MICRO•CHEM

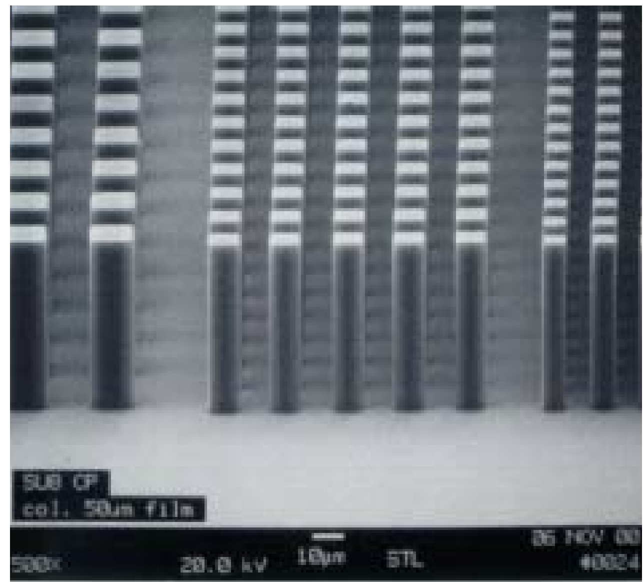
NANO™ SU-8 2000

Negative Tone Photoresist Formulations 2002-2025

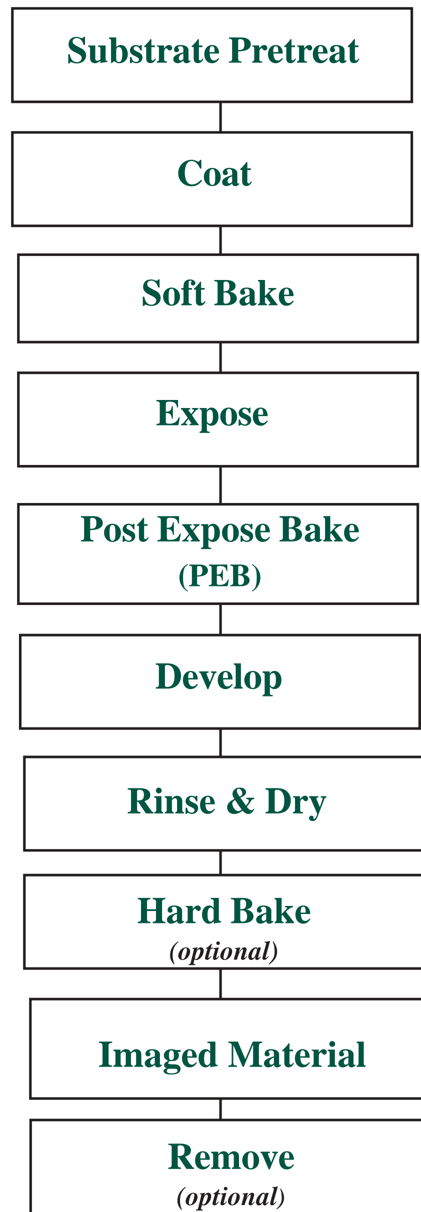
- **High aspect ratio imaging**
  Near vertical side walls
- **Near UV (350-400nm) processing**
- **Improved coating properties**
  Uniformity (lower surface tension)
  Adhesion
- **Faster drying**
  Improved throughput

SU-8 2000 is a high contrast, 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 0.5 to >200mm 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 (350-400nm) 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.



5µm, 10µm and 20µm post arrays in a 50µm thick film.



A normal process is: spin coat, soft bake, expose, post expose bake (PEB) followed by 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. Where applicable, substrates should be subjected to a piranha etch / clean (H_2SO_4 & H_2O_2). 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. For applications that require electroplating and subsequent removal of SU-8 2000 apply MicroChem's OmniCoat prior to processing.

Coat

SU-8 2000 resists are designed to produce low defect coatings over a very broad range of film thickness. The film thickness versus spin speed data displayed in Table 1 and Figure 1 provide the information required to select the appropriate SU-8 2000 resist and spin conditions, to achieve the desired film thickness.

The recommended coating conditions are:

(1) STATIC Dispense: Approximately 1ml of SU-8 2000 per inch of substrate diameter.
(2) Spread Cycle: Ramp to 500 rpm at 100 rpm/second acceleration. This will take 5 seconds.
(3) Spin Cycle: Ramp to final spin speed at an acceleration of 300 rpm/second and hold for a total of 30 seconds.

Product Name	Viscosity** (cSt)	Thickness** (µms)	Spin Speed (rpm)
		2	3000
SU-8 2002	7.5	2.5	2000
		3	1000
		5	3000
SU-8 2005	45	6	2000
		7.5	1000
		7	3000
SU-8 2007	140	8.5	2000
		12.5	1000
		10	3000
SU-8 2010	380	13	2000
		20	1000
		15	3000
SU-8 2015	1250	21	2000
		38	1000
		25	3000
SU-8 2025	4500	41	2000
		75	1000

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

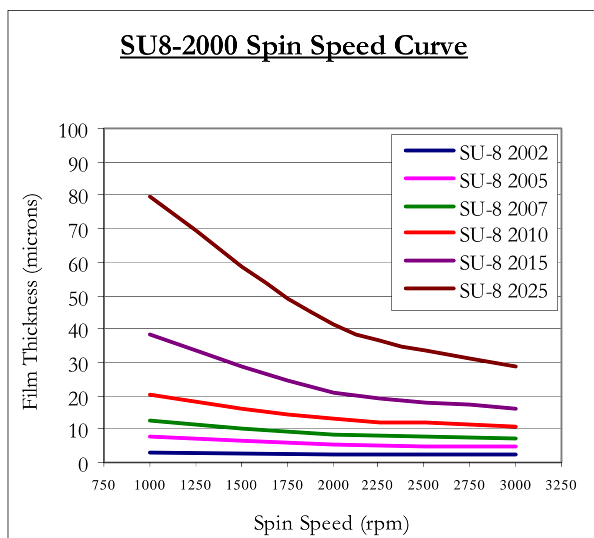


Figure 1. Spin speed vs. thickness curves for selected SU-8 2000 resists.

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 level 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 the 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 bead and better resist -to-substrate adhesion. Refer to Table 2. for TWO STEP contact hot plate process recommendations.

Product Name	Thickness (µms)	Pre-bake @ 65° C	Softbake @ 95° C
	2	1	2
SU-8 2002	2.5	1	2
	3	1	2
	5	1	2
SU-8 2005	6	1	2
	7.5	1	2
	7	1	2
SU-8 2007	8.5	1	2
	12.5	1	2
	10	1	2
SU-8 2010	13	1	2
	20	1	3
	15	1	2
SU-8 2015	21	1	3
	38	2	5
	25	1	3
SU-8 2025	41	2	5
	75	3	9

Table 2. Recommended soft bake parameters

Expose

SU-8 is optimized for near UV (350-400nm) exposure. i-line exposure tools are recommended. SU-8 is virtually transparent and insensitive above 400nm but has high actinic absorption below 350nm. This can be seen in Figure 2. Excessive dose below 350nm may, therefore, 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 recommendations in Table 3. are based on 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 often indicate an under cross-linking condition. To correct the problem, increase the exposure dose and/or increase the post exposure bake (PEB) time.

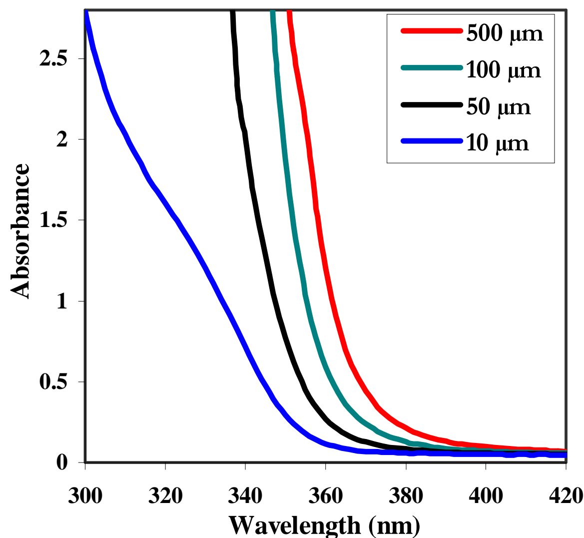


Figure 2. SU-8 absorbance vs. film thickness

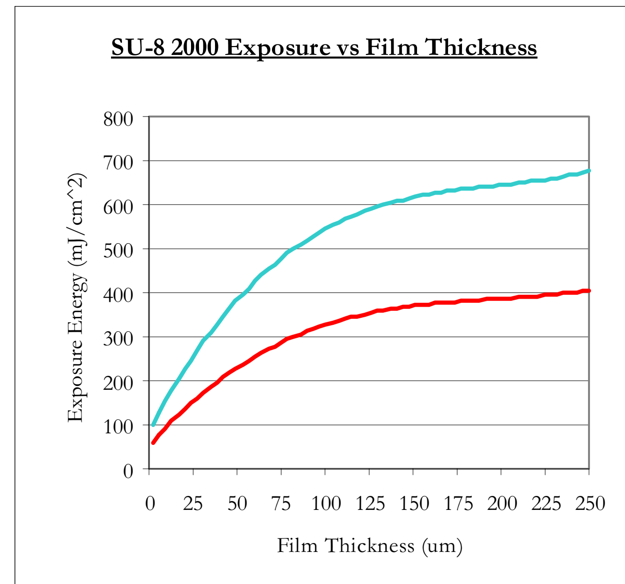


Table 3. Recommended expose dose processes

Post Expose Bake

Following exposure, a post expose bake (PEB) must be performed to selectively cross-link the exposed portions of the film. This bake can be performed either on a hot plate or in a convection oven. Optimum cross-link density is obtained through careful adjustments of the exposure and PEB process conditions. The bake recommendations below are based on results obtained with 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. Rapid cooling after PEB should be avoided.

Product Name	Thickness (µms)	PEB 1 @ 65° C	PEB 2 @ 95° C
	2	1	1
SU-8 2002	2.5	1	1
	3	1	1
	5	1	1
SU-8 2005	6	1	1
	7.5	1	1
	7	1	1
SU-8 2007	8.5	1	2
	12.5	1	2
	10	1	2
SU-8 2010	13	1	2
	20	1	2
	15	1	2
SU-8 2015	21	1	2
	38	1	3
	25	1	3
SU-8 2025	41	1	3
	75	1	7

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 based 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 Name	Thickness (μms)	Development (minutes)
	2	1
SU-8 2002	2.5	1
	3	1
	5	1
SU-8 2005	6	1
	7.5	1
	7	1
SU-8 2007	8.5	2
	12.5	3
	10	2
SU-8 2010	13	3
	20	3
	15	3
SU-8 2015	21	3
	38	4
	25	4
SU-8 2025	41	5
	75	7

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.

Removal

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. However, if OmniCoat has been applied immersion in Remover PG should effect a clean and thorough Lift-Off of the SU-8 2000 Material. It will not remove fully cured or hard baked SU-8 2000 without the use of OmniCoat. Alternate removal processes include immersion in oxidizing acid solutions such as piranha etch / clean, plasma ash, RIE, laser ablation and pyrolosis.

To remove minimally cross-linked SU-8 2000, or if using Omnicoat, 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
For more information on MicroChem Omnicoat and Remover PG please see the relevant product data sheets.

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 resists 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 2000 resists. 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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Rev. 2/02