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# Photolithography

## STANDARD OPERATION PROCEDURE

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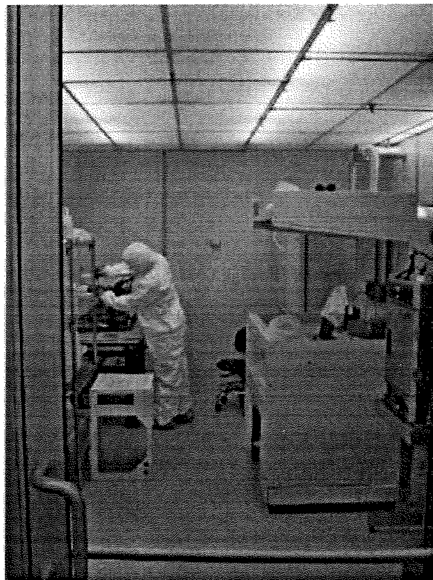
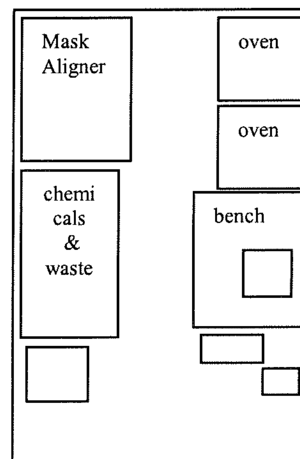
## 1. INTRUDUCTION

Photolithography is a standard procedure to transfer patterns onto substrates. This standard operational procedure (SOP) provides information on the equipments, necessary personal protective equipment, primary hazards, and operational procedures. The basic operational procedure involves several steps, i.e., preheating substrates, spin-coating photoresist, prebaking, exposing to UV light using the mask aligner, developing, post-baking.

## 2. LOCATION OF EQUIPMENT, ACCESARIES, TOOLS, AND SUPPLIES

The photolithography bench, the maks aligner, and two convection ovens are located in the yellow room. The photoresist spin coater is located in the bench. Photoresist, photoresist developer, aluminum foil, glass dishes, plastic containers are located on the rack. A waste container for used developing solution and a waste container bag for excess photoresist accumulated on aluminum foils are also on the rack.





## 3. PRIMARY HAZARDS AND PERSONAL PROTECTIVE EQUIPMENT

The primary hazard is the chemicals. Wear safety glasses and latex or PVC gloves when handling chemicals. Ultraviolet light radiation can cause burns of the skin and eyes. Chronic exposure to UV light can cause skin cancer. The mask aligner is designed so that the user is not exposed to the direct UV light. However, the user should avoid looking directly at the UV source and avoid exposure to reflected or scattered UV light. Wear UV protection goggles during photoresist UV exposures.

Spinning substrates without holding the substrate by vacuum is extremely dangerous. Use the lid when spinning. Wear safety glasses.

## 4. OPERATIONAL PROCEDURE

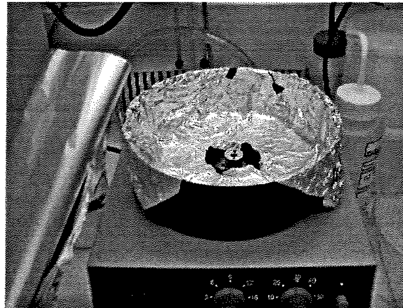
**Procedure 1. Substrate pretreatment (Dehydration Bake)**

Residual water molecules on the substrates need to be removed by heating up the substrate in convection oven.

- Make sure no one is using the oven. Increase convection oven setpoint to 120 C. See the convection oven operation manual for details on changing setpoint.
- Place the substrate in the oven for 20 minutes.
- Decrease the setpoint to default value.

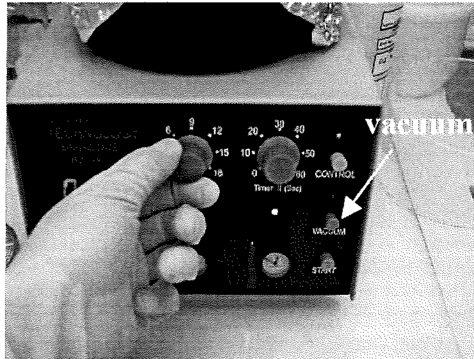
**Procedure 2. Spin Coating Photoresist**

- Turn on the switch for the yellow light on the bench. This switch also opens the air vent valve for the exhaust.
- Wrap the photoresist spinner bowl with aluminum foil. This makes cleaning easier.



- Turn on the spin coater and vacuum pump. The pump is located under the bench.
- Mount the chuck. Three different sizes of chucks are available. Chose the one that is smaller than the substrates, otherwise substrates cannot be held during spinning.

- Mount substrates on the center of the chuck and **press the vacuum valve switch**. [Note: Spinning without holding the substrate by vacuum is extremely dangerous.] Put the lid on. Wear safety glasses.




- Adjust rotation speeds and time for both the first and the second steps. For AZ5214, typically 4000 rpm at 40 sec.
- Apply few drops pf HMDS adhesion promoter and press start to spin, if necessary.
- Appy photoresist to the substrate and press the start button of the spinner.
- The spinner will be automatically stop when coating is completed.
- Press the vacuum valve switch to release the substrate from the chuck.

- Finishing: remove aluminium foil carefully and put into waste bug.

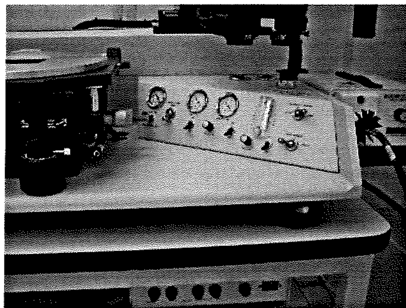
**Procedure 3. Prebake (Soft Bake)**

- Set the convection oven tempreture to 90 degree.
- Put the photoresist coated substrates into the oven for 15 minutes.
- Take out and let it cool down to room tempreture.

**Procedure 4. Alignment and UV exposure**

Alignment is a step to precisely place the mask on top of the substrate prior to exposure. 7 inch and 5 inch mask holder is available. 4 inch mask holder is not available at this stage. For film type masks and 4 inch masks, use home position when exposing UV light. For small sample, use small sample stage. For 4 inch silicon wafer, both small and large sample holders may be used. *See also mask aligner standard operational procedures.*

- Turn on the mask aligner main switch. Make sure vacuum pump is on. Turn on UV light source switch, and push ignition switch only once. It takes 15 min to warm up the lamp.

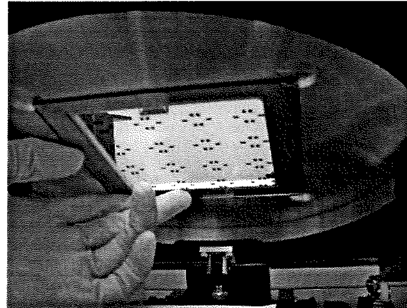


- Set appropriate mask holder and sample stage.

*Example.*

5 inch mask holder with small sample stage

- Place substrates on the stage. Turn sample vacuum switch on. Place a mask to the holder and pull the vacuum knob.



- Align the sample position and move the sample closer to the mask, while pressing the flexible-stage button.

- Sample vacuum is used to make tight contact between sample and the mask. If sample is larger than the seal (white rubber), this option cannot be used.
- Set Auto Exposure switch off. Set appropriate time.
- Move the UV light assembly to center position.
- Wear UV protective goggle.
- Press Auto Exposure. The shutter is automatically open for the set period of time.
- Move the UV light assembly back to home position.

Home position exposure

- Place the sample on the home position.
- Place the mask on top of the sample.
- Set Auto Exposure switch off. Set the timer.
- Press Auto Exposure at home position.

## Procedure 5. Develop

- Prepare glass container ready.
- Dilute developing solution. (1:5= developer: DI water)
- Immerse the sample in the developer for 1 min 40 second for 4000 rpm AZ5214.
- Wash the sample with DI water.
- Blow nitrogen gas to dry.
- Dump used solution to a developer waste bottle.

**Procedure 6. Postbake**

Postbake may be required to stabilize and harden the developed photoresist prior to processing steps that the resist will mask. Use convection oven and set appropriate time.

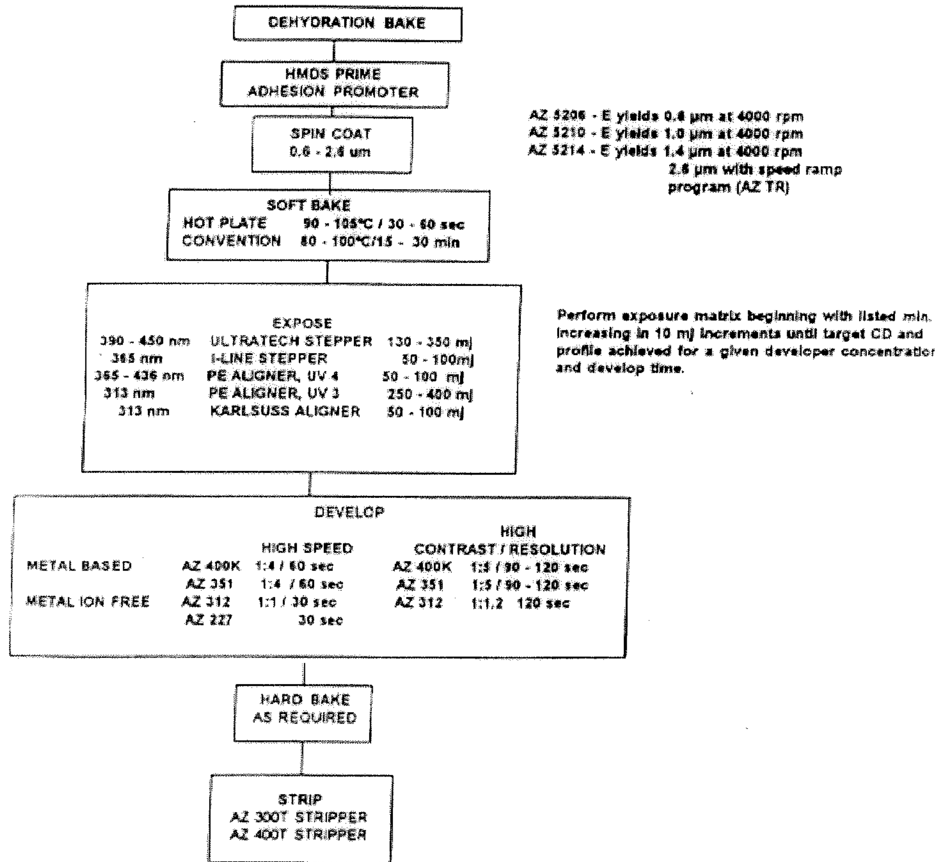
## 5. References.

**AZ5214 Positive Resist**

# AZ 5200-E

## POSITIVE TONE PROCESSING

STEPS




Post Exposure Bakes are not recommended for positive tone lithography as Image Reversal may occur.

**Protocol for Image Reversal Using AZ5214**

1. Make sure wafer is clean and dry. Bake at 105 °C for 10 min.

2. HMDS prime. This is only necessary when there is oxide present on the wafer surface. As received wafer are H-terminated and do not require HMDS.

3. Cover center 2/3 of wafer with resist while wafer is stationary. Spin at 4000rpm for 40 seconds.

4. Soft bake at 90 °C for 30 minutes.

5. Expose with i-line source. Dose is 400 $mj/cm^2$, this is approximately 15 seconds.

6. Post exposure bake at 105 °C for 30 minutes.

7. Flood exposure of substrate. Dose is 1-2 $J/cm^2$, this is approximately 35 seconds.

8. Develop with mixture of AZ 351 developer and D.I. water. Suggest 1:3 ratio of developer removes entire pattern.

9. Hard at 90 °C for 30 minutes.

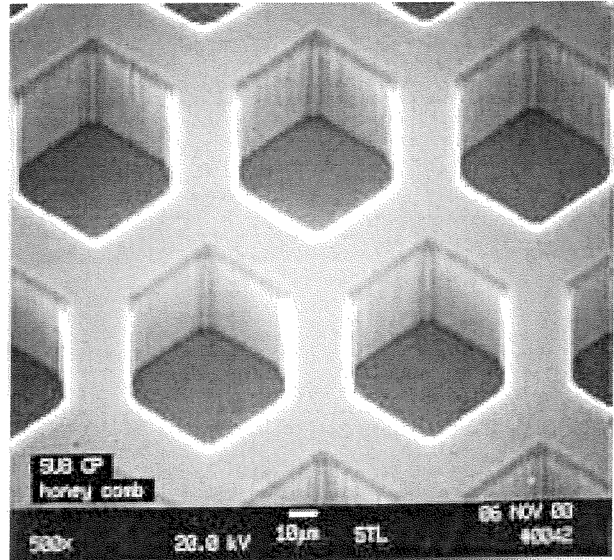
Variables to consider:

1. Temp for post exposure bake. Perhaps higher would make transferred image more robust.
2. Duration of flood exposure. Not sure on cost of over exposure during this step.
3. Ratio of developer to water. My experience dictates that high ratios of developer removes all pattern. Less developer is slower, but may allow for better image transfer.

Documented by Hajime Takano (7/25/02)
Note: Details are not optimized for maximum performance. Please revise SOP.

# 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**



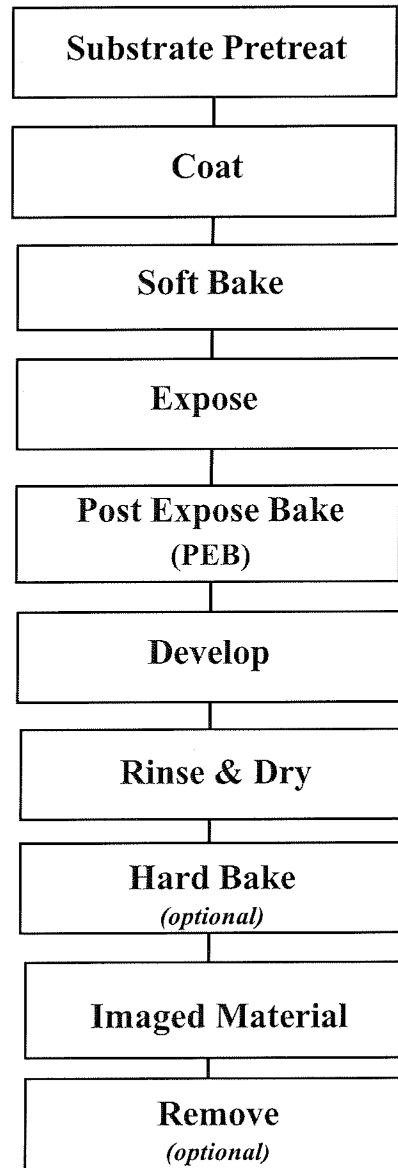

*Honey comb structure in thick SU-8 resist*

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 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*

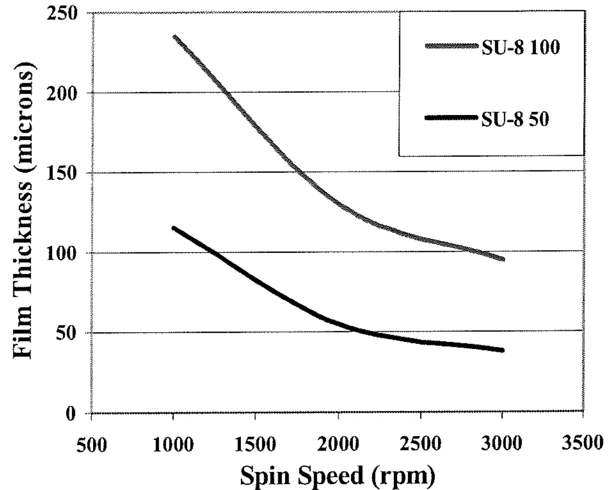



***Figure 1. Film thickness vs. spin speed.***

## 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.

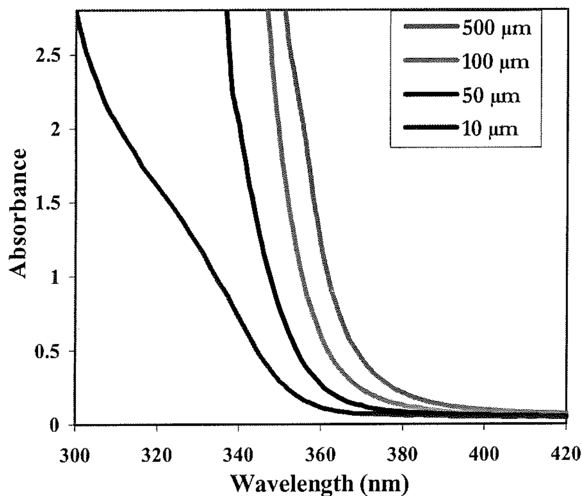



*Figure 2. SU-8 absorbance vs. film thickness*

| 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° 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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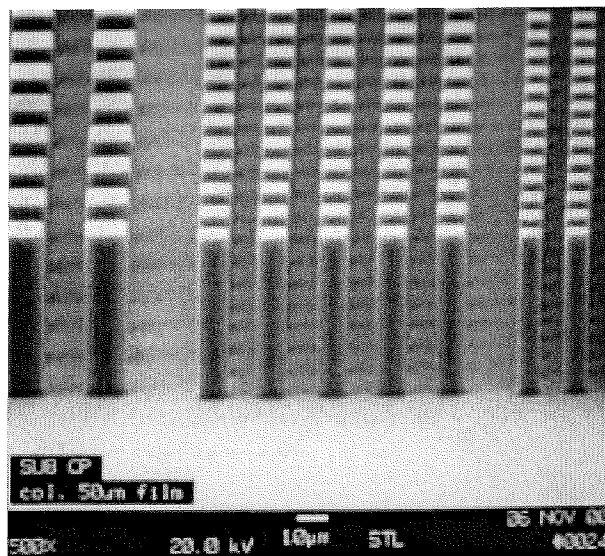
# NANO™ SU-8
## Negative Tone Photoresists Formulations 2 - 25




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

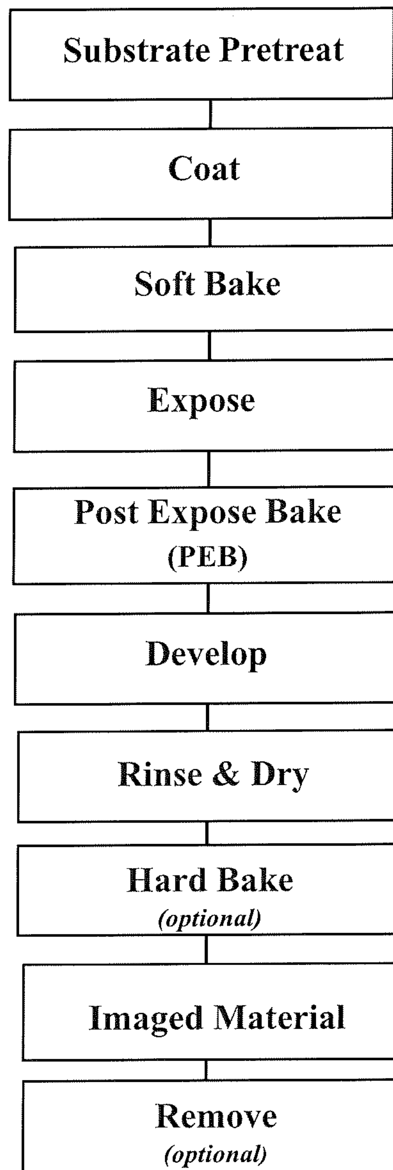
- **High aspect ratio imaging with near vertical side walls**
- **Near UV (350-400nm) processing**
- **Film thicknesses from 1 to >200µm with single spin coat processes**
- **Superb chemical and temperature resistance**

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.



## 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 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. 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.

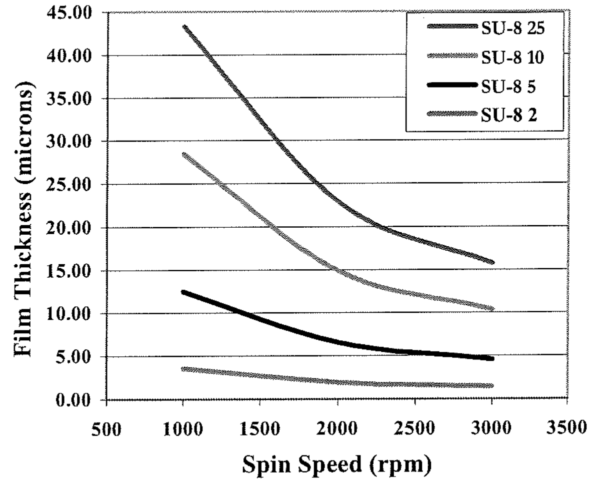



***Figure 1. Spin speed vs. thickness curves for selected SU-8 resists.***

***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 | Viscosity ** | Thickness | Spin Speed |
|---|---|---|---|
| | cst @ 25°C | µm | rpm |
| SU-8 2 | 43 | 1.5 | 3000 |
| | | 2 | 2000 |
| | | 5 | 1000 |
| SU-8 5 | 293 | 5 | 3000 |
| | | 7 | 2000 |
| | | 15 | 1000 |
| SU-8 10 | 1050 | 10 | 3000 |
| | | 15 | 2000 |
| | | 30 | 1000 |
| SU-8 25 | 2525 | 15 | 3000 |
| | | 25 | 2000 |
| | | 40 | 1000 |
| SU-8 50* | | | |
| SU-8 100* | | | |

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

*** Approximate*
** Please refer to data sheet, SU-8 formulations 50 & 100, for details on these resist products.*

## 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 | Thickness | Soft Bake Time (secs) STEP 1 | |
|---|---|---|---|
| | µm | STEP 1 65°C | STEP 2 95°C |
| SU-8 2 | 1.5 | 60 | 60 |
| | 2 | 60 | 180 |
| | 5 | 60 | 180 |
| SU-8 5 | 5 | 60 | 180 |
| | 7 | 120 | 300 |
| | 15 | 120 | 300 |
| SU-8 10 | 10 | 120 | 300 |
| | 15 | 120 | 300 |
| | 30 | 180 | 420 |
| SU-8 25 | 15 | 120 | 300 |
| | 25 | 180 | 420 |
| | 40 | 300 | 900 |

***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.

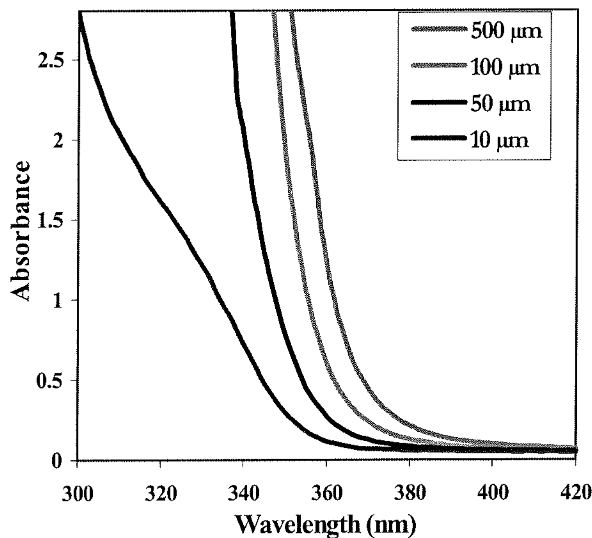



*Figure 2. SU-8 absorbance vs. film thickness*

| Product | Film Thickness | Exposure Dose |
|---|---|---|
| | µm | mJ/cm$^2$ |
| SU-8 2 | 1.5 | 85-100 |
| | 2 | 95-115 |
| | 5 | 120-130 |
| SU-8 5 | 5 | 120-130 |
| | 7 | 150-185 |
| | 15 | 190-210 |
| SU-8 10 | 10 | 185-200 |
| | 15 | 190-210 |
| | 30 | 230-250 |
| SU-8 25 | 15 | 190-210 |
| | 25 | 220-230 |
| | 40 | 250-300 |

*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 | Film Thickness | P E B Time (sec) | |
|---|---|---|---|
| | µm | 65°C | 95°C |
| SU-8 2 | 1.5 | 60 | 60 |
| | 2 | 60 | 60 |
| | 5 | 60 | 60 |
| SU–8 5 | 5 | 60 | 60 |
| | 7 | 60 | 60 |
| | 15 | 60 | 120 |
| SU-8 10 | 10 | 60 | 120 |
| | 15 | 60 | 120 |
| | 30 | 60 | 180 |
| SU–8 25 | 15 | 60 | 120 |
| | 25 | 60 | 180 |
| | 40 | 120 | 240 |

*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 | Thickness | Develop Time |
|---|---|---|
| | µm | seconds |
| SU-8 2 | 1.5 | 60 |
| | 2 | 60 |
| | 5 | 60 |
| SU-8 5 | 5 | 60 |
| | 7 | 60 |
| | 15 | 180 |
| SU-8 10 | 10 | 120 |
| | 15 | 180 |
| | 30 | 300 |
| SU-8 25 | 15 | 180 |
| | 25 | 240 |
| | 40 | 360 |

*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. It will not remove fully cured or hard baked SU-8. Alternate removal processes include immersion in oxidizing acid solutions 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°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 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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Rev. 1/01

# AZ 5200-E
## POSITIVE TONE PROCESSING

### STEPS

DEHYDRATION BAKE

HMDS PRIME
ADHESION PROMOTER

SPIN COAT
0.6 - 2.6 um

AZ 5206 - E yields 0.8 μm at 4000 rpm
AZ 5210 - E yields 1.0 μm at 4000 rpm
AZ 5214 - E yields 1.4 μm at 4000 rpm
2.6 μm with speed ramp program (AZ TR)

SOFT BAKE

| | |
|---|---|
| HOT PLATE | 90 - 105°C / 30 - 60 sec |
| CONVENTION | 80 - 100°C/15 - 30 min |

EXPOSE

| | | |
|---|---|---|
| 390 - 450 nm | ULTRATECH STEPPER | 130 - 350 mj |
| 365 nm | I-LINE STEPPER | 50 - 100mj |
| 365 - 436 nm | PE ALIGNER, UV 4 | 50 - 100 mj |
| 313 nm | PE ALIGNER, UV 3 | 250 - 400 mj |
| 313 nm | KARLSUSS ALIGNER | 50 - 100 mj |

Perform exposure matrix beginning with listed min. dose, increasing in 10 mj increments until target CD and profile achieved for a given developer concentration and develop time.

DEVELOP

| | HIGH SPEED | | HIGH CONTRAST / RESOLUTION | |
|---|---|---|---|---|
| METAL BASED | AZ 400K | 1:4 / 60 sec | AZ 400K | 1:5 / 90 - 120 sec |
| | AZ 351 | 1:4 / 60 sec | AZ 351 | 1:5 / 90 - 120 sec |
| METAL ION FREE | AZ 312 | 1:1 / 30 sec | AZ 312 | 1:1.2 120 sec |
| | AZ 227 | 30 sec | | |

HARD BAKE
AS REQUIRED

STRIP
AZ 300T STRIPPER
AZ 400T STRIPPER

Post Exposure Bakes are not recommended for positive tone lithography as Image Reversal may occur.

Clariant
Clariant Corporation

# Process for Positive PR

1. Clean the wafer

- Use acetone, isopropyl, and DI water to degrease the wafer
- Bake the wafer on the 125C hot plate to dry the wafer for at least 5 minutes
- Cool the wafer on the cooling plate

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**Example of Recommended Process** (data provided by Clariant):

| | **AZ 5214-EIR** (see attachment for Positive Tone Processing) | **AZ4620** (10μm thickness) |
|---|---|---|
| Spin coat | 1.4 μm at 4000RPM | ~1500 RPM (see attached Spin Curve) |
| Soft Bake | 90-100 °C hotplate, 30-60 sec | 110 °C, 200 sec |
| | 80-100 °C oven, 15-30min | |
| Exposure | i-line exposure tool | 400 $mJ/cm^2$ |
| Post-Exposure Bake | none unless special application required | not necessary in most applications |

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2. Spin Coat PR

- Select a proper spinning stage
- Set the spinning rate and the spinning duration (30sec)
- Check that the wafer is centered and held tightly when spinning
- Use the $N_2$ gun (make sure the gun is dry) to blow the wafer while spinning
- Coat the adhesion promoter (HMDS) in the HMDS Application Box *(HMDS should form a monolayer - more HMDS will not help; also, use HMDS on needed materials only, like oxide, etc. )*
- Coat the PR - there are two major types: AZ5214-E (1.4 μm at 5000rpm) or AZ4620 (6.2 μm at 4000rpm) (The amount of photoresist should cover approximately 2/3 of center of the wafer area)

3. Soft bake

- Bake the PR-coated wafer on a 110°C hot plate

- For AZ5214: 45 ~ 60 sec
- For AZ4620: 60 ~ 120 sec
- Note: Baking time depends on thickness. For AZ5214, roughly 45sec (110°C hotplate) is good enough (or 10-20min 90 °C convection oven). Baking times for AZ4620 has a **much greater** dependence on thickness.

4. Exposure (Using the flood exposure tool. An alternative is to use the contact aligner)

- Turn on the Power Supply and Blower switches
- Wait about 10 minutes until the temperature of the light source stabilizes at about 300 C
- Set the exposure dose: 125 mJ (AZ5214) or 400mJ (AZ4620) Make sure it is on the DOSE option and not on the TIME option
- Push on the "Lamp" button in the front panel
- Put the mask/wafer into the dark box of the exposure machine
- Push the "Run" button and wait until the machine turns off automatically
- Take the exposed wafer and mask out of the exposure machine
- Turn off the switches (lamp, power, blower)

5. PR developing

- Use the PR developer (AZ 400K Developer Diluted 1:4; see AZ5214 notes on diluting developer) to develop the exposed PR (AZ5214: 35-45 sec, AZ4620: 1-2 min). Note: The most important factor is not time, but color change. A rule of thumb for process development is that the development time should be controlled to around 1 minute; if the development takes too long, then increase the exposure time accordingly.
- Use DI water to rinse the wafer
- Check the result of developing under the microscope with a UV filter
- Re-develop as needed

6. Hard bake

- Hard bake the PR on the 110°C hot plate (AZ5214: 60 sec, AZ4620: 1-2 min)

MK