國立清華大學 103 學年度碩士班考試入學試題

系所班組別：0520 奈米工程與微系統研究所、0514 動力機械工程學系 丁組

考試科目（代碼）：2002 科技英文、1402 科技英文

　　*請在【答案卡】作答

Part I. 選擇題。每題請選一個最佳的答案 (答對 3 分，答錯倒扣 1 分):

A. Reading Comprehension (27%)
Please read the SU-8 3000 data sheet in the **appendix,** and choose one best fit answer for each question:

1. SU-8 3000 is a/an (A) Opaque Material (B) Positive Photoresist (C) Epoxy Based Polymer (D) UV radiation。
2. HMDS is a/an (A) Adhesion Promoter (B) Cleaning Material (C) De-Ionized Water (D) Etching Plasma。
3. How much volume of SU-8 3000 should be used to coat on one 4" wafer? (A) 1 ml (B) 2 ml (C) 3 ml (D) 4 ml。
4. The approximate thickness of the SU-8 will be (A) 40um (B) 50 um (C) 60 um (D) 30um, when using SU-8 3035 with 2000 (rpm) spin-speed.
5. By thick photoresist lithography, it is better to filter out (A) short wavelength (B) long wavelength (C) 365 nm (D) 350 nm。
6. The appropriate development time for 50um thick SU-8 should be (A) 2 minutes (B) 4 minutes (C) 6 minutes (D) 8 minutes.
7. The approximate young's modulus of the cross-linked SU-8 3000 is (A) 4.8 (B) 2.0 (C)0.2 (D) 52, Gpa。
8. The main reason to use OmniCoat is to (A) develop the unexposed SU-8 (B) promote the adhesion (C) remove the entire SU-8 (D) dissolve the Remover PG.
9. After manufacturing, how long the SU-8 will not be expired? (A) 13 Days (B) 13 Months (C) 13 Hours (D) 3 Years.

B. Cloze I (24 %)

Except for the sandy west coast, coral reef ecosystems are found all around Taiwan. Not only are these ecosystems noted __10__ the abundance and variety of reefs, ___11__they are home to a wide range of endemic species. Scientists, however, have recently listed Taiwan among one of the ten areas in the world __12__ corals reefs are most at risk. Major threat to the coral reefs here __13__ overfishing, destructive fishing techniques, sediment and pollution ___14__ by coastal development and inappropriate land use. __15__ matters worse, heat discharge from Taipower's nuclear plant in Nanwan Bay caused extensive local bleaching from 1987 to 1990. Bleaching refers to the decoloration of corals due to the death of seaweeds that cover them. ___16___ proper conservation efforts, the corals and the creatures they support will become __17__ fairly soon.

10. (A) at (B) by (C) for (D) in
11. (A) and (B) so (C) also (D) but
12. (A) that (B) where (C) which (D) in that
13. (A) include (B) including (C) includes (D) that include
14. (A) bring about (B) bringing about (C) that brought about (D) brought about
15. (A) Making (B) To take (C) Taking (D) To make
16. (A) Unless (B) Without (C) Of (D) Nevertheless
17. (A) extinction (B) extinct (C) die out (D) endanger

C. Cloze II (12%)

Riboflavin, or vitamin B2, a vitamin commonly__18__ in cottage cheese, green veggies and meat, could be used to 3-D print medical implants that are more compatible with the human body, according to new research from a group of biomedical engineers in North Carolina.

Two-photon polymerization uses ___19___ chemicals, known as photoinitiators, to turn a liquid into a solid polymer. The liquid only becomes solid at the focal point of the laser __20__ the light, so an object can be 3-D printed by tracing its outline. Then the rest of the liquid is washed away, leaving only the solid structure. This technique can create finely detailed objects like scaffolds for tissue engineering custom body parts or microneedles to deliver drugs painlessly.

However, many of the materials used to make the liquid mixture react to light are also toxic __21__ humans, which makes them less than ideal for creating structures that will later be implanted into the body. The researchers found that using riboflavin, which is naturally light-sensitive, as the photoinitiator in the process resulted in scaffolds that were more biocompatible than mixtures made with other light-reactive chemicals..

18. (A)finds (B) found (C) has found (D) had found。

19. (A) light-sensing (B) light-sensed (C) light-sensitive (D) light-sense。

20. (A) provides (B) provided (C) providing (D) has provided。

21. (A) for (B) at (C) to (D) in 。

D. Complete the sentence (12%)

22. The research institution plans to collaborate with foreign organizations ______ the technology of biological engineering.

(A) to advance (B) upgrading (C) to improving (D) further

23. The marine biologist advises that the government _____ the use of certain toxic chemicals.

(A) bans (B) would ban (C) ban (D) banning

24. Scientist debate heatedly among themselves ______ the ethics of transgenic cloning, such as the cloning of pigs that carry human genes.

(A) regards (B) concerning (C) respect (D) as

25. In 1994, those women employees who gave birth to a child during the previous year ____ 1.4 percent of all female regular workers in Taiwan.

(A) representing (B) surveyed (C) accounted for (D) amount to

Part II 翻譯

A. Translation (from English to Chinese) (25%)

Scientists have been doing some amazing things to our brains with ultrasound, like breaking up blood clots, boosting alertness for soldiers, and even connecting the human mind with a rat's. Now, they have shown that ultrasound can sharpen our tactile perception, too.

Researchers at the Virginia Tech Carilion Research Institute have demonstrated that by directing an ultrasound beam to a specific region of the brain, they can boost participants' ability to detect differences in sensations.

To test their theory, the research team hooked up the volunteers with EEG-monitoring devices and placed small electrodes on their wrists. Just before buzzing their hands with the electrodes, the team ultrasound-beamed the volunteers' brains in a region responsible for processing tactile stimulation. They then gave the participants two classic neurological tests: the first measured the ability to distinguish whether two nearby objects touching the skin are two distinct points or one; the second measured sensitivity to the frequency of a chain of air puffs.

The result was a surprise. The ultrasound actually weakened participants' brainwaves associated with tactile stimulation, but improved their performance on the tests. How did that happen? The researchers speculate that the specific ultrasound waveform they used may have affected the balance between neurons that excite and neurons that inhibit the processing of sensory stimuli in the targeted brain region.

And it affects a very specific region of the brain—move the beam one centimeter left or right, and the effect disappears.

"That means we can use ultrasound to target an area of the brain as small as the size of an M&M, "William Tyler", who led the study, said in a statement. This specificity could make ultrasound a better technology for non-invasive brain stimulation than two other leading candidates, magnets and electric currents, the researchers said in the study.

Understanding how exactly it works can help scientists make more precise maps of our brain connections and, yes, link our minds with rats'—or our fellow human beings'.

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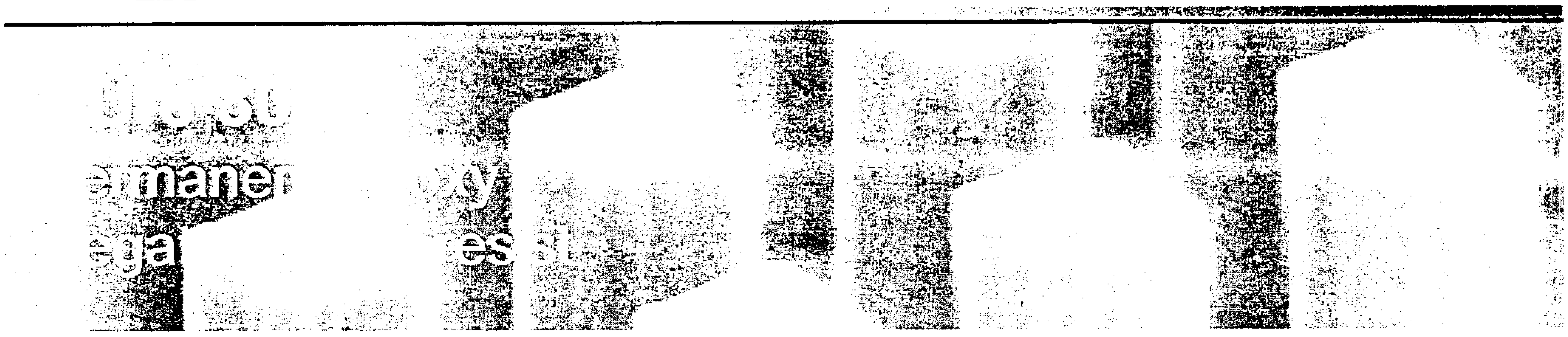
Appendix



SU-8 3000 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 3000 is an improved formulation of SU-8 and SU-8 2000, which has been widely used by MEMS producers for many years. SU-8 3000 has been formulated for improved adhesion and reduced coating stress. The viscosity range of SU-8 3000 allows for film thicknesses of 4 to 120 μm in a single coat. SU-8 3000 has excellent imaging characteristics and is capable of producing very high, over 5:1 aspect ratio structures. SU-8 3000 has very high optical transmission above 360 nm, which makes it ideally suited for imaging near vertical sidewalls in very thick films. SU-8 3000 is best suited for permanent applications where it is imaged, cured and left on the device.

Features

- Improved adhesion
- Reduced coating stress
- High aspect ratio imaging
- Vertical sidewalls
- Greater than 100 μm film thickness in a single coat
- Excellent dry etch resistance

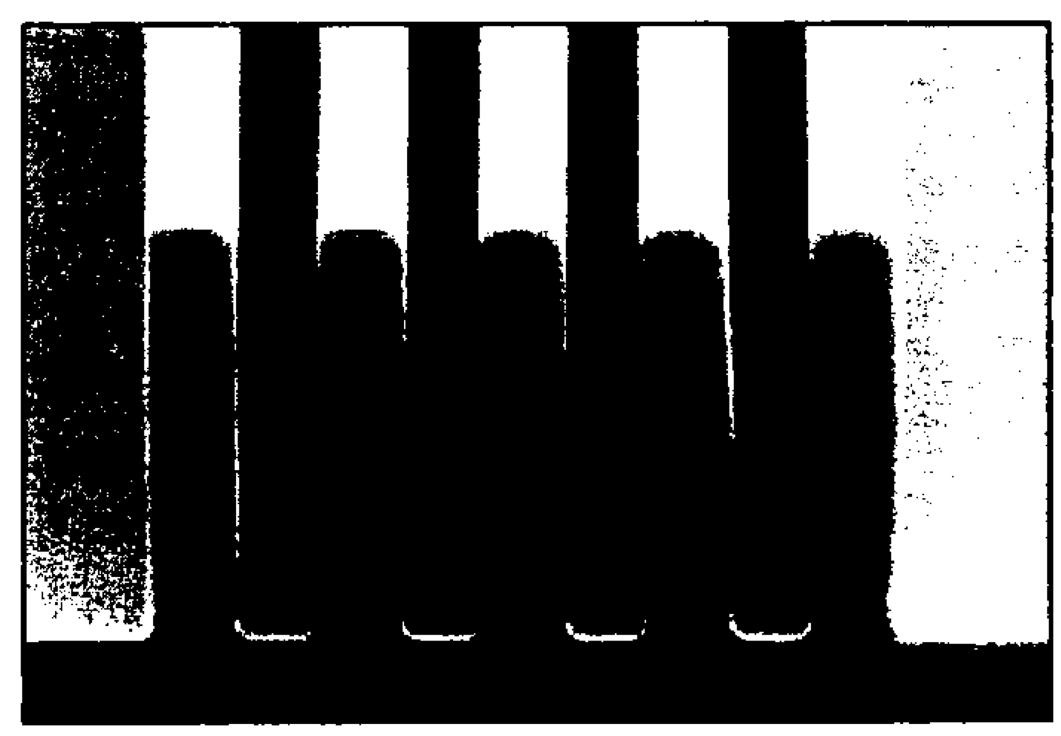
Processing Guidelines

SU-8 3000 is most commonly exposed with conventional UV (350-400 nm) radiation, although i-line (365 nm) is recommended. It may also be exposed with e-beam or x-ray radiation. Upon exposure, cross-linking proceeds in two steps (1) formation of a strong acid during the exposure step, followed by (2) acid-catalyzed, thermally driven epoxy cross-linking during the post exposure bake (PEB) step. A normal process is: spin coat, soft bake, expose, PEB, followed by develop.

Substrate Preparation

To obtain maximum process reliability, substrates should be clean and dry prior to applying SU-8 3000 resist. For best results, substrates should be cleaned with a piranha wet etch (using H_2SO_4 & H_2O_2) followed by a de-ionized water rinse. Substrates may also be cleaned using reactive ion etching (RIE) or any barrel asher supplied with O_2. Adhesion promoters are typically not required. For applications that require electroplating it is recommended to pre-treat the substrate with MCC Primer 80/20 (HMDS).

Applications



Contact aligner exposure
10 um features, 50 um SU-8 3000 coating

Coat

SU-8 3000 resists are available in five standard viscosities, shown in Table 1. Figure 1 provides the information required to select the appropriate SU-8 3000 resist and spin conditions, to achieve the desired film thickness.

Recommended Program

(1) Dispense 1ml of resist for each inch(25mm) of substrate diameter
(2) Spin at 500 rpm for 5-10 sec with acceleration of 100 rpm/second
(3) Spin at 3000 rpm for 30 sec with acceleration of 300 rpm/second

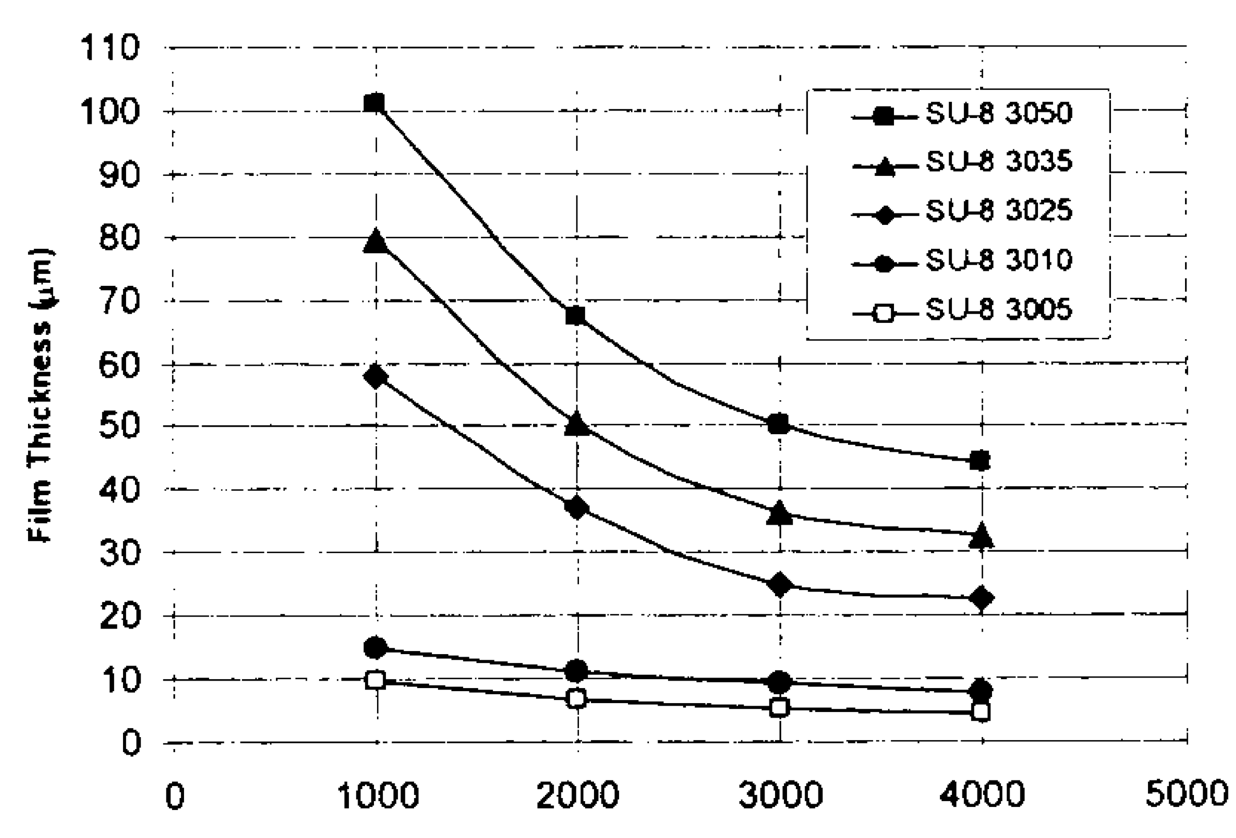


Figure 1. Spin speed vs. Thickness
for SU-8 3000 resists (21°C US & EU)

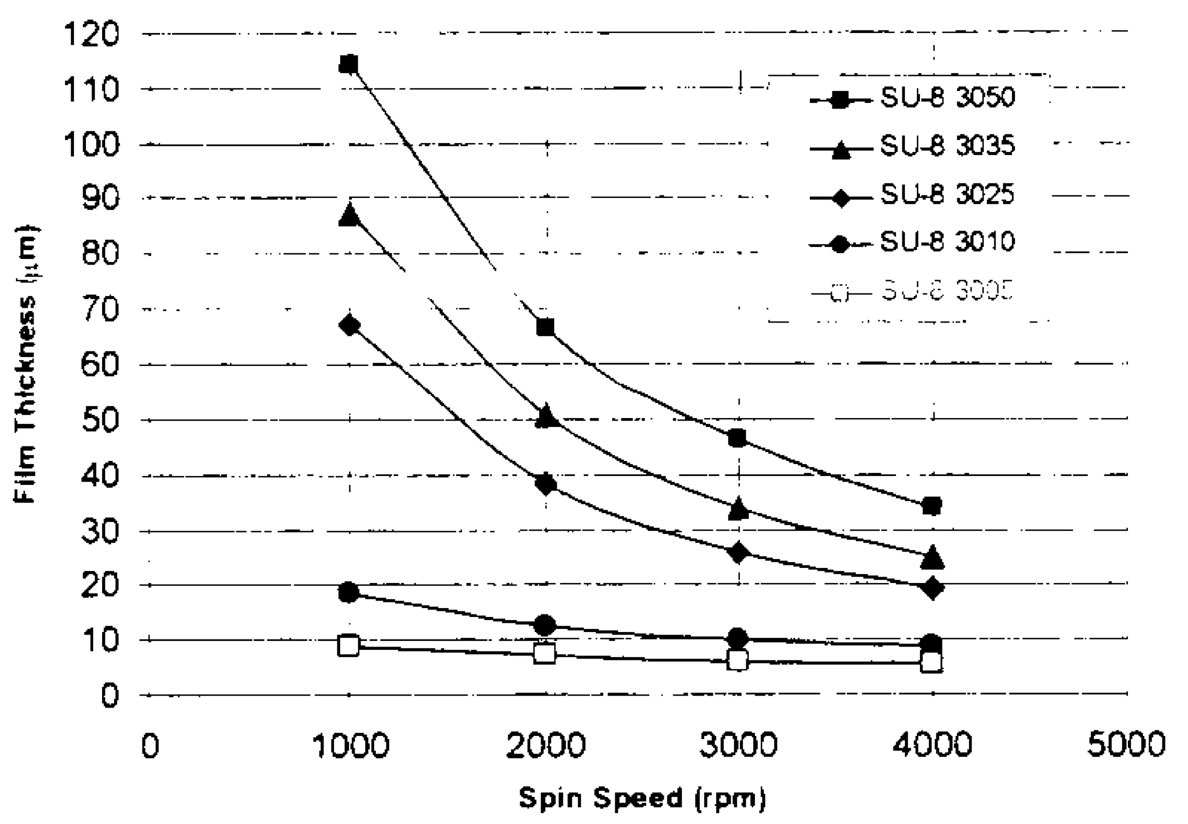


Figure 2. Spin speed vs. Thickness
for SU-8 3000 resists (23°C Japan & Asia)

Table 1. SU-8 3000 Viscosity

SU-8 3000	% Solids	Viscosity (cSt)	Density (g/ml)
3005	50	65	1.075
3010	60.4	340	1.106
3025	72.3	4400	1.143
3035	74.4	7400	1.147
3050	75.5	12000	1.153

Soft Bake

A level hotplate with good thermal control and uniformity is recommended for use during the Soft Bake step of the process. Convection ovens are not recommended. During convection oven baking, a skin may form on the resist. This skin can inhibit the evolution of solvent, resulting in incomplete drying of the film and /or extended bake times. Table 2 shows the recommended Soft Bake temperatures and times for the various SU-8 3000 products at selected film thicknesses.

THICKNESS microns	SOFT BAKE TIME minutes @ 95°C
4 - 10	2 - 3
8 - 15	5 - 10
20 - 50	10 - 15
30 - 80	10 - 30
40 - 100	15 - 45

Table 2. Soft Bake Times

Note: *To optimize the baking times/conditions, remove the wafer from the hotplate after the prescribed time and allow to cool to room temperature. Then return the wafer to the hotplate. If the film 'wrinkles', leave the wafer on the hotplate for a few more minutes. Repeat the cool-down and heat-up cycle until 'wrinkles' are no longer seen in the film after placing the wafer on the hotplate.*

The dispersion curve and Cauchy coefficients are shown in Figure 3. This information is useful for film thickness measurements based on ellipsometry and other optical measurements.

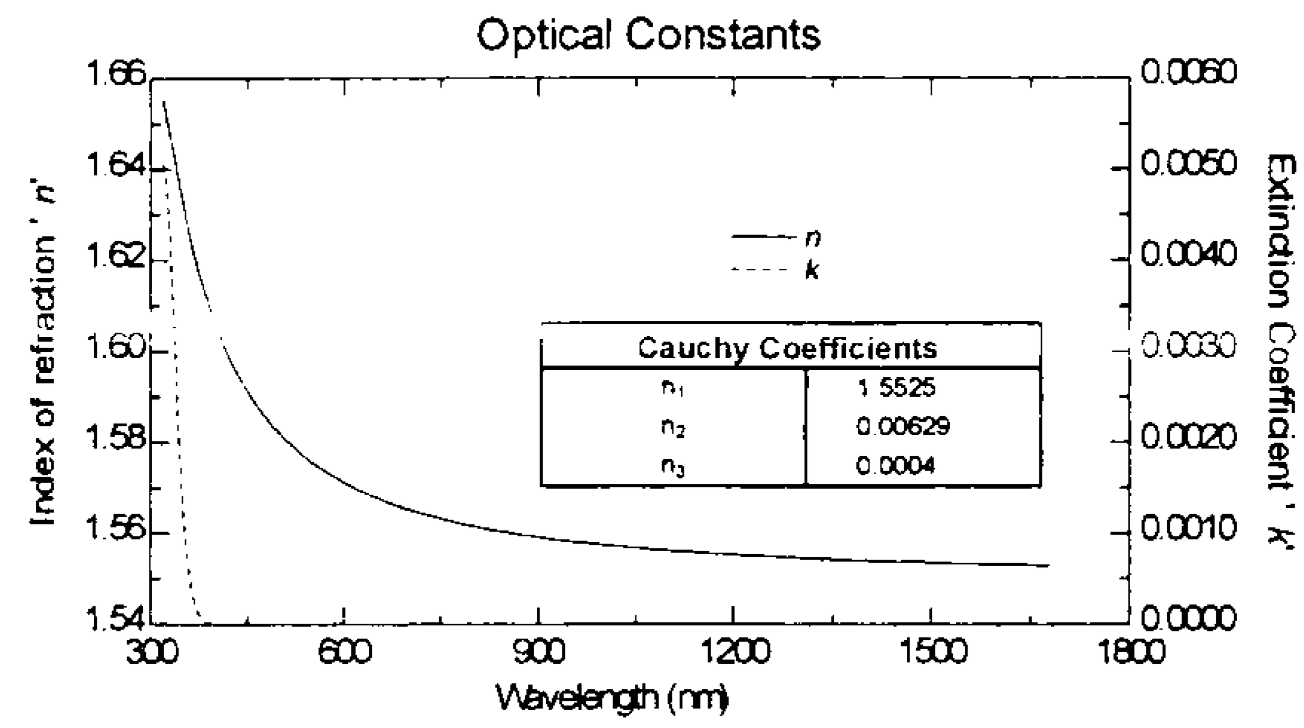


Figure 3. Cauchy Coefficients

Exposure

To obtain vertical sidewalls in the SU-8 3000 resist, we recommend the use of a long pass filter to eliminate UV radiation below 350 nm. With the recommended filter (PL-360-LP) from Omega Optical (www.omegafilters.com) or Asahi Technoglass filters V-42 plus UV-D35 (www.atgc.co.jp), an increase in exposure time of approximately 40% is required to reach the optimum exposure dose.

Note: *Optimal exposure will produce a visible latent image within 5-15 seconds after being placed on the PEB hotplate and not before. An exposure matrix experiment should be performed to optimize the exposure dose*

THICKNESS microns	EXPOSURE ENERGY mJ/cm^2
4 - 10	100 - 200
8 - 15	125 - 200
20 - 50	150 - 250
30 - 80	150 - 250
40 - 100	150 - 250

Table 3. Exposure Dose

	RELATIVE DOSE
Silicon	1X
Glass	1.5X
Pyrex	1.5X
Indium Tin Oxide	1.5X
Silicon Nitride	1.5 - 2X
Gold	1.5 - 2X
Aluminum	1.5 - 2X
Nickel Iron	1.5 - 2X
Copper	1.5 - 2X
Nickel	1.5 - 2X
Titanium	1.5 - 2X

Table 4. Exposure Doses for Substrates

Post Exposure Bake (PEB)
Should take place directly after exposure. Table 5 shows the recommended times and temperatures

Note: After 1 minute of PEB at 95°C, an image of the mask should be visible in the SU-8 3000 photoresist coating. No visible latent image during or after PEB means that there was insufficient exposure, temperature or both.

THICKNESS microns	PEB TIME (65°C)* minutes	PEB TIME (95°C) minutes
4 - 10	1	1 - 2
8 - 15	1	2 - 4
20 - 50	1	3 - 5
30 - 80	1	3 - 5
40 - 100	1	3 - 5

* Optional step for stress reduction

Table 5. Post Exposure Bake Times

Develop
SU-8 3000 resist has been designed for use in immersion, spray or spray-puddle processes with MicroChem's SU-8 developer. Other solvent based developers such as ethyl lactate and diacetone alcohol may also be used. Strong agitation is also recommended for high aspect ratio and/or thick film structures. The recommended develop times for immersion processes are given in Table 6. These develop times are approximate, since actual dissolution rates can vary widely as a function of agitation

***Note:** The use of an ultrasonic or megasonic bath is helpful for developing out photoresist vias or holes.*

THICKNESS microns	DEVELOPMENT TIME minutes
4 - 10	1 - 3
8 - 15	4 - 6
20 - 50	5 - 8
30 - 80	6 - 12
40 - 100	7 - 15

Table 6. Development Times for SU-8 Developer

Rinse and Dry
When using SU-8 developer, spray/wash the developed image with fresh developer solution for approximately 10 seconds, followed by a second spray/wash with Isopropyl Alcohol (IPA) for another 10 seconds. Air dry with filtered, pressurized air or nitrogen.

***Note:** A white film produced during IPA rinse indicates 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.*

Physical Properties
(Approximate values)

Adhesion Strength (mPa) Silicon/Glass/Glass & HMDS	69/35/59
Glass Transition Temperature (Tg °C), tan δ peak	200
Thermal Stability (°C @ 5% wt. loss)	300
Thermal Conductivity (w/mK)	0.2
Coeff. of Thermal Expansion (CTE ppm)	52
Tensile Strength (Mpa)	73
Elongation at break (εb %)	4.8
Young's Modulus (Gpa)	2.0
Dielectric Constant @ 1GHz	3.28
Bulk Resistivity (Ωcm)	7.8×10^{14}
Water Absorption (% 85°C/85 RH)	0.55

Optical Properties

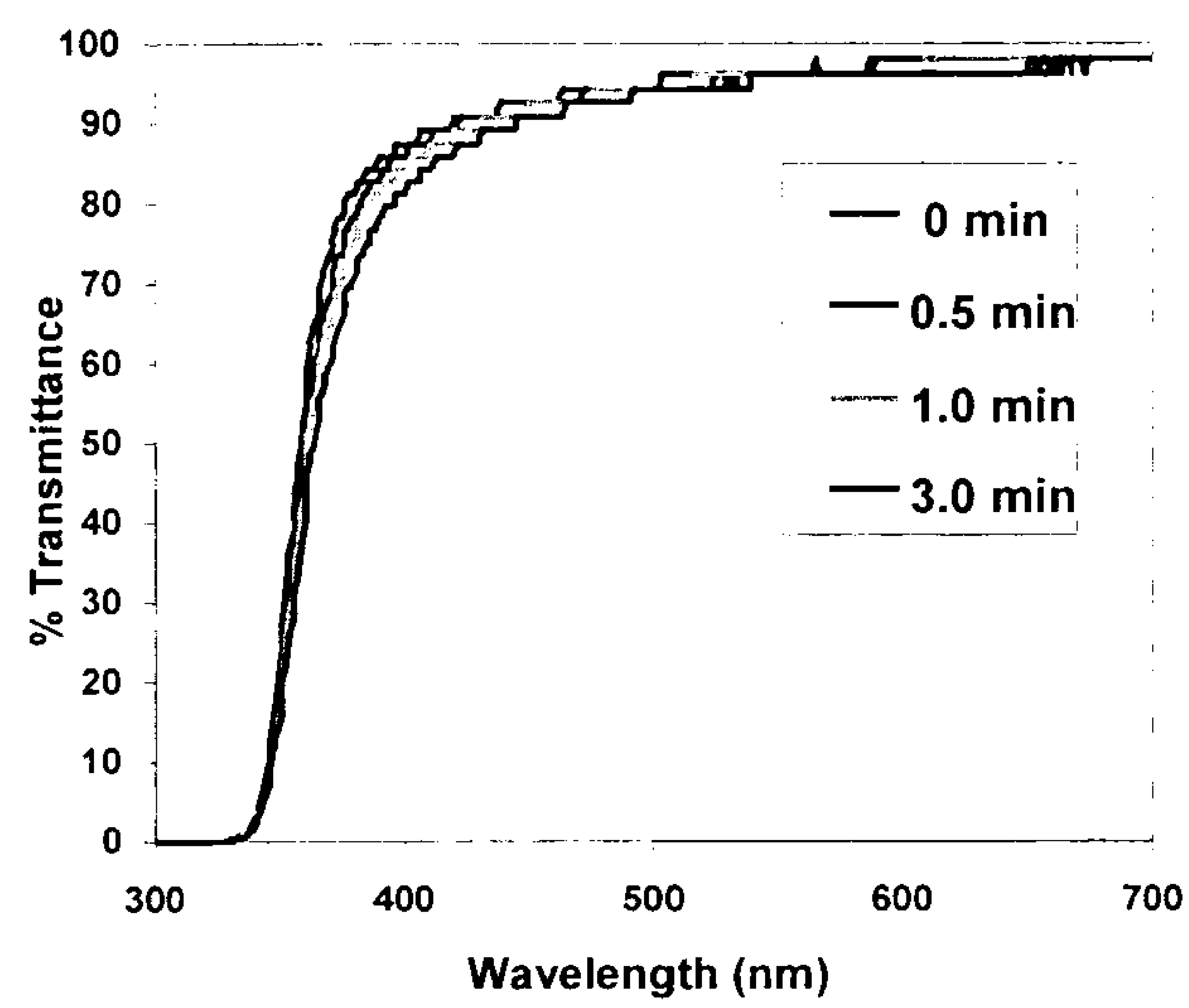


Figure 4. Optical Transmitance after 300°C Hard Bake

Hard Bake (cure)
SU-8 3000 has good mechanical properties. However 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 3000 has been designed as a permanent, highly cross-linked epoxy material, 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 3000. However if OmniCoat (30-100 nm) has been applied, immersion in Remover PG can effect a clean and thorough Lift-Off of the SU-8 3000 material. It will not remove fully cured or hard baked SU-8 3000 without the use of OmniCoat.

To remove minimally cross-linked SU-8 3000, or when using Omnicoat, heat the Remover PG 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.

To re-work fully cross-linked SU-8 3000, wafers can be stripped using oxidizing acid solutions such as piranha etch, plasma ash, RIE, laser ablation and pyrolysis.

Plasma Removal

RIE 200W, 80 sccm O_2, 8 sccm CF_4, 100mTorr, 10°C

Storage

Store SU-8 3000 resists upright and 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 3000 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 3000 resists and residues made in observance all federal, state, and local environmental regulations.

Environmental, Health and Safety

Consult the product Material Safety Data Sheet before working with SU-8 3000 resists. Handle with care. Wear chemical goggles, chemical gloves and suitable protective clothing when handling SU-8 3000 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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