SU-8 Permanent Negative Epoxy Photoresist

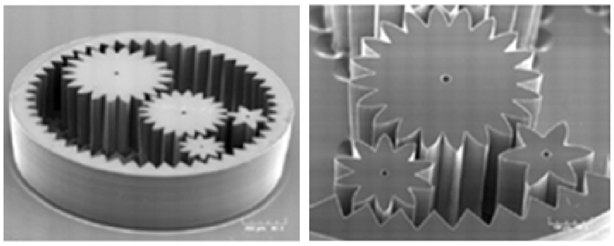
Formulations 50–100

Description

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 crosslinked portions of the film are rendered insoluble to liquid developers. SU-8 has very high optical transparency above 360 nm 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.

Features

- High aspect ratio imaging with near vertical sidewalls
- i-Line (365 nm) and broadband processing
- Film thicknesses from 1 to > 200 µm with single spin coat processes
- Superb chemical and temperature resistance



MEMS gears with SU-8 removed

Process Flow

1. Substrate Pretreat
2. Coat
3. Edge Bead Removal (EBR)
4. Soft Bake
5. Expose
6. Post Exposure Bake (PEB)
7. Develop
8. Rinse and Dry
9. Hard Bake (cure) optional / Removal optional

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PROCESSING GUIDELINES

SU-8 is most commonly processed with conventional near UV (350–450 nm) radiation, although it may be imaged with e-beam or X-ray. i-Line (365 nm) is recommended. Upon exposure, crosslinking proceeds in two steps (1) formation of a strong acid during the exposure process, followed by (2) acid-initiated, thermally driven epoxy crosslinking 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 crosslink the imaged SU-8 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 Preparation

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 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.

Recommended Coating Conditions

(1) Static Dispense: Approximately 1 ml 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	VISCOSITY cSt	THICKNESS microns	SPIN SPEED rpm
SU-8 50	12250	40 50 100	3000 2000 1000
SU-8 100	51500	100 150 250	3000 2000 1000

Table 1. Approximate Thickness vs. Spin Speed Data for Selected SU-8 Resists

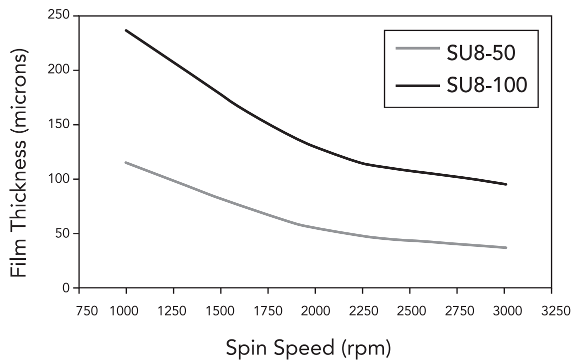

Figure 1. Thickness vs. Spin Speed

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 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.

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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	THICKNESS microns	SOFT BAKE TIME minutes @ 65ºC	minutes @ 95ºC
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 Parameters

Exposure

SU-8 is optimized for near UV (350–450 nm) exposure. i-Line exposure tools are recommended. SU-8 is virtually transparent and insensitive above 400 nm but has high actinic absorption below 350 nm. This can be seen in Figure 2. Excessive dose below 350 nm 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 (365 nm) radiometer and probe.

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

Catastrophic adhesion failure and excessive cracking often indicate an under crosslinking condition. To correct the problem, increase the exposure dose and/or increase the post exposure bake (PEB) time.

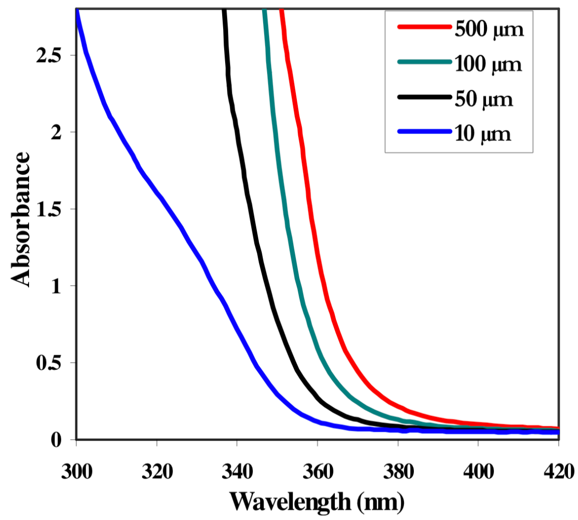

Figure 2. SU-8 Absorbance vs. Film Thickness

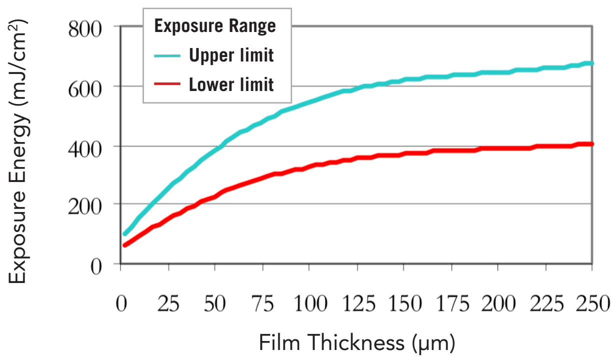

Figure 3. Exposure Dose

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Post Exposure Bake (PEB)

Following exposure, a post expose bake (PEB) must be performed to selectively crosslink the exposed portions of the film. This bake can be performed either on a hot plate or in a convection oven. Optimum crosslink 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 crosslinked 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 is recommended, as shown in Table 4. Rapid cooling after PEB should be avoided.

PRODUCT	THICKNESS	PEB TIME	
	microns	minutes@65°C	minutes@95°C
SU-8 50	40	1	4
	50	1	5
	100	1	10
SU-8 100	100	1	10
	150	1	12
	200	1	20

Table 4. Recommended Post Exposure Bake Parameters

Develop

SU-8 resists have been optimized for use with 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 approxinrate, since actual dissolution rates can vary widely as a function of agitation rate, temperature and resist processing parameters.

PRODUCT	THICKNESS	DEVELOPMENT TIME
	microns	minutes
SU-8 50	40	6
	50	6
	100	10
SU-8 100	100	10
	150	15
	250	20

Table 5. Recommended Develop Processes

Rinse and Dry

Following development with SU-8 Developer, spray rinse with fresh developer then dry with a gentle stream of filtered pressurized air or nitrogen.

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 crosslink the material. Bake times vary based on type of bake process and film thickness.

Removal

After exposure and PEB, SU-8 is a highly crosslinked epoxy, which makes it extremely difficult to remove with conventional solvent-based resist strippers. Kayaku Advanced Materials' Remover PG will swell and lift off minimally crosslinked SU-8.

However, if OmniCoat has been applied, immersion in Remover PG should effect a clean and thorough lift-off of the SU-8 material. It will not remove fully cured or hard baked SU-8 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 crosslinked SU-8, or if using OmniCoat, with Remover PG, heat the bath to 50-

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80°C and immerse the substrates for 30–90 minutes. Actual strip time will depend on resist thickness and crosslink density. For more information on Kayaku Advanced Materials' OmniCoat and Remover PG, please see the relevant product data sheets.

PLASMA REMOVAL

Plasma removal conditions are: RIE 200W, 80 sccm O_2, 8 sccm CF_4, 100 mTorr, 10°C. For more information, refer to the SU-8 / KMPR® Removal applications note on the website www.kayakuAM.com. Also see www.r3t.de or www.tepla.com for microwave plasma tools for high throughput without damaging other microstructures.

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

The material and its container must be disposed in accordance with all local, state, federal and/or international regulations.

Handling

Consult Safety Data Sheet (SDS) for details on the handling procedures and product hazards prior to use. If you have any questions regarding handling precautions or product hazards, please email productsafety@kayakuAM.com.

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