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NANO™ SU-8

Negative Tone Photoresist Formulations 2-25

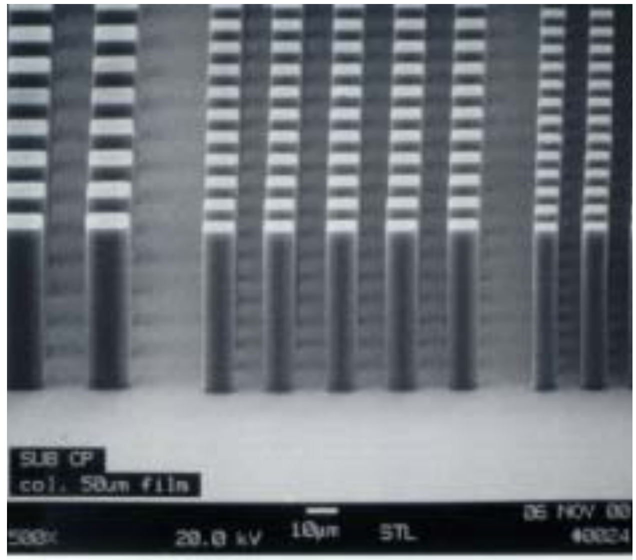
- **High aspect ratio imaging with near vertical side walls**
- **Near UV (350-400nm) processing**
- **Film thicknesses from 1 to >200µm with single spin coat processes**
- **Superb chemical and temperature resistance**

SU-8 is a high contrast, epoxy based photoresist designed for micromachining and other microelectronic applications, where a thick chemically and thermally stable image is desired. The exposed and subsequently cross-linked portions of the film are rendered insoluble to liquid developers. SU-8 has very high optical transparency above 360nm, 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.

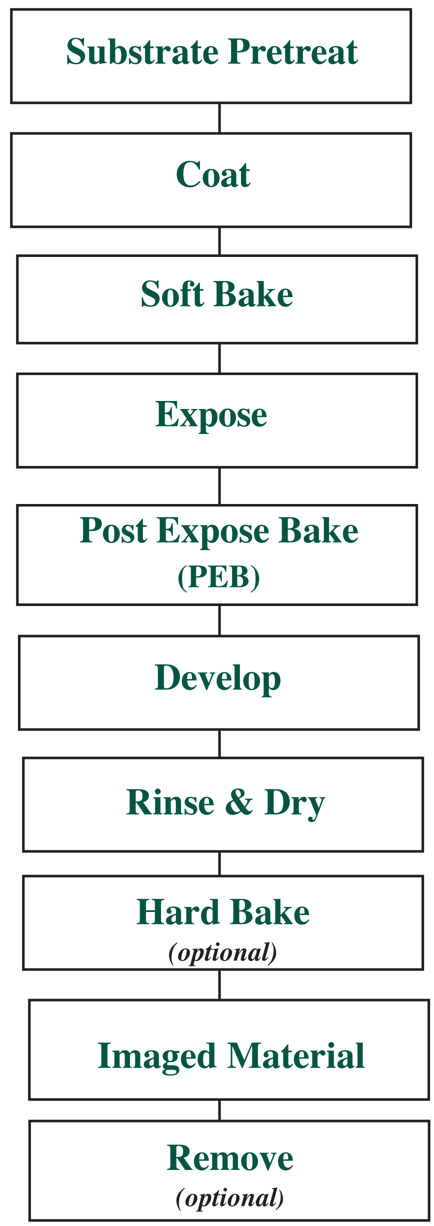
Process Guidelines

SU-8 is most commonly processed with conventional near UV (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.

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.



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



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. 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 hotplate. For applications that require electroplating and subsequent removal of SU-8 apply MicroChem's OmniCoat prior to processing SU-8.

Coat

SU-8 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 resist and spin conditions, to achieve the desired film thickness.

The recommended coating conditions are:

(1) STATIC Dispense: Approximately 1ml of SU-8 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)
		1.5	3000
SU-8 2	45	2	2000
		5	1000
		5	3000
SU-8 5	290	7	2000
		15	1000
		10	3000
SU-8 10	1050	15	2000
		30	1000
		15	3000
SU-8 25	2500	25	2000
		40	1000

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

***** Approximate***

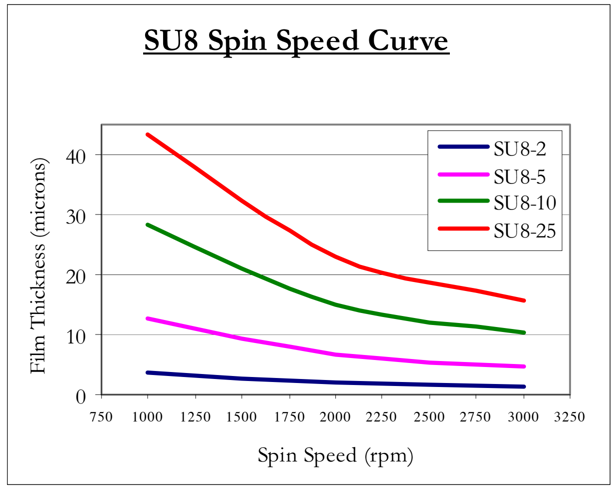


Figure 1. Spin speed vs. thickness curves for selected SU-8 resists.

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 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
	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

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.

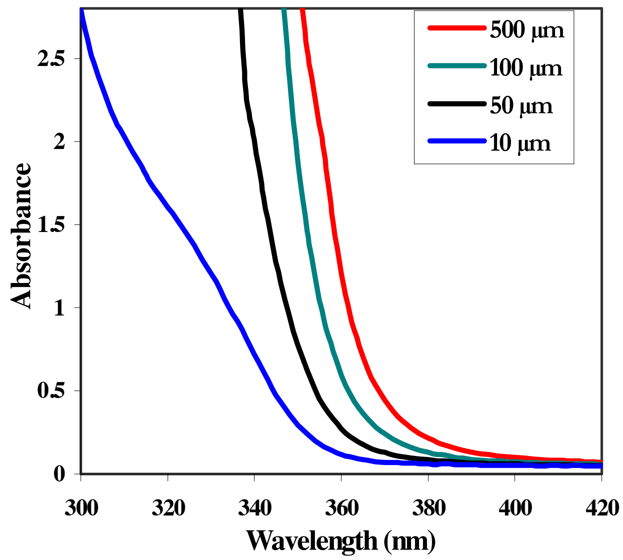


Figure 2. SU-8 absorbance vs. film thickness

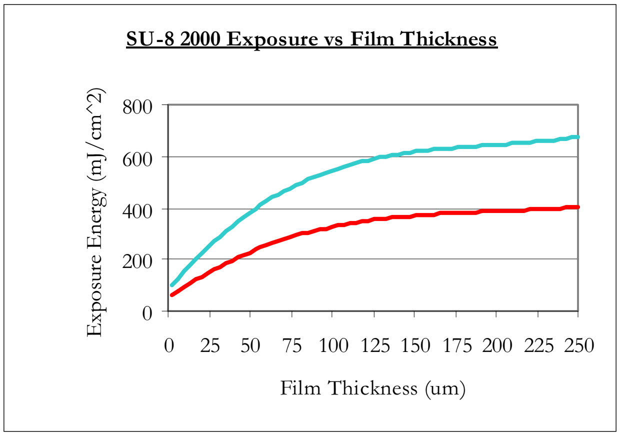


Table 3. Recommended exposure dose processes

Post Exposure 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
	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

Table 4. Recommended post exposure bake parameters

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 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)
	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

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 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 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 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 thirteen months from date of manufacture.

Disposal

SU-8 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 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 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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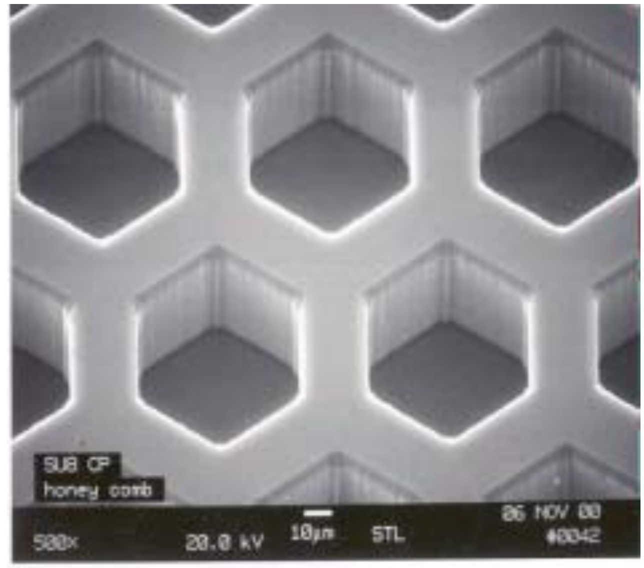
NANO™ SU-8

Negative Tone Photoresist Formulations 50-100



Honeycomb structure in thick SU-8 resist

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- **Film thicknesses from 1 to >200μm with single spin coat processes**
- **Superb chemical and temperature resistance**

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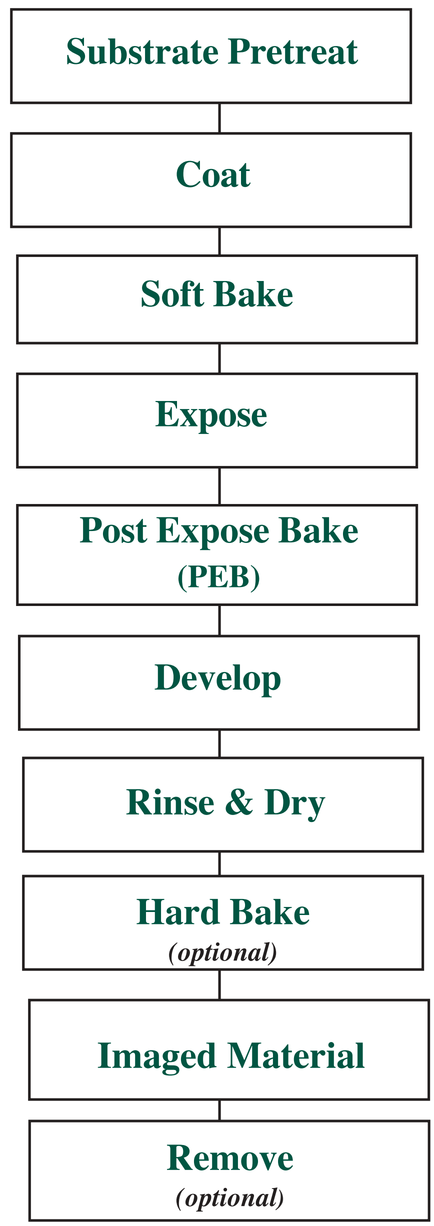
A normal process is: spin coat, soft bake, expose, post expose bake (PEB) and develop. A controlled hard bake is recommended to further cross-link the imaged SU-8 structures when they it will remain as part of the device. The entire process should be optimized for the specific application. A baseline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



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SU-8 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 resist and spin conditions, to achieve the desired film thickness.

The recommended coating conditions are:

(1) STATIC Dispense: Approximately 1ml of SU-8 per inch of substrate diameter.
(2) Spread Cycle: Ramp to 500 rpm at 100 rpm/second acceleration. Hold at this speed for 5-10 seconds to allow the resist to cover the entire surface.
(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)
		40	3000
SU-8 50	12250	50	2000
		100	1000
		100	3000
SU-8 100	51500	150	2000
		250	1000

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

***** Approximate***

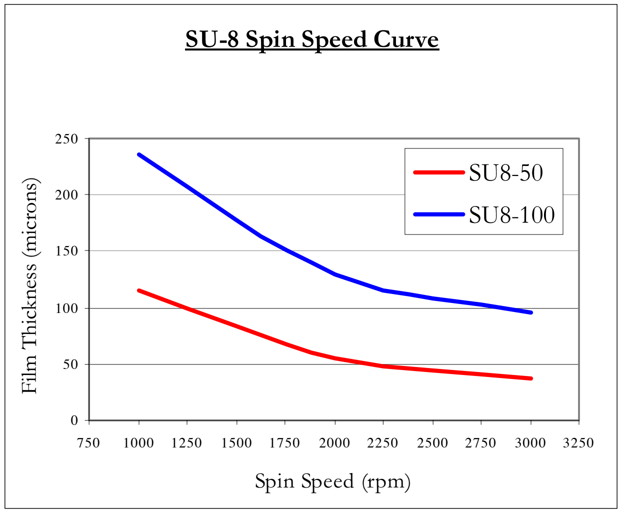

Figure 1. Spin speed vs. thickness curves for selected SU-8 resists.

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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

Table 2. Recommended soft bake parameters

Expose

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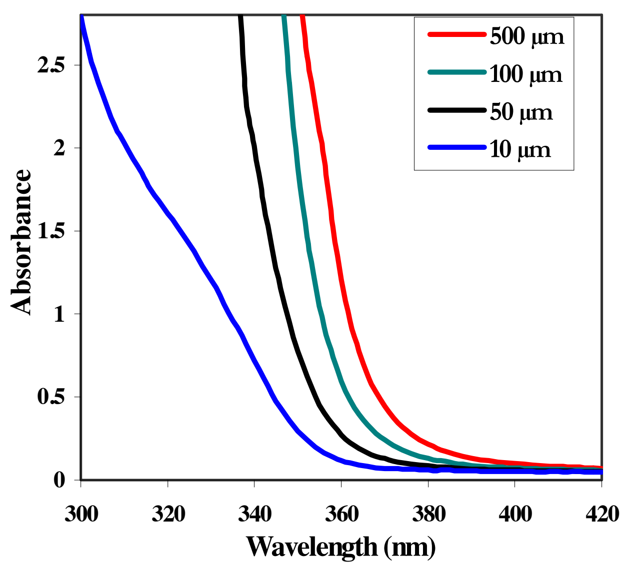

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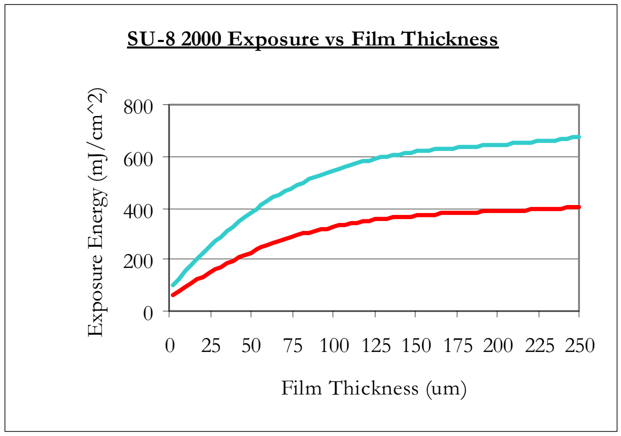

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Product Name	Thickness (µms)	PEB 1 @65°C	PEB 2 @95°C
	40	1	4
SU-8 50	50	1	5
	100	1	10
	100	1	10
SU-8 100	150	1	12
	250	1	20

Table 4. Recommended post exposure bake parameters

Develop

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

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Rinse and Dry

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