aspect ratio imaging**
  Near vertical side walls
- **Near UV (350-400nm) processing**
- **Improved coating properties**
  Uniformity (lower surface tension)
  Adhesion
- **Faster drying**
  Improved throughput

Substrate Pretreat → Coat → Soft Bake → Expose → Post Expose Bake (PEB) → Develop → Rinse & Dry → Hard Bake *(optional)* → Imaged Material → Remove *(optional)*

SU-8 2000 is a high contrast, negative tone, chemically amplified, epoxy based photoresist designed for micromachining and other microelectronic applications, where a thick, chemically and thermally stable image is desired. SU-8 2000 is an improved formulation of SU-8, which has been widely used by MEMs producers for many years. By using a faster drying, more polar solvent system, improved coating properties and higher throughput are realized. Film thicknesses of 50 to >200μm can be achieved with a single coat process. The excellent imaging characteristics of SU-8 are maintained. The exposed and subsequently cross-linked portions of the film are rendered insoluble to liquid developers. SU-8 2000 has very high optical transparency above 360nm, which makes it ideally suited for imaging near vertical sidewalls in very thick films. SU-8 2000 is best suited for permanent applications where it is imaged, cured and left in place.

Process Guidelines

SU-8 2000 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 2000 structures when they 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

To obtain maximum process reliability, substrates should be clean and dry prior to applying the SU-8 2000 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 2000 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 2000 resist and spin conditions, based upon the desired film thickness.

Recommended 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.

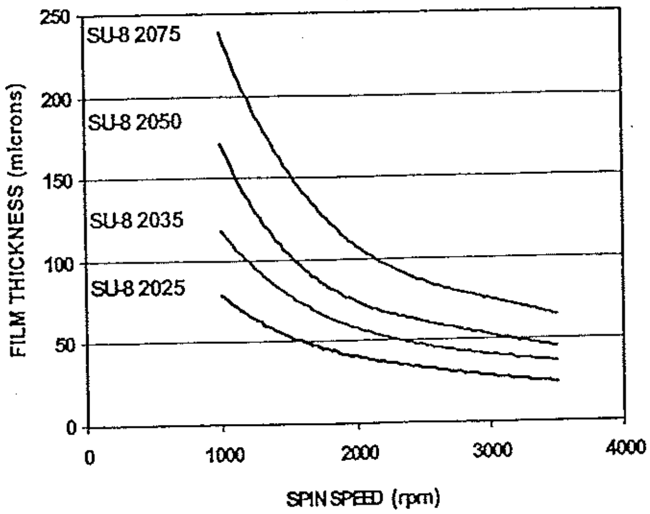


Figure 1. Spin speed vs. thickness curves for selected SU-8 2000 resists.

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 2000 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	Viscosity	Thicknesses	Spin Speed
	cst @ 25°C	μm	rpm
SU-8 2025	4,800	25	3000
		41	2000
		75	1000
SU-8 2035	7,000	35	3000
		55	2000
		110	1000
SU-8 2050	17,000	50	3000
		75	2000
		165	1000
SU-8 2075	32,000	75	3000
		110	2000
		225	1000

Table 1. Thickness vs. spin speed data for selected SU-8 2000 resists.
*** Approximate*

Product	Thickneses	Soft Bake Time (min)	
		STEP 1 65°C	STEP 2 95°C
	μm		
SU-8 2025	25	1	3
	40	2	5
	75	3	9
SU-8 2035	35	2	5
	55	3	6
	110	5	20
SU-8 2050	50	3	6
	75	3	9
	165	5	30
SU-8 2075	75	3	9
	110	5	20
	225	5	45

Table 2. Recommended soft bake parameters

Product	Thicknesses	Develop Time
	μm	min
SU-8 2025	25	4
	40	5
	75	7
SU-8 2035	35	5
	55	6
	110	10
SU-8 2050	50	6
	75	7
	165	12
SU-8 2075	75	7
	110	10
	225	12

Table 5. Recommended 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 2000 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 2000, 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 2000. It will not remove fully cured or hard baked SU-8 2000. Alternate removal processes include immersion in oxidizing acids such as piranha etch/clean, plasma ash, RIE, laser ablation and pyrolosis.

To remove minimally cross-linked SU-8 2000 with Remover PG, heat the bath to 50-80° 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 2000 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 2000 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 2000 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 2000 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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MicroChem Corp.
1254 Chestnut Street
Newton, MA 02464
tel: (617)965-5511 fax: (617)965-5818
email: mcc@microchem.com www.microchem.com

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Expose

SU-8 2000 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 the post exposure bake (PEB) time.

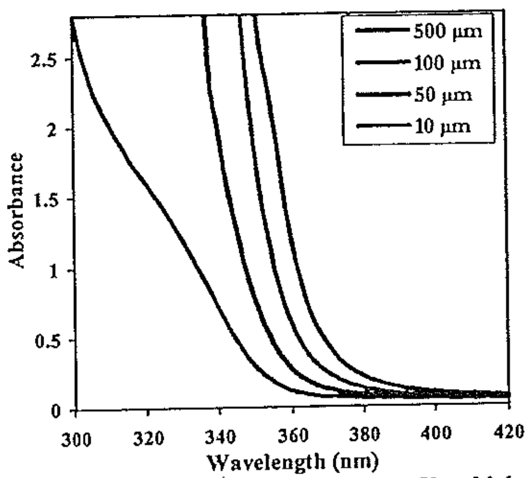

Figure 2. SU-8 2000 absorbance vs. film thickness

Product	Thicknesses	Exposure Dose
	µm	mJ/cm^2
SU-8 2025	25	220-240
	40	250-350
	75	500-600
SU-8 2035	35	250-350
	55	400-500
	110	500-650
SU-8 2050	50	400-500
	75	500-600
	165	600-650
SU-8 2075	75	500-600
	110	500-650
	225	625-675

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 2000 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 2000 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	Thicknesses	P.E.B. Time (min)	
	µm	STEP 1 65°C	STEP 2 95°C
SU-8 2025	25	1	3
	40	1	3
	75	1	7
SU-8 2035	35	1	3
	55	1	5
	110	1	10
SU-8 2050	50	1	5
	75	1	7
	165	1	12
SU-8 2075	75	1	7
	110	1	10
	225	1	15

Table 4. Recommended post expose bake parameters

Develop

SU-8 2000 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.