# Резисты для фотолитографии

**ООО «Остек-Интегра»**

Молдавская ул., д. 5, стр. 2, Москва, Россия, 121467

Тел.: +7 (495) 788-44-44, факс: +7 (495) 788-44-42,

www.ostec-group.ru, info@ostec-group.ru

ИНН 7731416984, КПП 773101001, ОГРН 1117746929717, ОКПО 37241715

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| Назначение резиста | Наименование резиста | Толщина плёнки резиста (мкм) | | | | | | | | | | | | | | | Тон резиста | Вид экспонирования | Рекомендуемые проявители | Рекомендуемые сниматели |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | < 0,5 | 0,5 | 1 | 1,5 | 2 | 2,5 | 3 | 5 | 8 | 10 | 15 | 20 | 50 | 100 | 150 | | | | |
| Жидкостное травление | AZ 1505 | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 1512 HS | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 1514 H | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 1518 | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 111 XFS | | | | | | | | | | | | | | | | Позитивный | 310 – 420нм | AZ 303 Developer | AZ 100 Remover |
| | TI 35E | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| | SU-8 | | | | | | | | | | | | | | | | Негативный | 350 – 400нм | SU-8 developer | Remover PG |
| | ma-N 400 | | | | | | | | | | | | | | | | Негативный | 300 – 380нм | водощелочные растворы | Станд. сниматели |
| | ma-N 1400 | | | | | | | | | | | | | | | | Негативный | 300 – 410нм | водощелочные растворы | Станд. сниматели |
| | ma-P 1200 | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | водощелочные растворы | Станд. сниматели |
| Сухое травление | AZ MiR 701 | | | | | | | | | | | | | | | | Позитивный | i(365нм), g(436нм) | AZ 726 MIF, AZ 351B и др. | Станд. сниматели |
| | AZ 6612 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 6624 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 6632 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ TI 35 ES | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| | SU-8 | | | | | | | | | | | | | | | | Негативный | 350 – 400нм | SU-8 developer | Remover PG |
| | KMPR 1000 | | | | | | | | | | | | | | | | Негативный | 350 – 400нм | ТМАН, SU-8 developer и др. | Remover PG |
| | ma-N 400 | | | | | | | | | | | | | | | | Негативный | 300 – 380нм | водощелочные растворы | Станд. сниматели |
| | ma-N 1400 | | | | | | | | | | | | | | | | Негативный | 300 – 410нм | водощелочные растворы | Станд. сниматели |
| | ma-P 1200 | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | водощелочные растворы | Станд. сниматели |
| Толстоплёночные резисты | AZ 4533 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 4562 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | Растворы ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 40 XT | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | AZ 300 MIF | Станд. сниматели |
| | AZ 9260 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | AZ 400 K, AZ 300 MIF | AZ 400T, AZ 300T |
| Высокое разрешение | AZ MiR 701 | | | | | | | | | | | | | | | | Позитивный | i(365нм), g(436нм) | AZ 726 MIF, AZ 351B и др. | Станд. сниматели |
| | AZ ECI 3000 | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | ТМАН, КОН и т.п | AZ 100 Remover и др. |
| | AZ 9260 | | | | | | | | | | | | | | | | Позитивный | 320 – 440нм | AZ 400 K, AZ 300 MIF | AZ 400T, AZ 300T |
| | ma-N 2400 | | | | | | | | | | | | | | | | Негативный | e-beam или ГУФ | водощелочные растворы | Станд. сниматели |
| | PMMA | | | | | | | | | | | | | | | | Позитивный | i(365нм), ГУФ, рентген, e-beam | MIBK | Remover PG, Acryl Strip |
| | XR-1541 | | | | | | | | | | | | | | | | Негативный | e-beam | 0.26 N TMAH | Станд. сниматели |
| Обратная (взрывная) литография | AZ 5214 E | | | | | | | | | | | | | | | | Обращаемый | 310 – 420 нм | AZ 351B, AZ 726 | AZ 100 Remover |
| | TI 35E | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| | TI Spray | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| | TI Plating | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| | TI xLift | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| | AZ nLof 2000 | | | | | | | | | | | | | | | | Негативный | i-линия (365нм) или e-beam | AZ 726 MIF, AZ 826 MIF | TechniStrip NI555 |
| | PMGI / LOR | | | | | | | | | | | | | | | | Позитивный | i,h,g линии, ГУФ, e-beam | ТМАН и т.п | Remover PG |
| | PMMA | | | | | | | | | | | | | | | | Позитивный | i(365нм), ГУФ, рентген, e-beam | MIBK | Remover PG, Acryl Strip |
| | ma-N 400 | | | | | | | | | | | | | | | | Негативный | 300 – 380нм | водощелочные растворы | Станд. сниматели |
| | ma-N 1400 | | | | | | | | | | | | | | | | Негативный | 300 – 410нм | водощелочные растворы | Станд. сниматели |
| Электроосаждение | AZ 15nXT | | | | | | | | | | | | | | | | Негативный | i-линия (365нм) | AZ 326/726/826 MIF | TechniStrip NI555 |
| | AZ 125 nXT | | | | | | | | | | | | | | | | Негативный | i-линия (365нм) | AZ 326/726/826 MIF | TechniStrip NI555 |
| | AZ 111 XFS | | | | | | | | | | | | | | | | Позитивный | 310 – 420нм | AZ 303 Developer | AZ 100 Remover |
| | KMPR 1000 | | | | | | | | | | | | | | | | Негативный | 350 – 400нм | ТМАН, SU-8 developer и др. | Remover PG |
| | ma-P 1200 | | | | | | | | | | | | | | | | Позитивный | i(365нм), h(405нм), g(436нм) | водощелочные растворы | Станд. сниматели |
| Нанесение распылением | TI Spray | | | | | | | | | | | | | | | | Обращаемый | i(365нм), h(405нм), g(436нм) | AZ 826 MIF, AZ 400K | AZ 100 Remover |
| Нанесение окунанием | AZ PL 177 | | | | | | | | | | | | | | | | Обращаемый | 310 – 440нм | AZ 400K, AZ 826MIF и др. | Ацетон и др. |
| Получение диэлектр. слоёв | Cyclotene | | | | | | | | | | | | | | | | Негативный | i(365нм), g(436нм) | DS3000, DS2100 | Prime Stripper A |

** Кликните по наименованию резиста для просмотра его технического описания (TDS)*

Product Data Sheet

# AZ 111 XFS
# AZ 8112
Standard
Photoresists

## GENERAL INFORMATION

Both photoresists are based on a similar chemistry. Besides the standard constituents novolak and naphthoquinone diazide, they contain a special additive which results in unique properties:

1. These resists exhibit extremely good adhesion on almost any surface like glass, oxides, highly doped oxides, metals etc.. This feature makes them a good choice for wet-etching.

2. They are less brittle than other positive photoresists.

3. They show almost no sticking to the mask which is important when exposed by contact or proximity printing. This properties lead to various applications. Besides semiconductor manufacturing they are also used for thin film and printed circuit technologies, electroplating, chemical milling etc..

4. Thermal stability during postbake is only 90°C (AZ 111 XFS) to 110°C (AZ 8112) without degradation of profile. For this reason they are not recommended for plasma-etching. On the other hand this allows for adjusting profile and final dimension by thermal treatment or thermal levelling of a non patterned wafer for back etch by applying a 120°C bake. Under this condition the resist does not crosslink (thermal crosslinking only starts at 125°C and above) and can easily be removed with solvents like acetone or NMP at room temperature.

5. Both photoresists do require a special developer which is not compatible with common positive photoresist developers, AZ 303 Developer, diluted 1:3 to 1:4 is recommended. Typical development time is 30 - 60 seconds, tank or spray development may be used.

6. Both photoresists are sensitive to UV-light in the range of 310 - 420 nm and intended for broadband exposure. It should be noted that they are almost insensitive to the g-line (436 nm) of the mercury spectrum. Sensitivity however is the main difference between both types:

AZ 111 XFS is the safer solvent version of the well known AZ 111 S and a plug-in-replacement therefore. It is mainly intended for contact- or proximity printing where low sensitivity is no concern. Exposure doses of about 150 mJ/cm² lead to exposure times of about 10 s. which can be well controlled.

AZ 8112 is 3 to 4 times faster, it is only intended for use on scanning projection printers, where AZ 111 XFS is by far to slow because it does not respond to g-line which accounts for a reasonable part of the overall UV-energy of those machines.

## PHYSICAL and CHEMICAL PROPERTIES

| | AZ 111 XFS | AZ 8112 |
|---|---|---|
| **Solids content [%]** | 19.3 | 24.0 |
| **Viscosity [cSt at 25°C]** | 25.2 | 27.5 |
| **Absorptivity [l/g*cm] at (...) nm** | 0.65 (375nm) | 0.72 (377nm) |
| **Solvent** | methoxy-propyl acetate (PGMEA) | |
| **Max. water content [%]** | 0.50 | |
| **Spectral sensitivity** | 310 - 420 nm | |
| **Coating characteristic** | striation free | |
| **Filtration [µm absolute]** | 0.1 | |

## FILM THICKNESS [µm] as FUNCTION of SPIN SPEED (characteristically)

| spin speed [rpm] | 2000 | 3000 | **4000** | 5000 | 6000 |
|---|---|---|---|---|---|
| **AZ 111 XFS** | 1.41 | 1.15 | **1.00** | 0.89 | 0.82 |
| **AZ 8112** | 1.73 | 1.41 | **1.22** | 1.09 | 1.00 |

## PROCESSING GUIDELINES

| | |
|---|---|
| **Dilution and edge bead removal** | AZ EBR Solvent |
| **Prebake** | 100°C, 50", hotplate |
| **Exposure** | broadband UV |
| **PEB** | not required |
| **Development** | AZ 303 DEV, 1:4 |
| **Postbake** | see "general information" |
| **Removal** | AZ 100 Remover, conc. |

## HANDLING ADVISES

Consult the **Material Safety Data Sheets** provided by us or your local agent!
This AZ Photoresists are made up with our patented safer solvent PGMEA. They are **flammable liquids** and should be kept away from oxidants, sparks and open flames.
**Protect from light and heat and store** in sealed original containers between 0°C and 25°C, exceeding this range to -5°C or +30°C for 1 week does not adversely affect the properties.
**Shelf life** is limited and depends on the resist series. The **expiration date** is printed on the label of every bottle below the batch number and coded as **[year/month/day]**.
AZ Photoresists are compatible with most commercially available wafer processing equipment. **Recommended materials** include PTFE, stainless steel and high-density poly-ethylene and -propylene.

# AZ® EXP 125nXT-10A

## FT=60 µm Lithographic Data
## Suss MA 200 Aligner

# AZ® EXP 125nXT-10A for FT=60 μm

## Process Conditions on Cu wafer

Test sample with viscosity of 5430 cSt

Target FT: 60 μm

Single coat at 2200 rpm @ 1.4 sec, then 1900 rpm @ 8 sec

SB condition: 140 °C / 8 min

Exposure tool: Suss MA-200
First Mask: Multi-transmission Mask, CH2 (g. h. i.)

Development: AZ 300 MIF; 2 puddles at 40 second

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# Optical Parameters of AZ® EXP 125nXT-10A

n & k Values

| | | |
|---|---|---|
| $\lambda$ = 365 nm: | n = 1.582 | k = 0.0013 |
| $\lambda$ = 633 nm: | n = 1.539 | k = 0.0000 |

Cauchy coefficients (A, B, C) fit the following Cauchy equation: $n = A + B/\lambda^2 + C\lambda^4$

A = 1.5206
B = 0.008114 $\mu m^2$
C = -0.000217 $\mu m^4$

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# AZ® EXP 125nXT-10A for FT=60 µm Line/Space @ 3000 mJ/cm²

60 µm

50 µm

40 µm

30 µm

20 µm

10 µm

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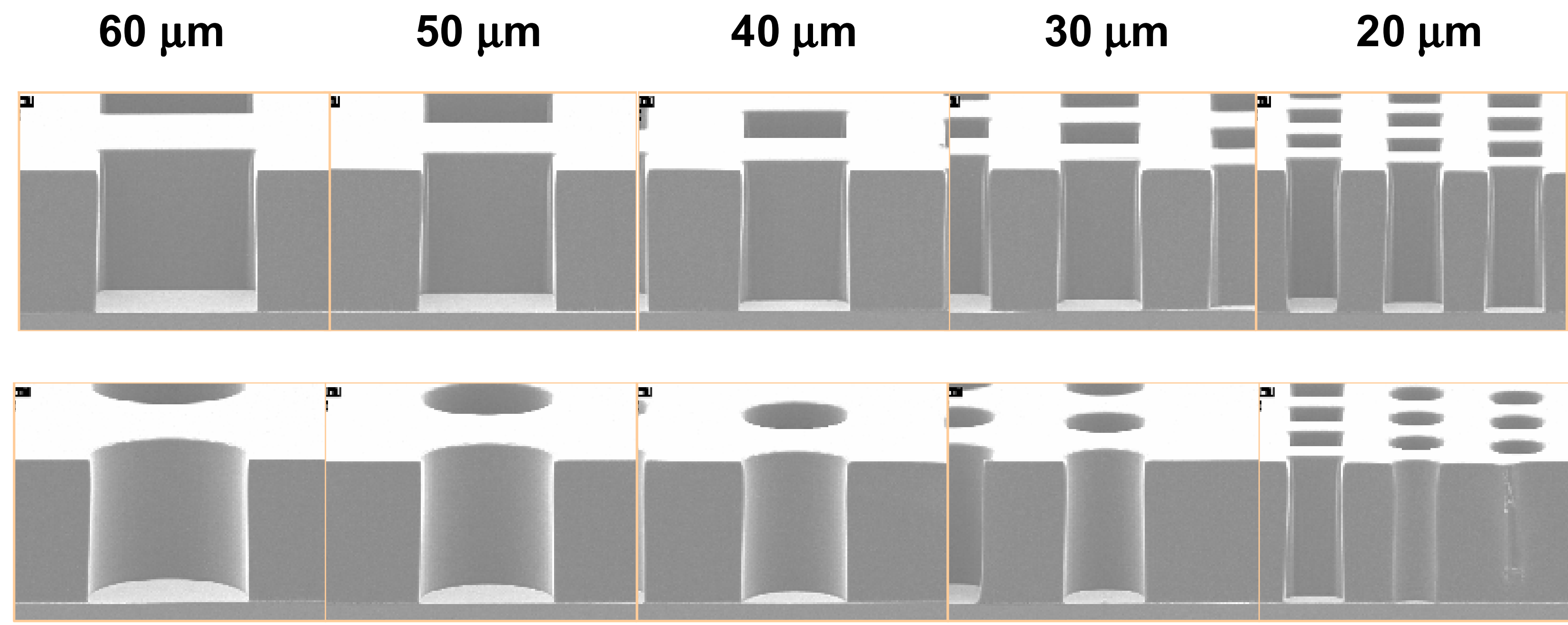
# AZ® EXP 125nXT-10A for FT=60 μm
# C/H Images @ 3000 mJ/cm²



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# 40 µm C/H Images at Different Ratios (3000 mJ/cm$^2$)

| 40 µm/40 µm | 40 µm/28 µm | 40 µm/12 µm |
|---|---|---|

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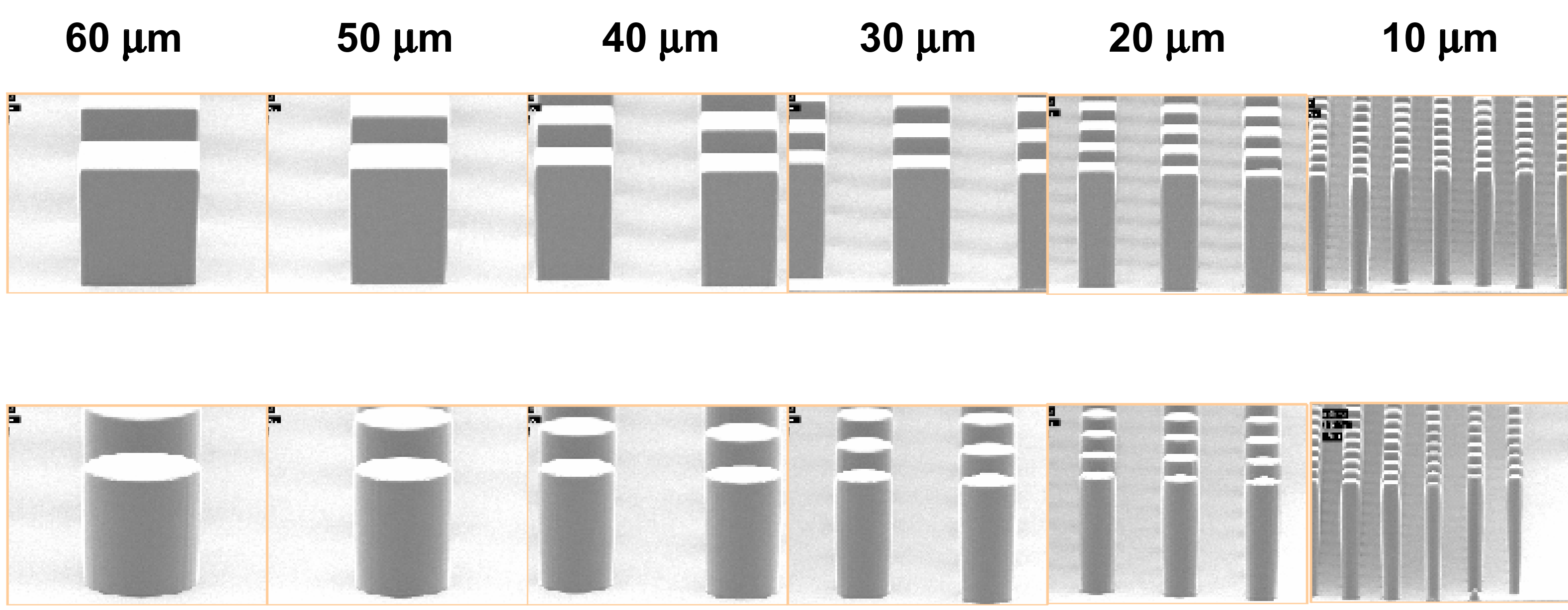
# AZ® EXP 125nXT-10 for FT=60 µm
# Post Images @ 3000 mJ/cm²



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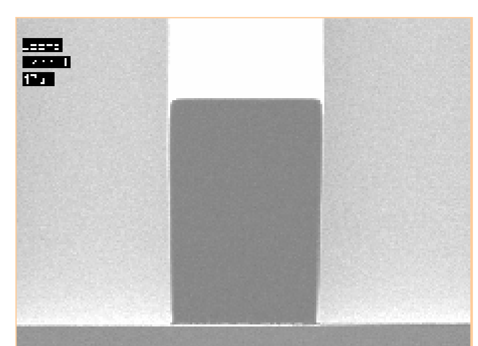
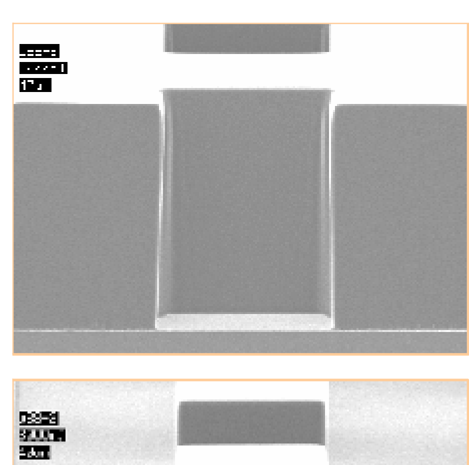
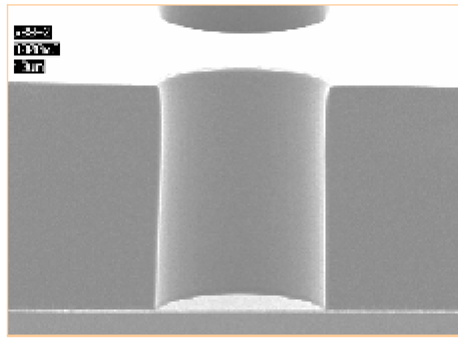
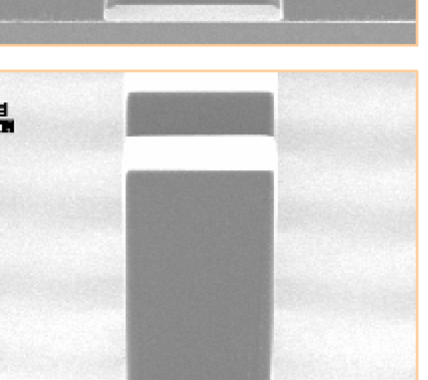
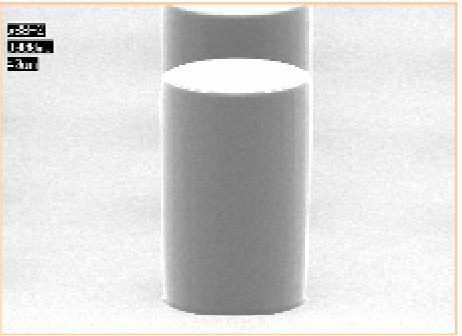
# AZ® EXP 125nXT-10A for FT=60 μm
# 40 μm Line, C/H, and Post @ 3000 mJ/cm²











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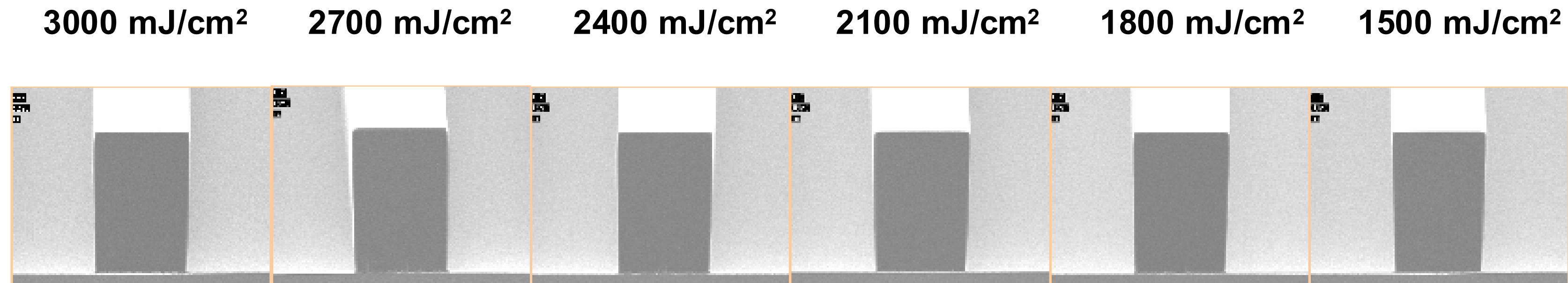
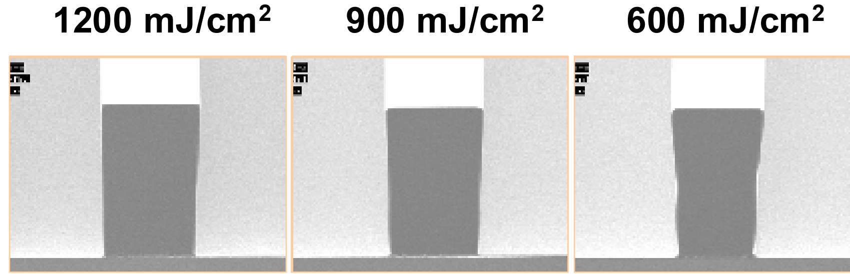
# AZ® EXP 125nXT-10A for FT=60 μm
# 40 μm Line Images

3000 mJ/cm² | 2700 mJ/cm² | 2400 mJ/cm² | 2100 mJ/cm² | 1800 mJ/cm² | 1500 mJ/cm²



1200 mJ/cm² | 900 mJ/cm² | 600 mJ/cm²



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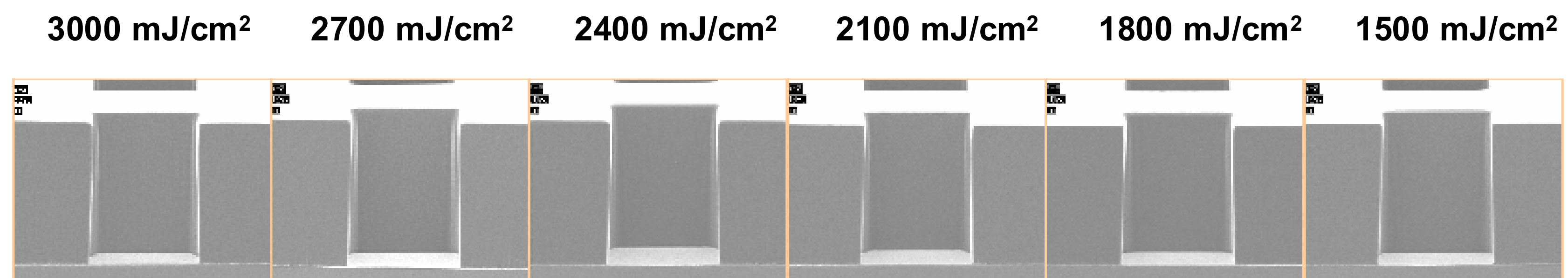
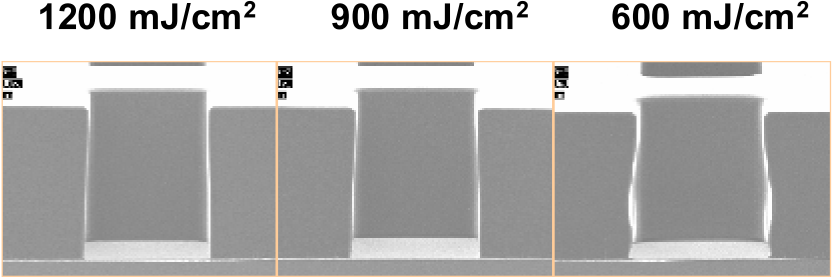
# AZ® EXP 125nXT-10A for FT=60 µm
# 40 µm C/H Images

3000 mJ/cm² 2700 mJ/cm² 2400 mJ/cm² 2100 mJ/cm² 1800 mJ/cm² 1500 mJ/cm²



1200 mJ/cm² 900 mJ/cm² 600 mJ/cm²



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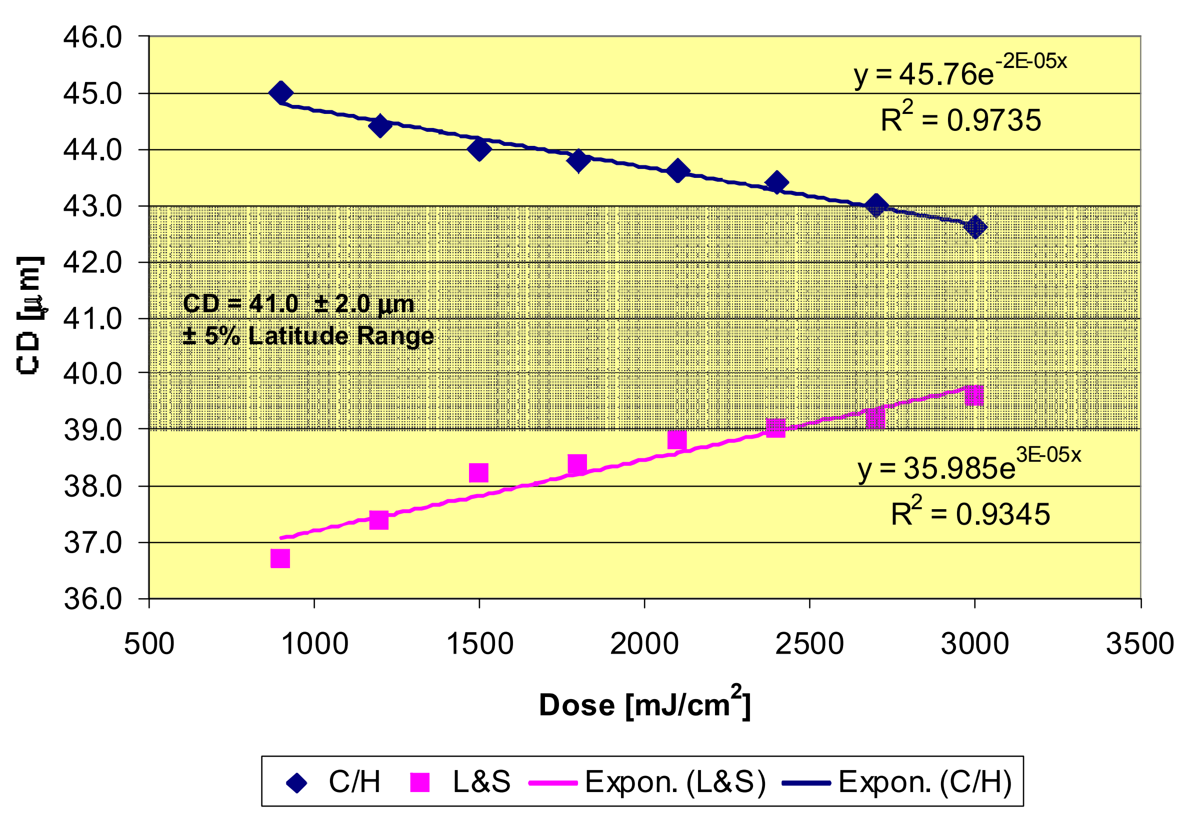
# Exposure Latitude of AZ® EXP 125nXT-10A



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# Conclusions

- **Film thickness of 60 µm by single coat was achieved @ 1900 rpm.**

- **Good performance above 1200 mJ/cm²**

- **Recommended soft back conditions:**
  - **Temp: 140 °C**
  - **Time: 8 min.**

- **Recommended dose and development time on Cu:**
  - **Dose: 1500 - 3000 mJ/cm²**
  - **Development: 2 puddles @ 40 sec.**

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# AZ® EXP 125nXT-10A

## FT=70 μm Lithographic Data
## Ultratech AP 300 Stepper

# Process Conditions of AZ® Exp 125nXT-10A

Test sample: viscosity @ 5038 cSt

Target FT: 70 µm by single coat on Suss ACS200
1200 rpm @ 1.0 sec, then 1000 rpm @ 12 sec

SB condition: 140 °C
5.1 mm@30 sec; 1.3mm@30 sec;
0.1 mm @ 120 sec; contact@ 600 sec.

Exposure tool: Ultratech AP 300 stepper
Dose: 1500 to 3500 mJ/cm$^2$
Focus: -22.5 to -7.5 µm

Development: AZ 300 MIF
3 puddles at 40 sec for Cu wafer

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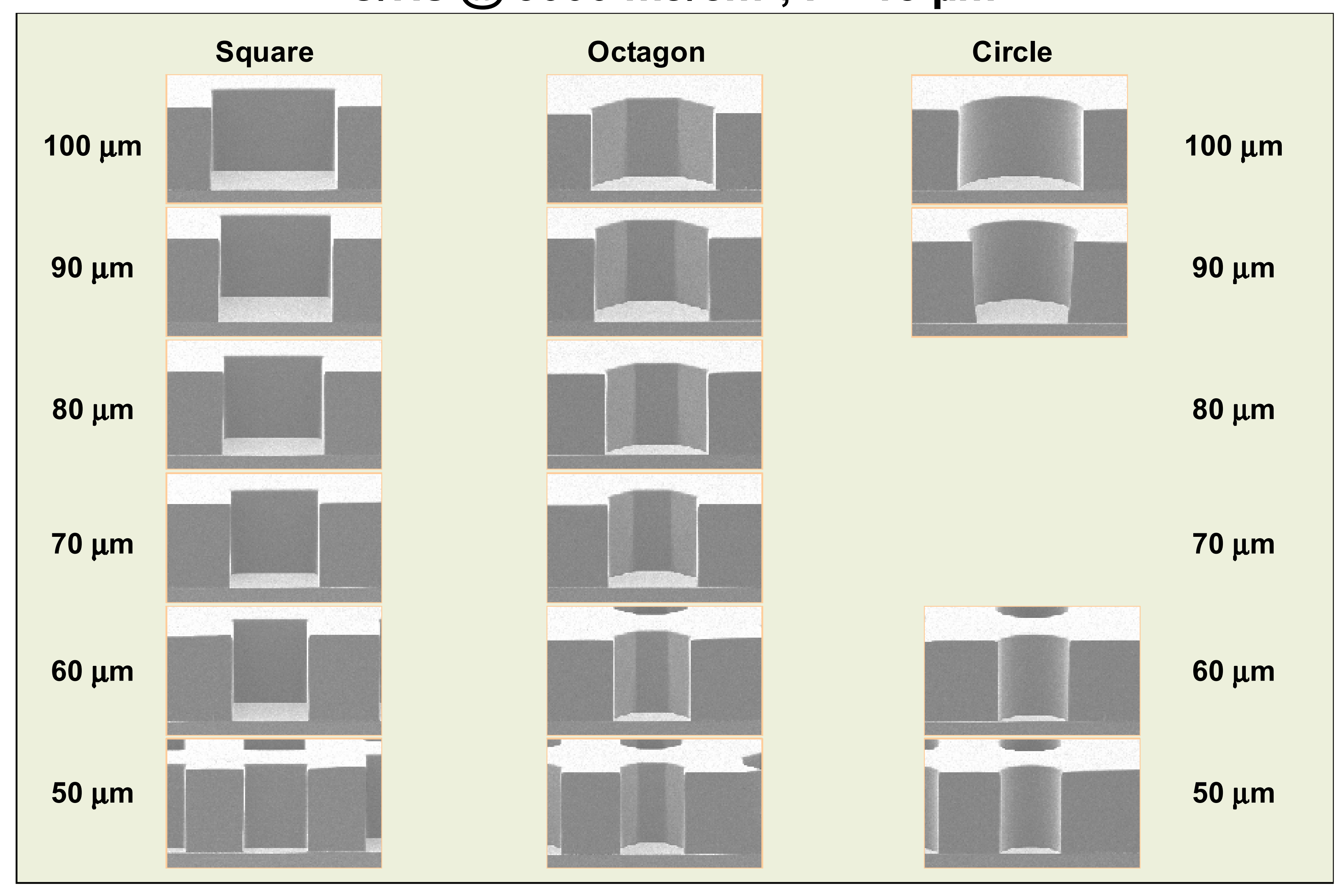
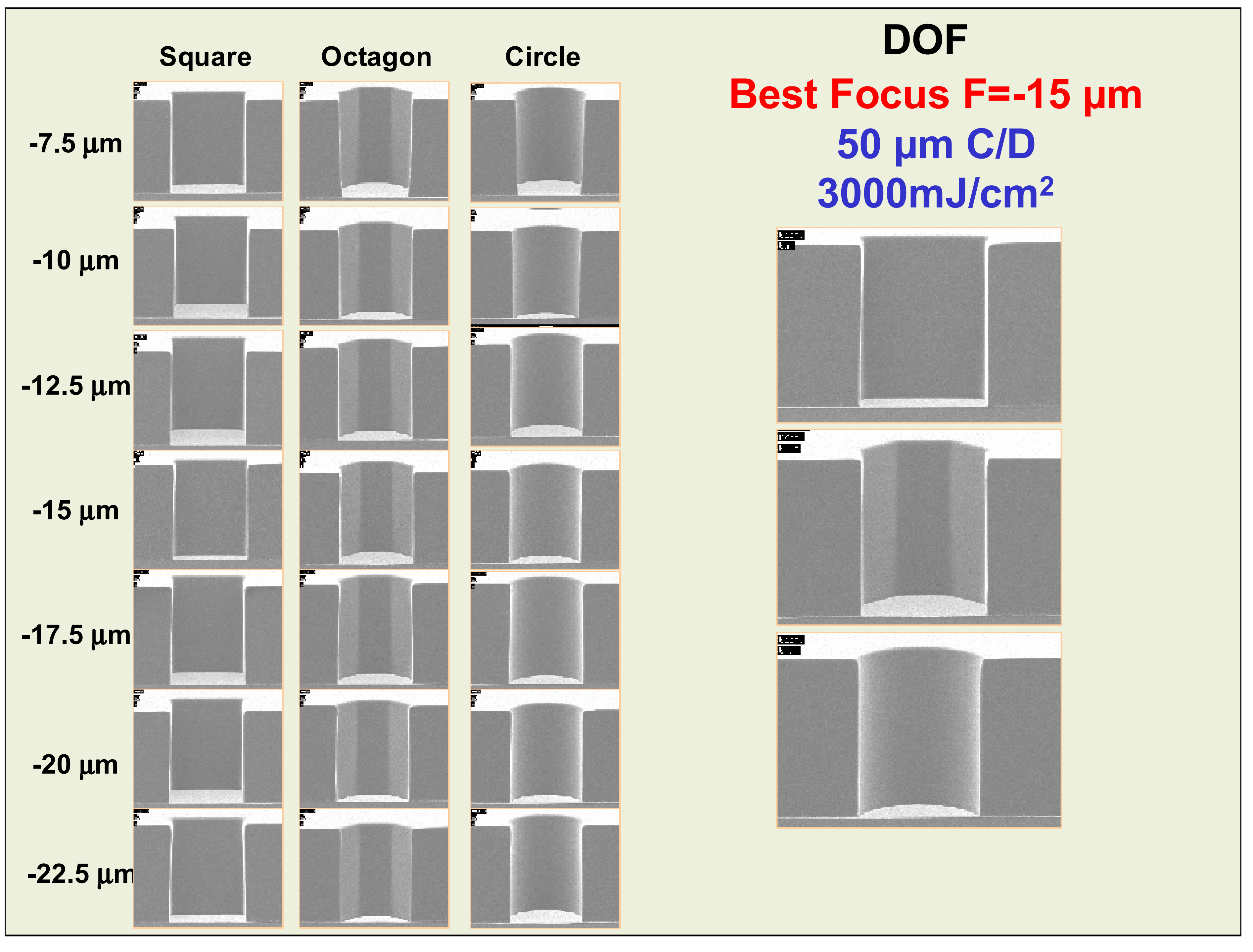
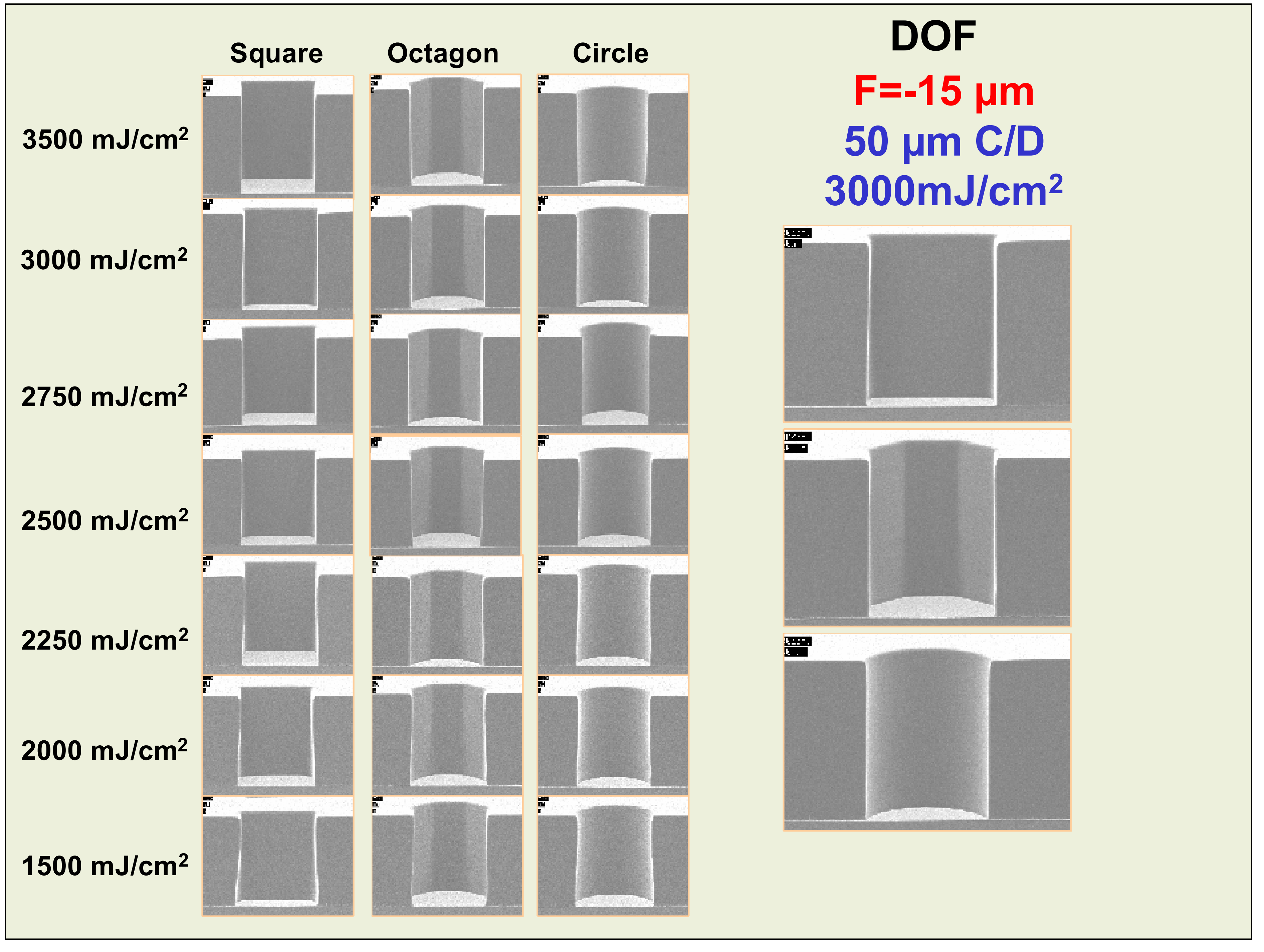
# AZ® Exp 125nXT-10A for FT=70 µm
# C/Hs @ 3000 mJ/cm², F=-15 µm




Square
Octagon
Circle
DOF
Best Focus F=-15 µm
50 µm C/D
3000mJ/cm²
-7.5 µm
-10 µm
-12.5 µm
-15 µm
-17.5 µm
-20 µm
-22.5 µm


Square
Octagon
Circle
3500 mJ/cm²
3000 mJ/cm²
2750 mJ/cm²
2500 mJ/cm²
2250 mJ/cm²
2000 mJ/cm²
1500 mJ/cm²
DOF
F=-15 µm
50 µm C/D
3000mJ/cm²

# AZ® EXP 125nXT-10A

## FT=75 µm Cu Plating Test

# AZ® Exp 125nXT-10A Cu Plating Test

Exposure tool: Suss Aligner MA-200
Dose: 2200 mJ/cm$^2$
Developer: AZ 300 MIF, 3x35

Descum: 10 min / 300W, Plasma Start AXIC Equipment
Cu solution: Intervia 8540
Tool: Semitool CFD 2 Reactor
Process conditions: 30 $^oC$, flow rate (5 GPM);
wafer rotation (60 rpm)
Deposition rate: between 0.4 - 0.8μm/min

Stripper: AZ® 400T at 75 $^oC$ for 20 min

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# Resist and Cu Plate Images (FT=75 µm)

| | 100 µm | 90 µm | 80 µm | 75 µm |
|---|---|---|---|---|
| **Resist Pattern** | | | | |
| **Cu Plate** | | | | |

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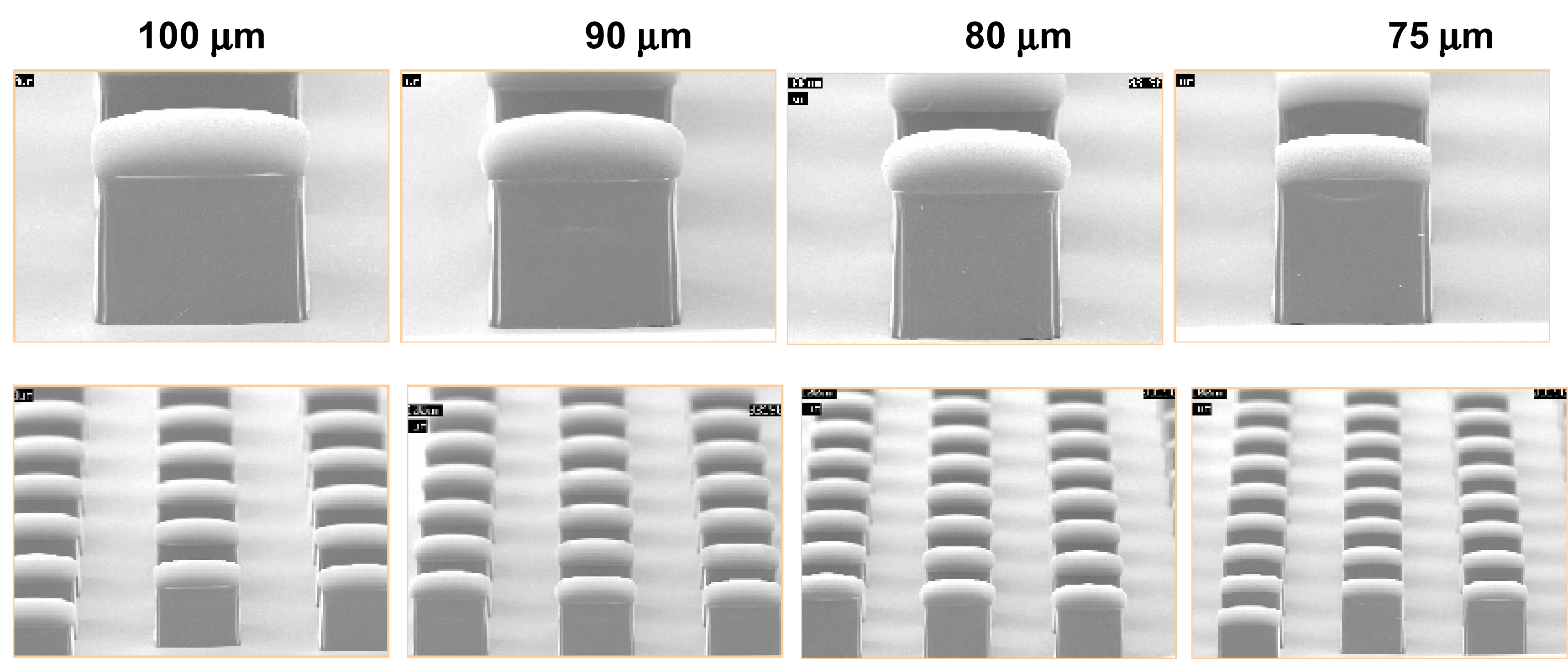
# Cu Plate Images (Cubic, FT=75 μm)



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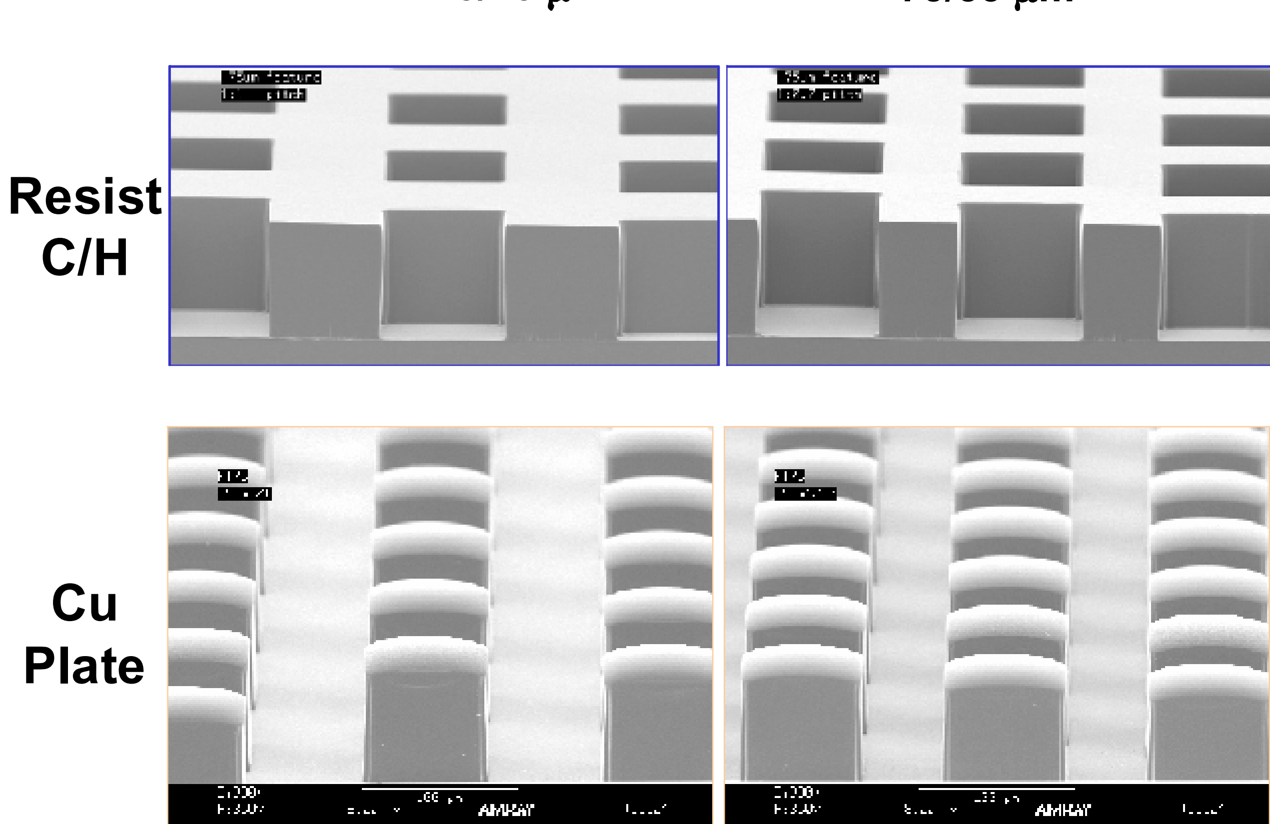
# 75 µm C/H and Cu Plate Images at Different Ratios



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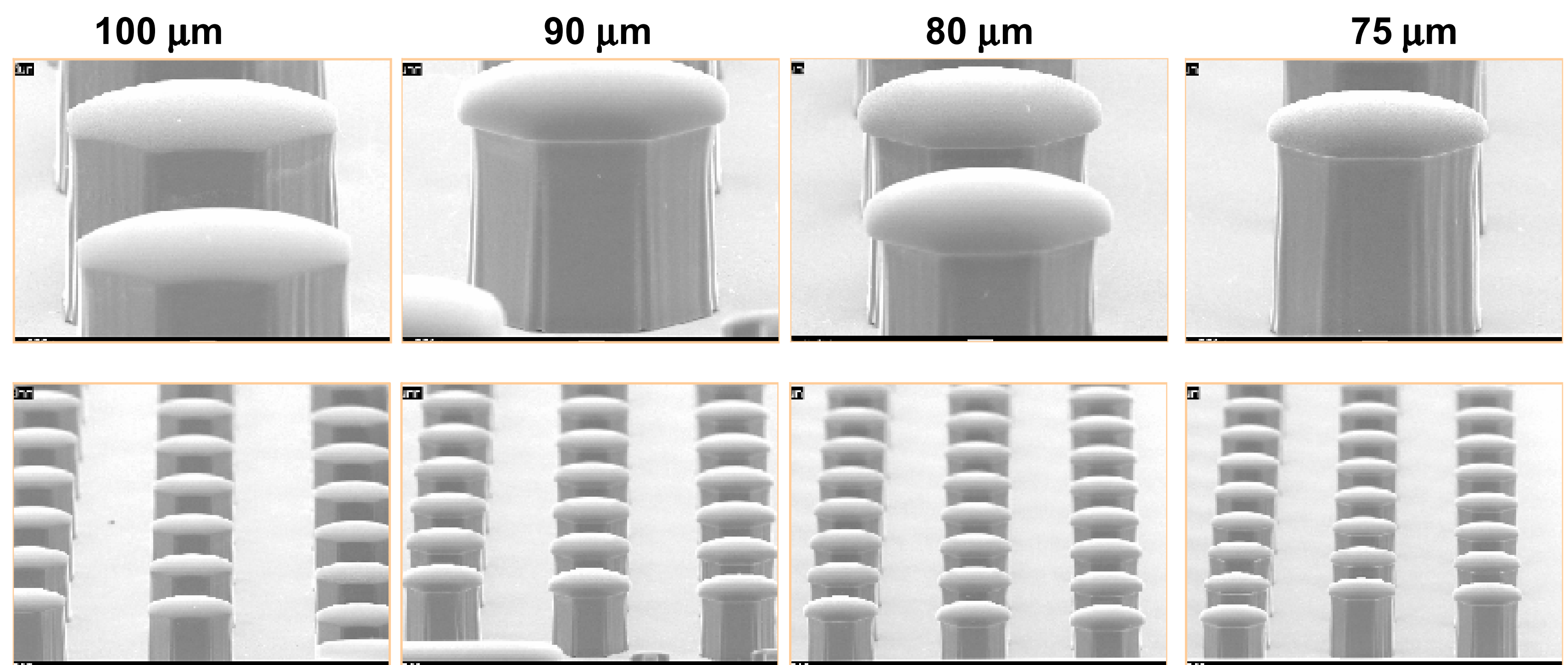
# Cu Plate Images (Octagon, FT=75 μm)



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# AZ® EXP 125nXT-10A

## FT=120 μm by Single Coating
## Lithographic Data

# AZ® EXP 125nXT-10A @ FT=120 µm

## Summary of Process Conditions on Cu Wafer

Test sample 2513-76 with viscosity of 5430 cSt

Target FT: 120 µm

Single coat at 1100 rpm @ 1.2 sec, then 620 rpm @ 12 sec

SB condition: 135 °C / 25 min

Exposure tool: Suss MA-200
Proximity mode Exposure @ CH2 (g. h. i.)

Development: AZ 300 MIF; 3 puddles at 60 second

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# AZ® EXP 125nXT-10A Coating Uniformity
# FT=120 µm @ 620 rpm

Wafer Statistics

| | |
|---|---|
| Mean: | 120.7945 |
| Maximum: | 131.9086 |
| Minimum: | 114.2892 |
| Std. Dev: | 4.8333 |
| | 4.00 % |
| Range: | 17.6194 |
| Hi/Lo Var: | 7.16 % |
| Unit: | microns |

Wafer Size

| | |
|---|---|
| Wafer Diam: | 300.00 mm |
| Test Diam: | 170.00 mm |
| No. Sites: | 40 |
| Style: | Notch |

Wafer Remarks

| | |
|---|---|
| Operator ID: | |
| Fab Name: | |
| Equip Info: | |
| Wafer ID: | AZ Exp125nXT-10A |
| Lot: | 2513-76 |
| Meas Equip: | Foothill KT-22 |
| Special: | |

Wafer

**Mean: 120.8 µm**
**Max: 131.9 µm**
**Min: 114.3 µm**
**S.D. : 4.0 %**
**Batch ID: 2513-76**
**Viscosity: 5430 cSt**

Legend

- 130.1467 - 131.9086
- 128.3847 - 130.1467
- 126.6228 - 128.3847
- 124.8608 - 126.6228
- 123.0989 - 124.8608
- 121.337 - 123.0989
- 119.575 - 121.337
- 117.8131 - 119.575
- 116.0511 - 117.8131
- 114.2892 - 116.0511

Notch

Plot- Options

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# AZ® EXP 125nXT-10A, Edge Scan
# FT=120 µm @ 620 rpm

**Wafer Statistics**

| | |
|---|---|
| Mean: | 126.9106 |
| Maximum: | 142.6167 |
| Minimum: | 116.1295 |
| Std. Dev: | 9.7904 |
| | 7.71 % |
| Range: | 26.4872 |
| Hi/Lo Var: | 10.24 % |
| Unit: | microns |

**Wafer Size**

| | |
|---|---|
| Wafer Diam: | 300.00 mm |
| Test Diam: | 192.00 mm |
| No. Sites: | 12 |
| Style: | Notch |

**Wafer Remarks**

| | |
|---|---|
| Operator ID: | |
| Fab Name: | |
| Equip Info: | |
| Wafer ID: | AZ EXP 125nXT-10A |
| Lot: | 2513-76 |
| Meas Equip: | Foothill KT-22 |
| Special: | |

Wafer

**Legend**

- 139.968 - 142.6167
- 137.3193 - 139.968
- 134.6705 - 137.3193
- 132.0218 - 134.6705
- 129.3731 - 132.0218
- 126.7244 - 129.3731
- 124.0757 - 126.7244
- 121.4269 - 124.0757
- 118.7782 - 121.4269
- 116.1295 - 118.7782

Notch

Plot- Options

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# AZ® EXP 125nXT-10A, Edge Scan
# FT=120 µm @ 620 rpm

**Wafer Statistics**

| | |
|---|---|
| Mean: | 126.9106 |
| Maximum: | 142.6167 |
| Minimum: | 116.1295 |
| Std. Dev: | 9.7904 |
| | 7.71 % |
| Range: | 26.4872 |
| Hi/Lo Var: | 10.24 % |
| Unit: | microns |

**Wafer Size**

| | |
|---|---|
| Wafer Diam: | 300.00 mm |
| Test Diam: | 192.00 mm |
| No. Sites: | 12 |
| Style: | Notch |

**Wafer Remarks**

| | |
|---|---|
| Operator ID: | |
| Fab Name: | |
| Equip Info: | |
| Wafer ID: | AZ EXP 125nXT-10A |
| Lot: | 2513-76 |
| Meas Equip: | Foothill KT-22 |
| Special: | |

142.6167
135.9949
129.3731
122.7513
116.1295

X=0.00 Y=-96.00 | X=0.00 Y=-40.00 | X=0.00 Y=0.00 | X=0.00 Y=40.00 | X=0.00 Y=96.00

Angle : 0 °

Plot-Options

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# AZ® EXP 125nXT-10A @ FT=120 μm Resolution Comparison (4000 mJ/cm²)

| 100 μm | 90 μm | 80 μm | 75 μm |
|---|---|---|---|

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# AZ® EXP 125nXT-10A @ FT=120 µm
# Resolution Comparison (4000 mJ/cm²)

| 100 µm | 90 µm | 80 µm | 75 µm |
| --- | --- | --- | --- |

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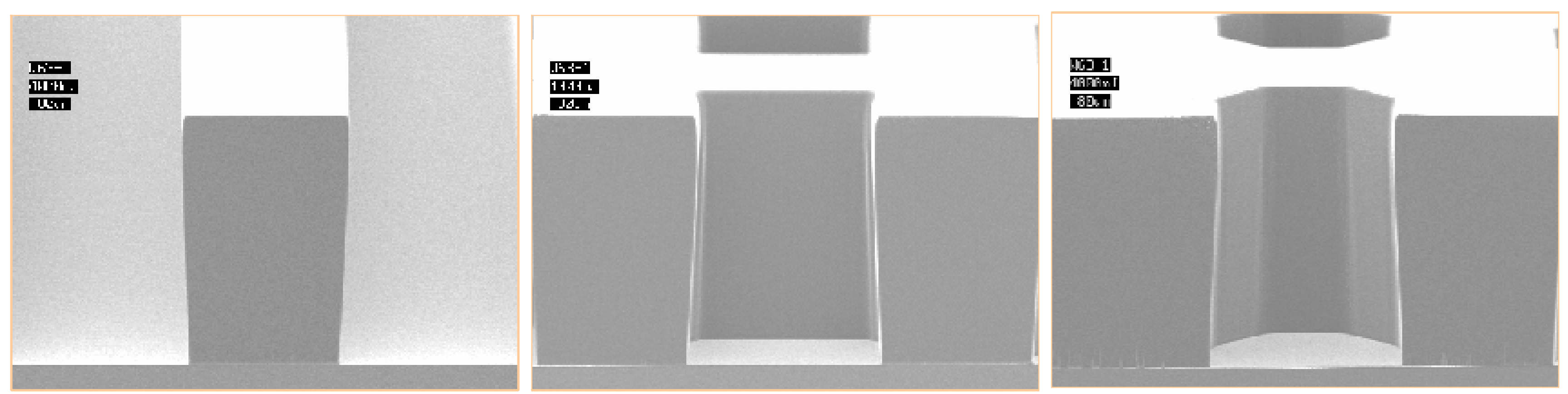
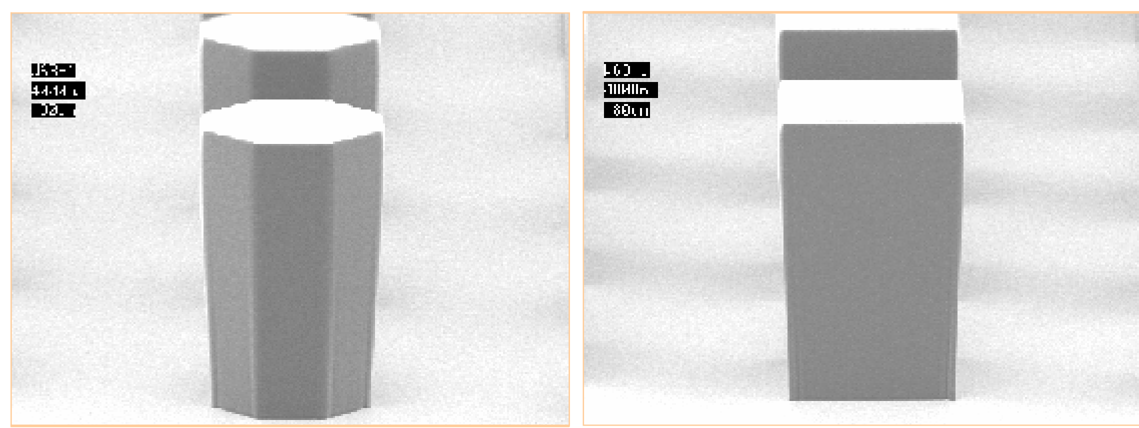
# AZ® EXP 125nXT-10A @ FT=120 μm
# 80 μm Lines, C/Hs and Posts at 4000 mJ/$cm^2$





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# AZ® EXP 125nXT-10A @ FT=120 µm
# 80 µm Line and C/H Images

| | 5000 mJ/cm² | 4500 mJ/cm² | 4000 mJ/cm² | 3500 mJ/cm² | 3000 mJ/cm² |
|---|---|---|---|---|---|
| **Line** | | | | | |
| **C/H** | | | | | |

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# AZ® 15nXT (450 CPS) Photoresist

## Negative Acting Thick Resist for Cu RDL, TSV, and other plating & etch applications

## Lithographic and Plating Performance Comparison at 10 µm FT on Cu wafers

**January 2009**

The information contained herein is, as far as we are aware, true and accurate. However, **no representations or warranties, either express or implied, whether of merchantable quality, fitness for any particular purpose or of any other nature are hereby made in respect of the information contained in this presentation or the product or products which are the subject of it.** In providing this material, no license or other rights, whether express or implied, are given with respect to any existing or pending patent, patent application, trademarks, or other intellectual property right.

# AZ's Thick Film Photoresist Roadmap

| Lift-off | TSV / Etch Implant, Plating | Copper/UBM Plating | Gold Plating | Solder / Metal Plating | MEMS / Ink Jet | DUV TFRH/Implant |
|---|---|---|---|---|---|---|
| FT: 2-10 µm | FT: 3-15 µm | FT: 5-30 µm | FT: 10-30 µm | FT: >30 µm | FT: >30 µm | FT: 3 - 8 µm |

**Commercialized materials**

<------------------------ P4620 ------------------------>

<------------ AZ® 10XT ------------>

<------------ AZ® 9200 ------------>

<------------ AZ® 50XT ---------->

<---------AZ® 40XT-11D-------->

| Lift-off | TSV / Etch Implant, Plating | Copper/UBM Plating | Gold Plating | Solder / Metal Plating | MEMS / Ink Jet | DUV TFRH/Implant |
|---|---|---|---|---|---|---|
| AZ® nLOF Series | AZ® N4000 | AZ® 4562 | AZ® PLP30/PLP40 | | | AZ® TX 1311<br>AZ® VS-01HJ |

**Materials in sampling** (all products)

<----------------------- AZ® 125nXT Series ----------------------->

<---AZ® 12XT Series--->

<---AZ® 15nXT--->

AZ® TX VS-02HJ

**Materials under development**

<--------- AZ® EXP 100 -------->

AZ® LExp 600

Red=Neg, Blue =Pos; nLOF, N4000, 5nXT/15nXT, 12XT, 40XT = chemically amplified; 125nXT = photopolymer; 10XT, 9200, P4620, PLP, 50XT, 4500 = DNQ

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# Through-Silicon-Via (TSV)
## Advantages to Use a Negative Photoresist

Drill/etch hole

| Coat **positive** photoresist | | Coat **negative** photoresist | |
|---|---|---|---|
| | Insoluble resist fills via | Soluble resist fills via | |
| **Expose** | Insufficiently exposed resist remains in via; Large overexposure may solubilize resist | No exposure needed to solubilize resist in via | **Expose** |
| **Develop** | Unexposed resist remains in via due to insufficient exposure; Overdevelopment does not clean via | Clean via for seed layer or plating | **Develop** |

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# Chemically Amplified Negative Resist

The original photo-event generates a catalyst for crosslinking (typically a proton). The photo-event is amplified by the number of cycles each proton catalyzes.

hν

PAG

Fragments

$H^+$

Soluble polymer & X-linker

PEB

[Δ]

Insoluble

Autocatalytic $H^+$ Generation

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# AZ® 15nXT (450 CPS)
## Process Conditions

| | |
|---|---|
| Substrate: | Si wafer for photospeed testing<br>Cu wafer for images |
| Film Thickness: | 10µm by single coat |
| Softbake: | 110°C / 180 seconds |
| Exposure tool: | ASML (i-line)<br>Dose = 400 ± 50 mJ/cm$^2$; Focus: 1 ± 0.5 µm |
| PEB: | 120°C / 60 seconds |
| Develop: | AZ 300 MIF (2.38% TMAH); 3 x 50 second puddles |

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# AZ® 15nXT (450 CPS)
## Optical Parameters

n & k Values at different wavelength

365 nm: $n = 1.6807$ $k = 0.0027$
633 nm: $n = 1.6063$ $k = 0.0034$

Cauchy coefficients (A, B, C) fit the following Cauchy equation: $n = A + B/\lambda^2 + C/\lambda^4$

$A = 1.5754$
$B = 0.013242\ \mu m^2$
$C = 0\ \mu m^4$

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# AZ® 15nXT (450 CPS)

## Spin Speed Curve

Film Thickness (μm)

24
22
20
18
16
14
12
10
8
6
4

500 1000 1500 2000 2500 3000 3500 4000 4500

Casting Speed (RPM)

Opti-Trak Coat and Bake
Hand dispense on 150 mm silicon
Spin 1000-4000 rpm for 30 sec
SB: 110°C/ 3 minutes

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# AZ® 15nXT (115 CPS) and AZ® 15nXT (450 CPS)
## Spin Speed Curves



Opti-Trak Coat and Bake
Hand dispense on 150 mm silicon
Spin 1000-4000 rpm for 30 sec
SB: 110°C/ 3 min for 15nXT
110°C/2 min for 5nXT

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# AZ® 15nXT (450 CPS)

## Depth of Focus

10µm

5µm

0.0 µm

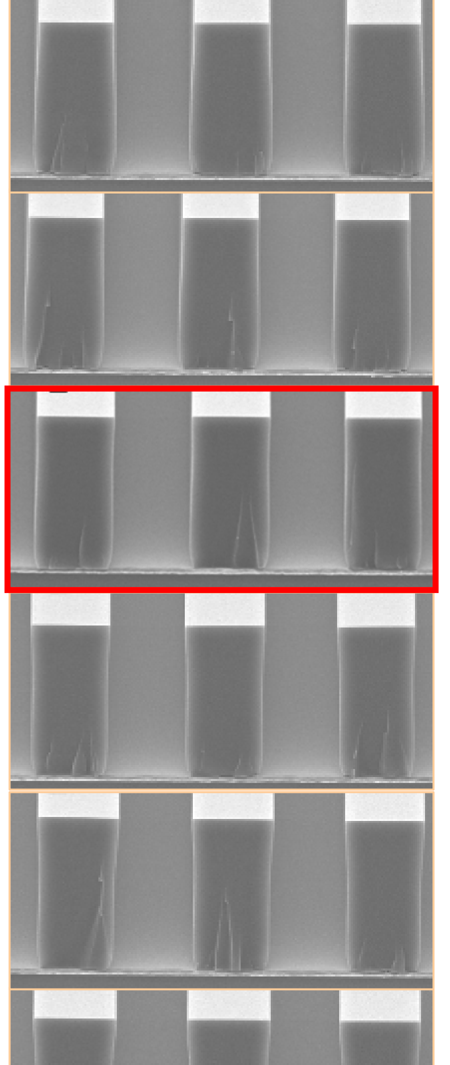
0.5 µm

1.0 µm

1.5 µm

2.0 µm

2.5 µm



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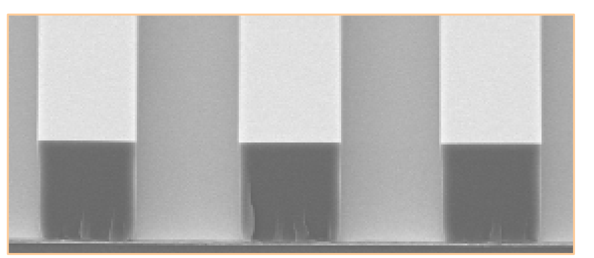
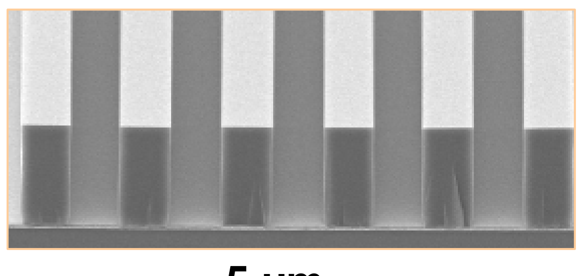
# AZ® 15nXT (450 CPS)
## Linearity, Resolution

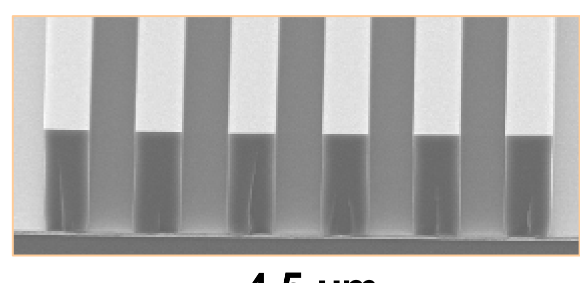
**400 mJ/cm$^2$, F = 1 µm**



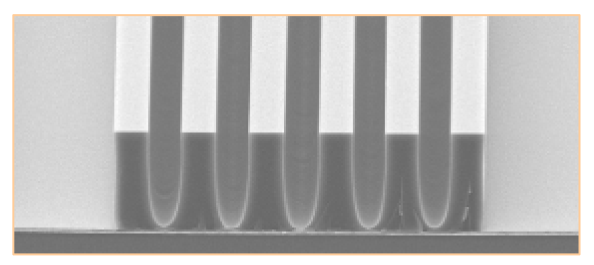
10 µm



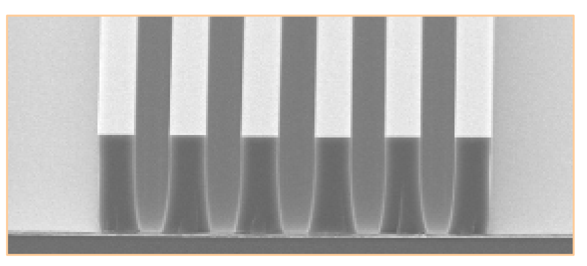
5 µm



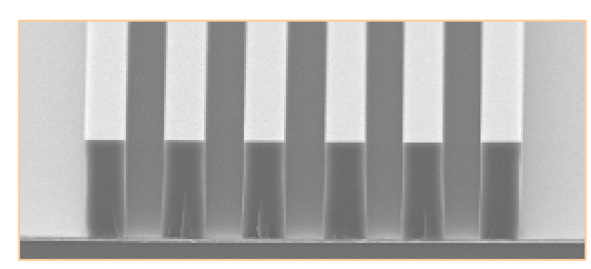
4.5 µm



3.4 µm



3.6 µm



4 µm

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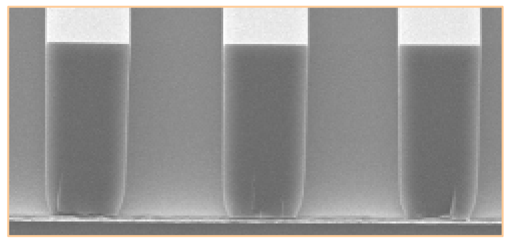
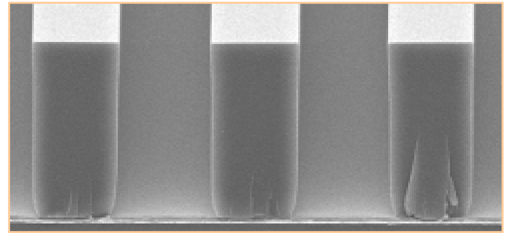
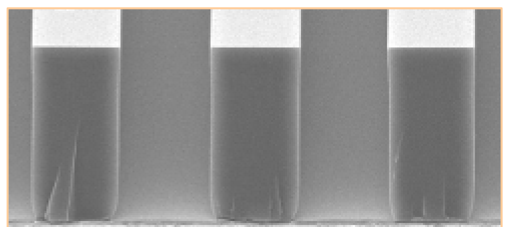
# AZ® 15nXT (450 CPS) - Exposure Latitude
## FT = 10 μm, Focus = 1.0 μm, 5.0 μm L/S on Cu Wafers



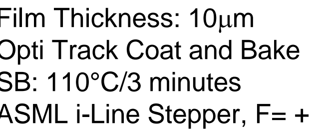
250 mJ/cm²



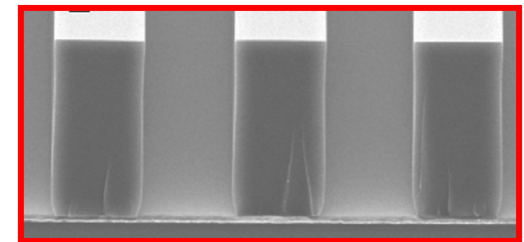
300 mJ/cm²



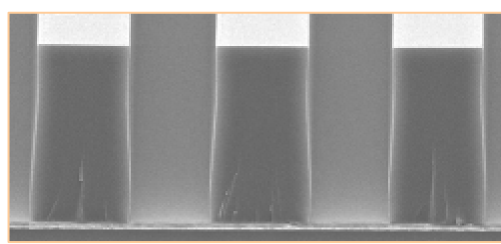
350 mJ/cm²



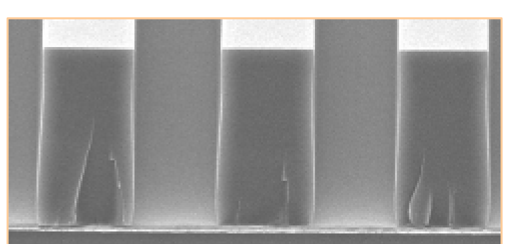
Film Thickness: 10μm
Opti Track Coat and Bake
SB: 110°C/3 minutes
ASML i-Line Stepper, F= +1.0μm
Opti Track PEB/Develop
PEB: 120°C/ 60 Seconds
AZ 300 MIF/ 3x50sec Spray/Puddle @23°C



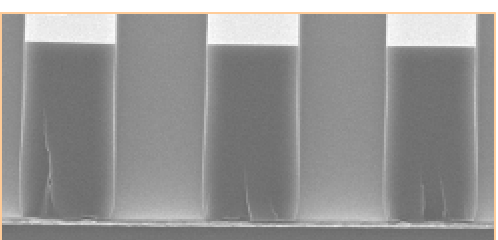
400 mJ/cm²



550 mJ/cm²



500 mJ/cm²



450 mJ/cm²

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# AZ® 15nXT (450 CPS) - Exposure Latitude
## FT = 10 μm, Focus = 1.0 μm, 5.0 μm L/S on Cu Wafers



Film Thickness: 10μm
Opti Track Coat and Bake
SB: 110°C/3 minutes
ASML i-Line Stepper, F= +1.0μm
Opti Track PEB/Develop
PEB: 120°C/ 60 Seconds
AZ 300 MIF/ 3x50sec Spray/Puddle @23°C

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# AZ® 15nXT (450 CPS)

## L/S Linearity @ 300 mJ/cm², F = +1.0 µm

Measured CD (µm)

Nominal CD (µm)

Film Thickness: 10µm
Opti Track Coat and Bake
SB: 110°C/3 minutes
ASML i-Line Stepper, F= +1.0µm
Opti Track PEB/Develop
PEB: 120°C/ 60 Seconds
AZ 300 MIF/ 3x50sec Spray/Puddle @23°C

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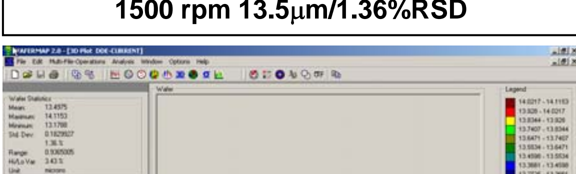
# AZ® 15nXT (450 CPS)

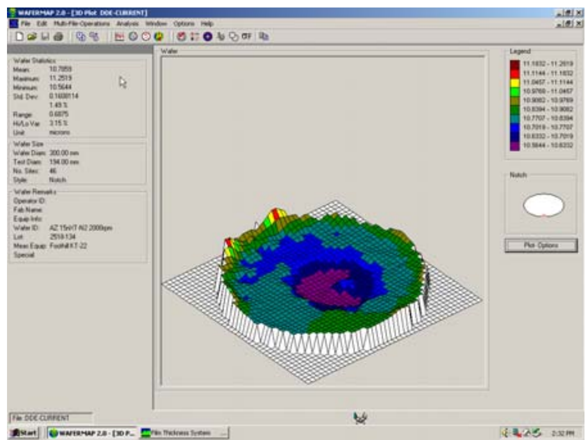
## Coating Uniformity Wafer Maps (3 mm Edge Exclusion)

**1000 rpm 17.8µm/4.49%RSD**

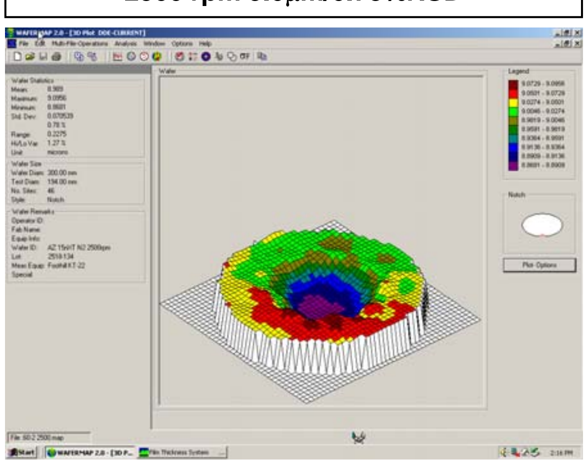
**1500 rpm 13.5µm/1.36%RSD**



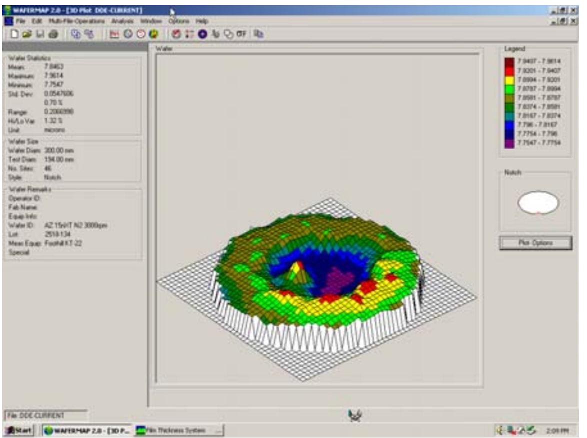
**2000 rpm 10.8µm/1.49%RSD**



**2500 rpm 9.0µm/0.78%RSD**



**3000 rpm 7.8µm/0.70%RSD**



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# AZ® 15nXT (450 CPS)
## Edge-Bead Coating Study (200 mm wafer)

**AZ EXP 15nXT Coating Study**
**Effects of Spin speed on Edge-Bead Profile**

Film Thickness (µm): 0.00, 5.00, 10.00, 15.00, 20.00, 25.00, 30.00

mm in from Wafer Edge: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

3000 rpm, 2500 rpm, 2000 rpm, 1500 rpm, 1000 rpm

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# AZ® 15nXT (450 CPS), FT=10.0 µm

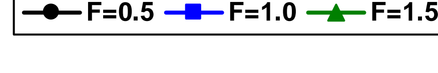
## Coat to Exposure Delay on Copper; 5 µm L/S

CD @ reference E-Nominal (um)

5.5
5.25
5
4.75
4.5

0 2 4 6 8 10 12 14 16 18 20 22 24

Coat to Expose Delay Time (Hours)




Film Thickness: 10.0 µm
Optitrac coat and Bake
SB: 110°C/ 180 sec Contact
ASML 0.48 NA 0.55 σ i-Line
PEB: 120°C/ 60 sec Contact
AZ 300 MIF 3x50 sec spray puddles @ 23 °C

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# AZ® 15nXT (450 CPS) , F = +1.0 µm, FT=10.0 µm
## Coat to Exposure Delay on Copper (hr:mm); 5 µm L/S

Measured CD (µm)
6.0
5.8
5.5
5.3
5.0
4.8
4.5
4.3
4.0
150 200 250 300 350 400 450 500 550
Dose (mJ/cm2)

23:35 Hrs
17:25 Hrs
12:00 Hrs
6:30 Hrs
3:35 Hrs
1:00 Hrs
0:30 hrs
0:01 Hrs

Film Thickness: 10.0 µm
Optitrac coat and Bake
SB: 110°C/ 180 sec Contact
ASML 0.48 NA 0.55 σ i-Line
PEB: 120°C/ 60 sec Contact
AZ 300 MIF 3x50 sec spray puddles @ 23 °C

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# AZ® 15nXT (450 CPS) , FT=10.0 µm

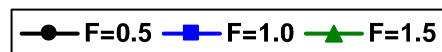
## Exposure to PEB Delay on Cu Wafers; 5 µm L/S

CD @ Reference E-Nominal (um)

5.5
5.25
5
4.75
4.5

0 30 60 90 120 150 180 210 240 270 300 330 360 390 420

Expose to PEB Delay Time (min)




Film Thickness: 10.0 µm
Optitrac coat and Bake
SB: 110°C/ 180 sec Contact
ASML 0.48 NA 0.55 σ i-Line
PEB: 120°C/ 60 sec Contact
AZ 300 MIF 3x50 sec spray puddles @ 23 °C

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# AZ® 15nXT (450 CPS), F = +1.0 µm, FT=10.0 µm

## Exposure to PEB Delay on Cu Wafers (Hr:mm); 5 µm L/S

Measured CD (µm)

6.0
5.8
5.5
5.3
5.0
4.8
4.5
4.3
4.0

150 200 250 300 350 400 450 500 550

Dose (mJ/cm2)

7:00 Hrs
3:20 Hrs
1:00 Hrs
0:30 Hrs
0:15 Hrs
0:00 Hrs

Film Thickness: 10.0 µm
Optitrac coat and Bake
SB: 110°C/ 180 sec Contact
ASML 0.48 NA 0.55 σ i-Line
PEB: 120°C/ 60 sec Contact
AZ 300 MIF 3x50 sec spray puddles @ 23 °C

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# AZ® 15nXT (450 CPS)

## Exposure and PEB Delays on Cu Wafers

## 300 mJ/cm², FT=10.0 μm, 5μm Features @ F= +1.0

No Delays

Exposure + 23 Hours

PEB/Develop + 7 Hours

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# AZ® 15nXT (450 CPS)

## Ni/Cu Plating Compatibility

Ni Plating solution: Enthone Microfab Ni-100
Process condition:
- Electrical density: 3.2 ASD
- Plating current: 0.103 A
- Stirring rate: 120 rpm
- Temp: 50°C
- Plating time: 3 min 12 sec

Cu Plating solution: Enthone Microfab Cu 200
Process condition:
- Electrical density: 3.2 ASD
- Plating current: 0.103 A
- Stirring rate: 120 rpm
- Temp: 25°C (Room Temp)
- Plating time: 4 min 48 sec

Stripping: AZ® Kwik Strip at 70 $^{o}$C for 3 min

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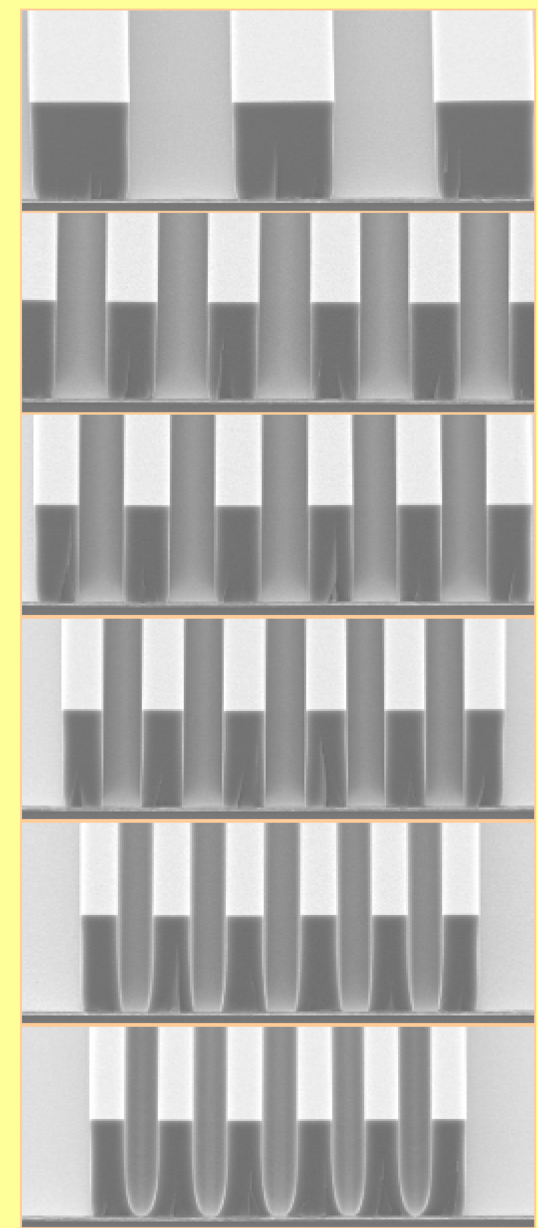
## AZ® 15nXT (450 CPS)
## Plated Ni/Cu Lines

| |
|---|
| 10 µm |
| 5 µm |
| 4.5 µm |
| 4 µm |
| 3.6 µm |
| 3.4 µm |

## AZ® 15nXT (450 CPS)
## F=1µm; 400 mJ/cm²



# AZ® 15nXT (450 CPS) Summary

- Compatible on Cu type substrates and other metals.
- Very good lithographic throughput; very competitive photospeed and develop time.
- Excellent adhesion, no underplating.
- Vertical sidewall profiles.
- Wide compatibility to plating solutions, including Cu, Ni, and Au.
- Easily strips after plating; stripped completely in AZ Kwik Strip at 70°C for 3 min.
- Very good stability and shelf life
- Thinner version available for lower FT range; 15nXT (115 CPS).

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# AZ 1500 Series

## Standard Photoresists

## GENERAL INFORMATION

This series of positive photoresists actually consists of three different products. They all contain the same photoactive compound (PAC) which responds to the whole UV-spectrum from 310 - 440 nm covering the three main mercury lines, i, h and g. They may be used with broadband as well as monochromatic exposure. Different novolak resins or fractions thereof were chosen to adopt them for different demands, this is indicated by a corresponding suffix of the product designation:

AZ 1500 (no suffix) is the most popular family and a direct safer solvent (PGMEA) substitute for AZ 1370, AZ 1470 , AZ 1350J, AZ 1450J, AZ 1375. It is available in different viscosities to cover the coating thickness range from 0.5 to 4.0 µm. Due to the slightly lower evaporation rate of the PGMEA (compared to cellosolve acetate based solvent system) these resists will show about 5 - 10% higher photospeed which may be compensated by increasing prebake temperature about 5°C. This resists may be used for wet- and dry-etch and cover all demands for general semiconductor manufacturing and other applications with resolution down to 1 µm.

AZ 1514 H is the safer solvent substitute for the well known AZ 1350 H which is now almost 25 years old and intended for contact and proximity printing. For this application a low photospeed for better control of exposure (about 10s at 15 mW/cm²) and thus a forgiving resist is the best choice. For many years the "non safe solvent" counterparts AZ 111 S and AZ 1350 H have been the standard resists for making semiconductors, AZ 111 S for wet-etch of oxides, AZ 1350 H for aluminium and nitride etch.

AZ 1500 HS family was developed in 1990. The background for this development was the fact that in making discrete and bipolar semiconductor devices wet-etching is still very common. For wet-etching adhesion is the most important issue. Especially on aluminium the mousebite-phenomenon is well known. To solve this problem we have chosen a low molecular weight novolak resin fraction resulting in significantly improved adhesion and also very high photospeed (therefore the suffix **H**igh **S**peed). Meanwhile AZ 1500 HS has proven its superior performance in several production lines and lead to less rework and higher yields.

All AZ 1500-series resists are compatible with all common developers used for positive photoresists, like AZ 351B (diluted 1:4), 0.5% NaOH solution and metal ion free developers like AZ 726 MIF. While AZ 1500-family and AZ 1514H are optimised for best process latitude at 50 - 60 seconds development time, AZ 1500HS-family performs best at 20 - 30 seconds development time resulting in a high throughput lithographic process.

## PHYSICAL and CHEMICAL PROPERTIES

| AZ | 1505 | | 1518 | 1529 | 1514H | 1512HS | 1518HS |
|---|---|---|---|---|---|---|---|
| Solids content [%] | 17.7 | | 29.9 | 34.0 | 27.8 | 26.5 | 30.4 |
| Viscosity [cSt at 25°C] | 6.3 | | 34.2 | 80.0 | 24.2 | 18.0 | 33.0 |
| Absorptivity [l/g*cm] at 398nm | 0.80 | | 1.30 | 1.36 | 1.22 | 1.32 | 1.50 |
| Solvent | methoxy-propyl acetate (PGMEA) | | | | | | |
| Max. water content [%] | 0.50 | | | | | | |
| Spectral sensitivity | 310 - 440 nm | | | | | | |
| Coating characteristic | striation free | | | | | | |
| Filtration [µm absolute] | 0.1 | | | 0.2 | 0.1 | | |

## FILM THICKNESS [µm] as FUNCTION of SPIN SPEED (characteristically)

| spin speed [rpm] | 2000 | 3000 | **4000** | 5000 | 6000 |
|---|---|---|---|---|---|
| AZ 1505 | 0.71 | 0.58 | **0.50** | 0.45 | 0.41 |
| AZ 1512HS | 1.70 | 1.39 | **1.20** | 1.07 | 0.98 |
| AZ 1514H | 1.98 | 1.62 | **1.40** | 1.25 | 1.14 |
| | | | | | |
| AZ 1518 and AZ 1518HS | 2.55 | 2.08 | **1.80** | 1.61 | 1.47 |
| AZ 1529 | 4.10 | 3.35 | **2.90** | 2.59 | 2.37 |

## PROCESSING GUIDELINES

| Dilution and edge bead removal | AZ EBR Solvent |
|---|---|
| Prebake | 100°C, 50", hotplate |
| Exposure | broadband and monochromatic |
| PEB | not required, optional with monochromatic exposure |
| Development | AZ 351B, 1:4 (tank, spray) or AZ 726 (puddle) |
| Postbake | 115°C, 50s hotplate or 30 min. oven |
| Removal | AZ 100 Remover, conc. |

## HANDLING ADVISES

Consult the **Material Safety Data Sheets** provided by us or your local agent!
This AZ Photoresists are made up with our patented safer solvent PGMEA. They are **flammable liquids** and should be kept away from oxidants, sparks and open flames.
**Protect from light and heat and store** in sealed original containers between 0°C and 25°C, exceeding this range to -5°C or +30°C for 1 week does not adversely affect the properties.
**Shelf life** is limited and depends on the resist series. The **expiration date** is printed on the label of every bottle below the batch number and coded as **[year/month/day]**.
AZ Photoresists are compatible with most commercially available wafer processing equipment. **Recommended materials** include PTFE, stainless steel and high-density poly-ethylene and -propylene.

# AZ® 40XT-11D Photoresist

## Thick Positive Chemically Amplified Photoresist Lithographic Performance at 40µm

The information contained herein is, as far as we are aware, true and accurate. However, **no representations or warranties, either express or implied, whether of merchantable quality, fitness for any particular purpose or of any other nature are hereby made in respect of the information contained in this presentation or the product or products which are the subject of it.** In providing this material, no license or other rights, whether express or implied, are given with respect to any existing or pending patent, patent application, trademarks, or other intellectual property right.

# AZ's Thick Film Photoresist Roadmap

| | Lift-off FT: 2-10 µm | TSV / Etch Implant FT: 3-15 µm | Copper/UBM Plating FT: 5-30 µm | Gold Plating FT: 10-30 µm | Solder / Metal Plating FT: >30 µm | MEMS / Ink Jet FT: >30 µm | DUV TFRH/Implant FT: 3 - 8 µm |
|---|---|---|---|---|---|---|---|
| **Commercialized materials** | AZ® nLOF Series | <------------ AZ® 10XT ------------><br><------------ AZ® 9200 ------------><br>AZ® N4000 | <------------------------ P4620 ------------------------><br>AZ® 4562 | AZ® PLP30/PLP40 | <----------- AZ® 50XT ----------> | | AZ® TX 1311 VS-01HJ |
| **Materials recently scaled up** (latest generation products) | | <--------AZ® 12XT Series------><br><---- AZ®15nXT Series --> | <------------------------ AZ® 125nXT Series ------------------------> | | <---------AZ® 40XT-11D--------> | | |
| **Materials under development** | | | <--------- AZ® EXP 100 --------> | | | | AZ® LExp 600 |

Red=Neg, Blue =Pos; nLOF, N4000, 15nXT, 12XT, 40XT = chemically amplified; 125nXT = photopolymer; 10XT, 9200, P4620, PLP, 50XT = DNQ

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# AZ® Electronic Materials

## Thick Photoresist Product Summary

| Thick Film Product | Platform | λ | FT Range (um) | Maximum Single coat | Aspect Ratio | Application | Developer Compatibility |
|---|---|---|---|---|---|---|---|
| P4000 Series | DNQ | g-h | 2 - 55 | 25 | 2:1 | Solder, Cu, Au | **400K** / TMAH |
| 4500 Series | DNQ | g-h | 2 - 55 | 25 | 2:1 | Solder, Cu, Au | **400K** / TMAH |
| 9200 Series | DNQ | ***g-h***-i | 3 - 50 | 25 | 3:1 | Solder, Cu, Au | **400K** / TMAH |
| 10XT | DNQ | ***g-h***-i | 4 - 50 | 25 | 3:1 | Solder, Cu, Au | **400K** / TMAH |
| 50XT | DNQ | g-h | 15 - 65 | 65 | 3:1 | Solder, Cu, Etch | 400K |
| PLP-30 | DNQ | g-h | 6 - 25 | 25 | 2:1 | Au, Cu | 303N |
| PLP-40 | DNQ | g-h | 20 - 30 | 30 | 2:1 | Au, Cu | 303N |
| 12XT Series | CA | g-h-***i*** | 5 - 20 | 20 | 4:1 | Si, Cu, Au, TSV | TMAH |
| 40XT Series | CA | g-h-***i*** | 20 - 100 | 60 | 4:1 | Etch, Solder, Cu | **TMAH /** 400K |
| 125nXT Series | PP | g-h-***i*** | 20 - 120 | 120 | 6:1 | Cu, Au, Solder | **TMAH** / 303N |
| 15nXT Series | CA | g-h-***i*** | 5 - 20 | 20 | 3:1 | Cu, TSV Etch | TMAH |
| TX 1311 | CA | DUV | 3 - 5 | 5 | 15:1 | Cu, NiFe, Si | TMAH |

- **Platform: DNQ = Novolak, CA = Chemically Amplified, PP = Photopolymer**
- **Wavelength: Red font indicates better performance.**
- **Developer Compatibility: Bold font indicates most compatible developer, resulting in shorter develop times and lower exposure energies.**

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# AZ® 40XT-11D
# Photoresist Optical Parameters

**n & k values**

2.5
2
1.5
1
0.5
0
-0.5

0 200 400 600 800 1000 1200 1400

**wavelenght (nm)**

n
k

## Cauchy Parameters

A = 1.560
B = 0.007 $\mu m^{-2}$
C = 0.0006 $\mu m^{-4}$

## n & k Values

$\lambda$ = 362.04 nm: n = 1.6443 k = 0.002779
$\lambda$ = 367.41 nm: n = 1.6431 k = 0.000630

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# AZ® 40XT-11D
## Process Conditions

Process Conditions:

| | |
|---|---|
| Substrate: | 200 mm Silicon |
| Coater Tool: | Suss ACS 300 Plus Coat/ Bake |
| Coat Process: | Dynamic dispense on Silicon @ 30 rpm |
| Target FT: | 40 µm |
| Softbake: | 126°C hotplate/ 120 sec @ 1.27 mm |
| | 126°C hotplate/ 120 sec @ 0.63 mm |
| | 126°C hotplate/ 180 sec @ 0.00 mm |
| Exposure: | Suss MA200 CC Mask Aligner; 20µm proximity gap |
| PEB: | 105°C hotplate/ 10 sec @ 1.3 mm |
| | 105°C hotplate/ 10 sec @ 0.6 mm |
| | 105°C hotplate/ 80 sec @ 0.0 mm |
| Develop: | AZ® 300 MIF/ 4x60 sec spray/puddle @ 23°C |

Analysis:

Amray SEM

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# AZ® 40XT-11D Photoresist

## Film Thickness vs. Spin Speed on 200 mm Silicon

Film Thickness (µm)

80
70
60
50
40
30
20
10

1000 1500 2000 2500 3000 3500 4000

Spin Speed (rpm)

Suss ACS 300 Plus coat and Bake
Hand dispense on 200 mm silicon
Spin 1000-3000 rpm for 20 sec
SB: 126°C/ 7 minutes

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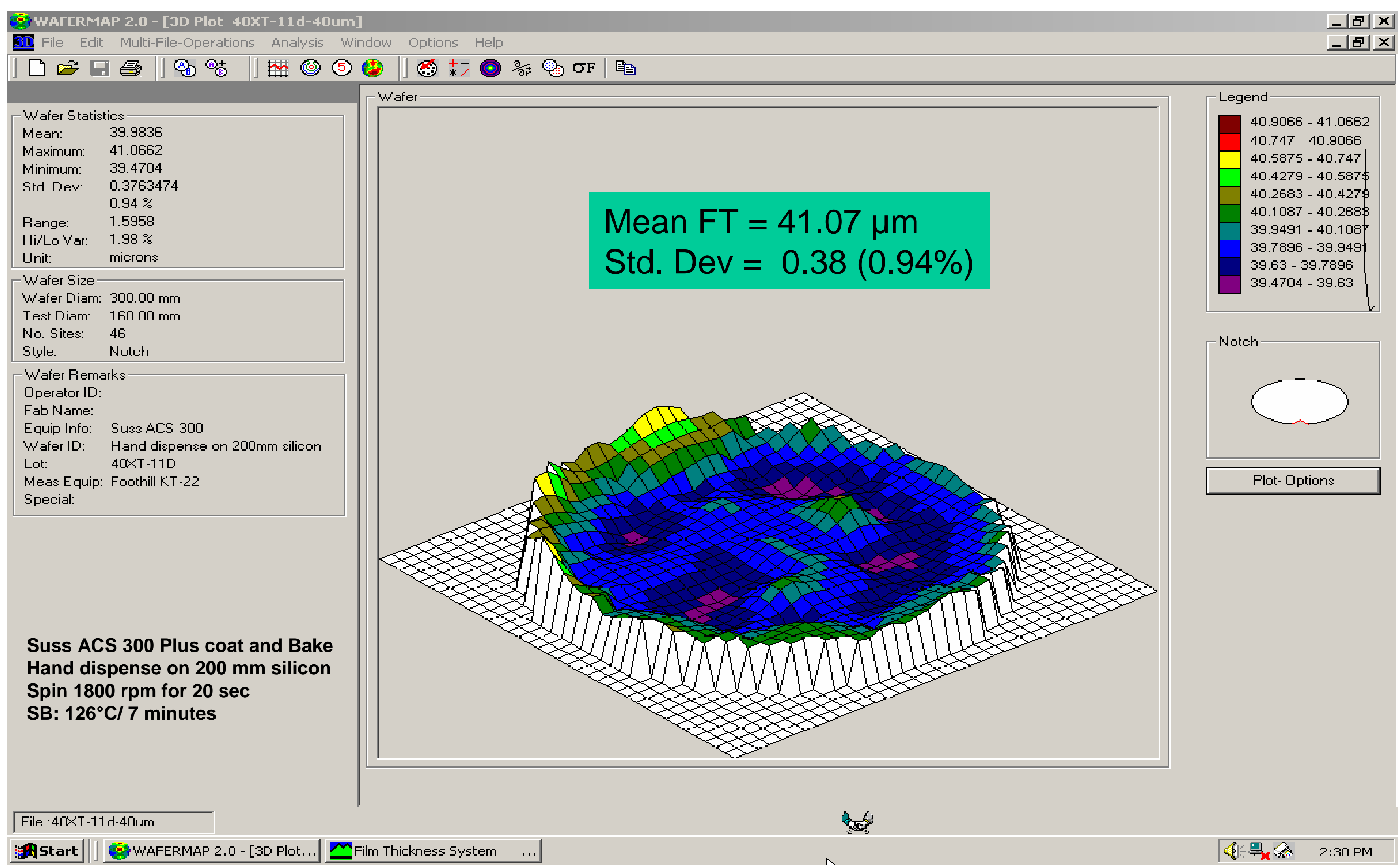
# AZ® 40XT-11D Photoresist, FT=40 µm
## Coat uniformity on 200 mm Silicon




**Suss ACS 300 Plus coat and Bake**
**Hand dispense on 200 mm silicon**
**Spin 1800 rpm for 20 sec**
**SB: 126°C/ 7 minutes**

AZ Electronic Materials



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# AZ® 40XT-11D Photoresist, FT=40 µm
## 40 µm L/S Exposure Latitude

427 mj/cm²
98% Exposure Latitude

Measured Linewidth (µm)

Exposure Dose (mj/cm²)

Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

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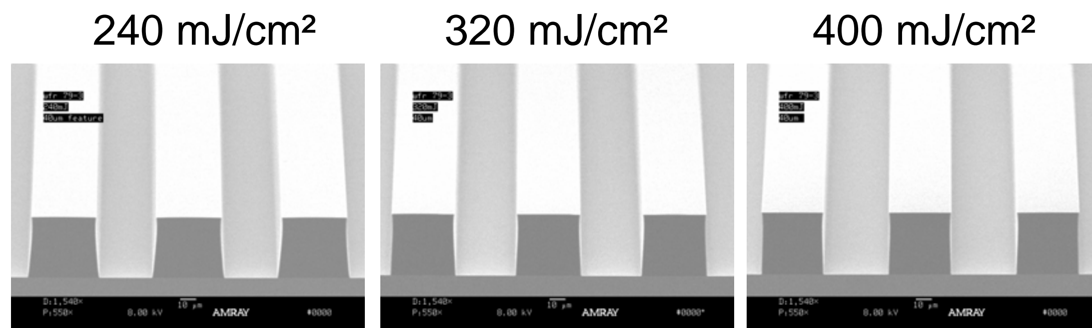
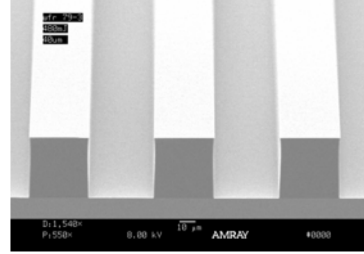
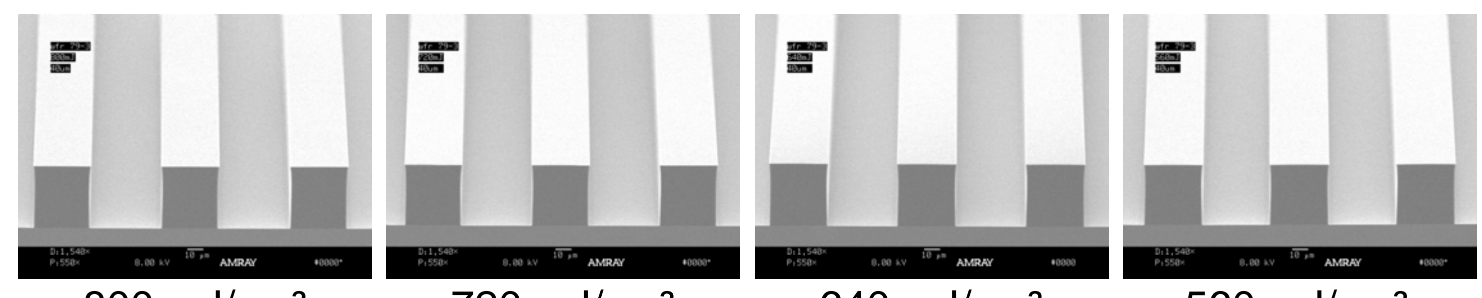
# AZ® 40XT-11D Photoresist, FT=40 µm
## 40 µm L/S Exposure Latitude




Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

480 mJ/cm²





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# AZ® 40XT-11D Photoresist, FT=40 µm
## 40.0 µm Contact Holes Exposure Latitude



Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

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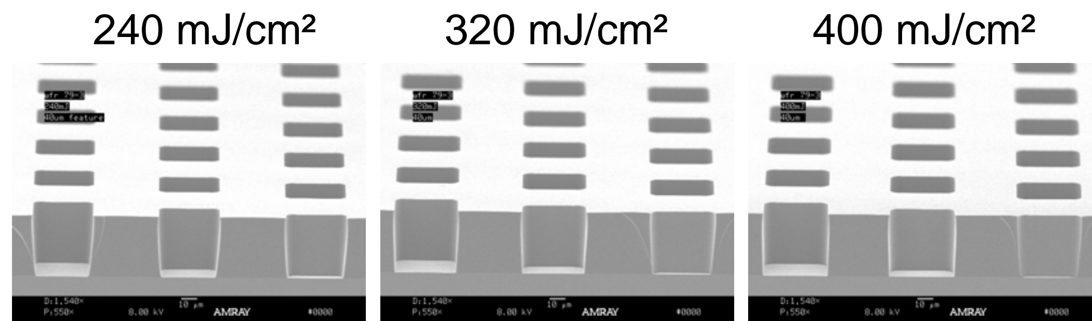
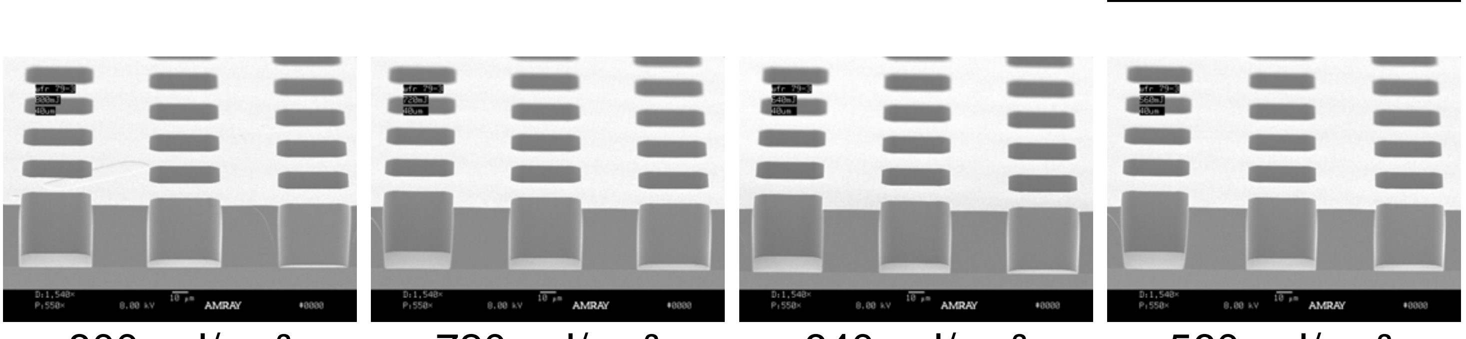
# AZ® 40XT-11D Photoresist, FT=40 µm
## 40 µm Contact Holes (1:1 Pitch) Exposure Latitude




Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

480 mJ/cm²



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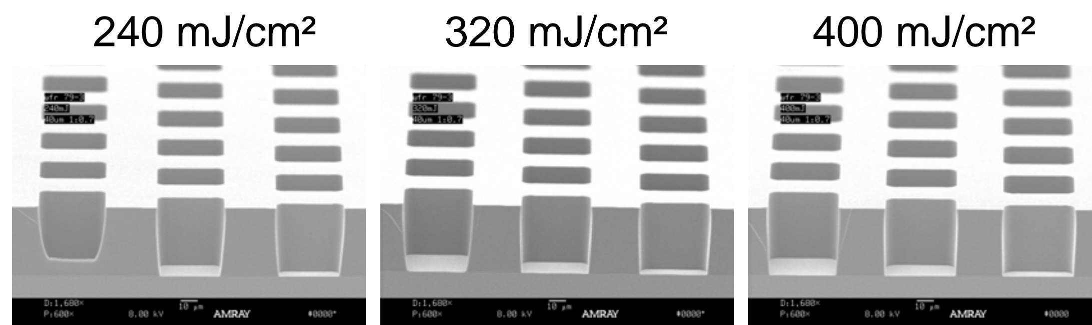
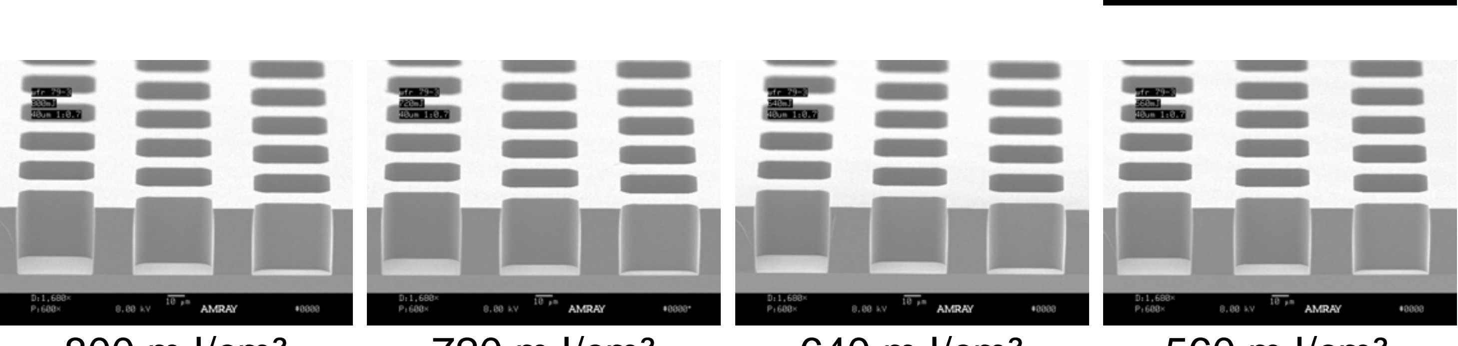
# AZ® 40XT-11D Photoresist, FT=40 µm
## 40 µm Contact Holes (1:0.7 Pitch) Exposure Latitude




Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

480 mJ/cm²



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# AZ® 40XT-11D Photoresist, FT=40 µm
## L/S Linearity @ 400 mJ/cm²



Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

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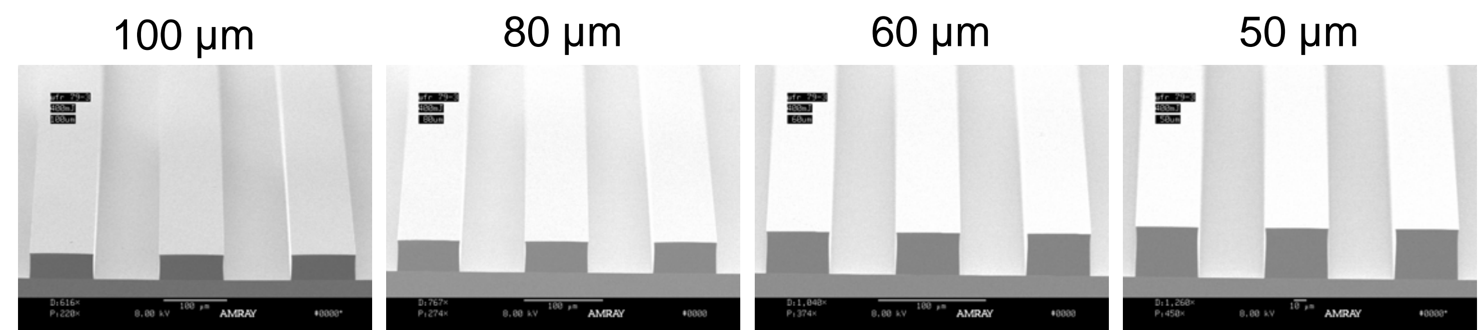
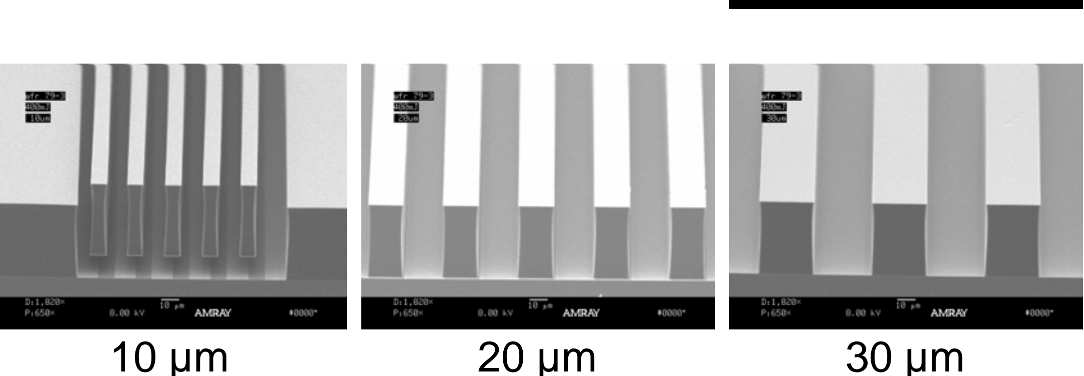
# AZ® 40XT-11D Photoresist, FT=40 µm
## L/S Linearity on Silicon @ 400 mJ/cm²




Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

40 µm



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# AZ® 40XT-11D Photoresist, FT=40 µm
## Contact Holes (1:1 Pitch) Linearity @ 400 mJ/cm²

Measured Linewidth (µm): 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0, 110.0

Nominal Linewidth (µm): 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0, 110.0

Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

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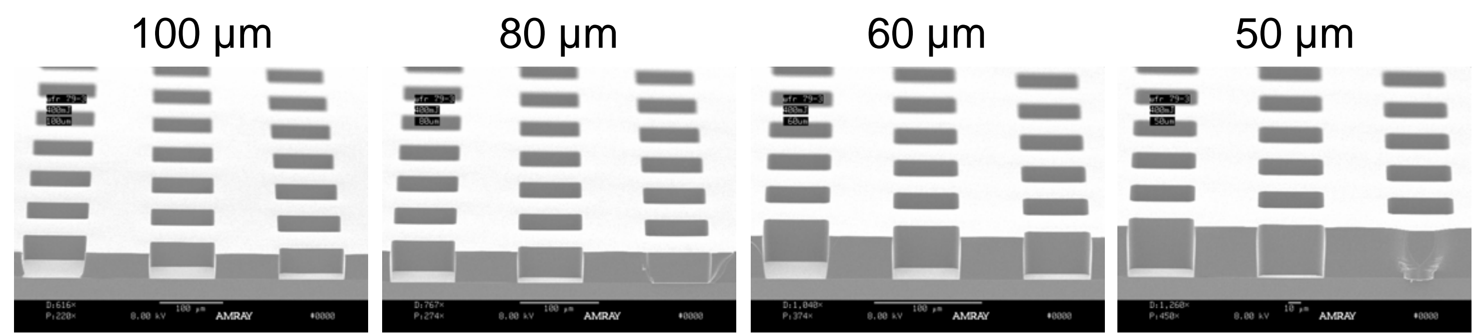
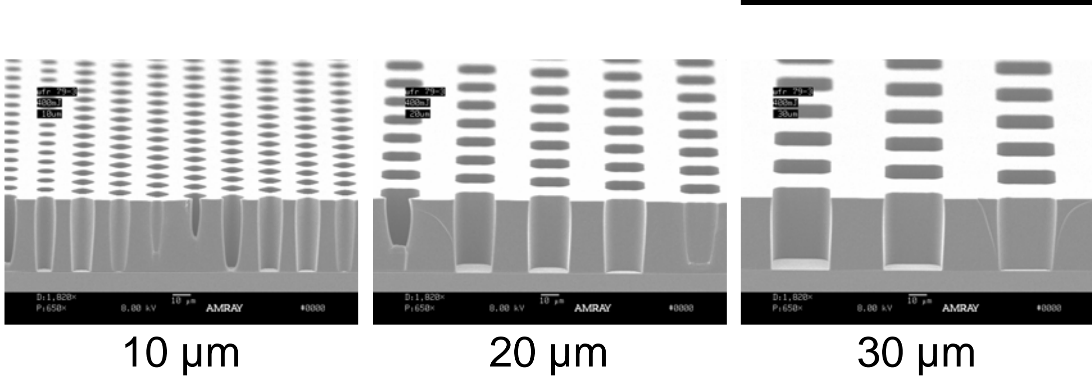
# AZ® 40XT-11D Photoresist, FT=40 µm
## Contact Holes (1:1 Pitch) Linearity @ 400 mJ/cm²




Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

40 µm



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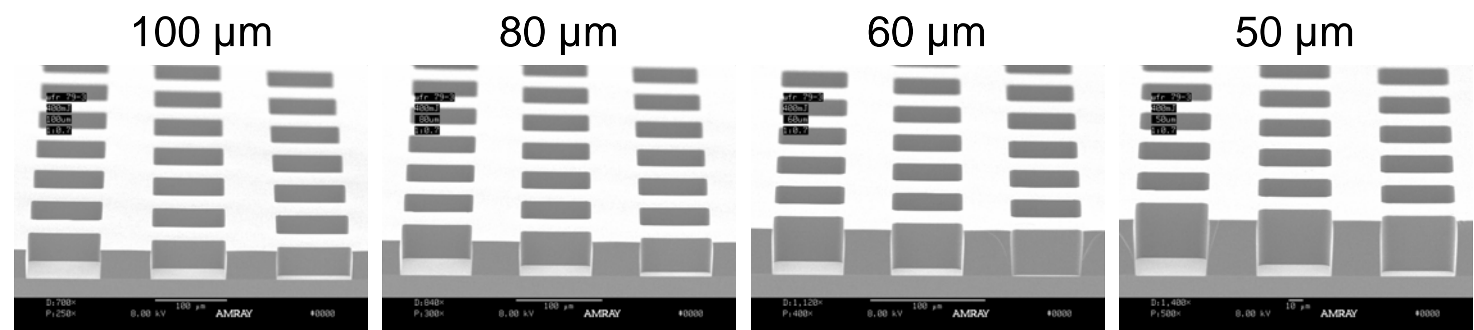
# AZ® 40XT-11D Photoresist, FT=40 µm

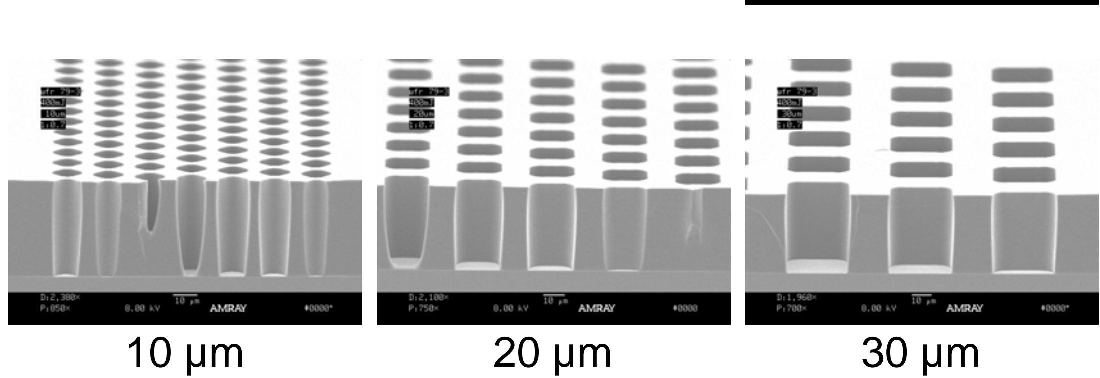
## Contact Holes (1:0.7 Pitch) Linearity @ 400 mJ/cm²

100 µm 80 µm 60 µm 50 µm



Film Thickness: 40 µm
Suss ACS 300 Plus coat and Bake
SB: 126°C/ 7 minutes
Suss MA200 CC Mask Aligner/ 20 µm proximity gap
PEB: 105°C/ 100 seconds
AZ 300 MIF/ 4X60 sec spray/puddle @ 23 °C

40 µm



10 µm 20 µm 30 µm

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# AZ® 40XT-11D Photoresist

Lithographic Performance Summary:

| Resist | Features (1:1) | Film Thickness (µm) | DTP 40 µm (mJ/cm²) | Exposure Latitude 40 µm (%) | Linearity (µm) |
|---|---|---|---|---|---|
| AZ® 40XT-11D | Dense Lines | 40 | 427 | 98 | 20 |
| AZ® 40XT-11D | Contact Holes | 40 | 443 | 114 | 20 |



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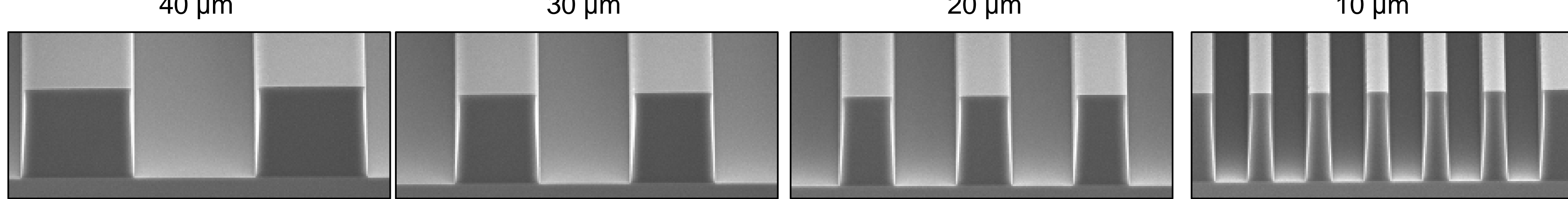
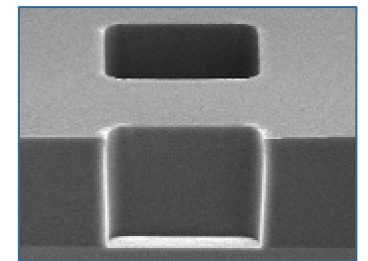
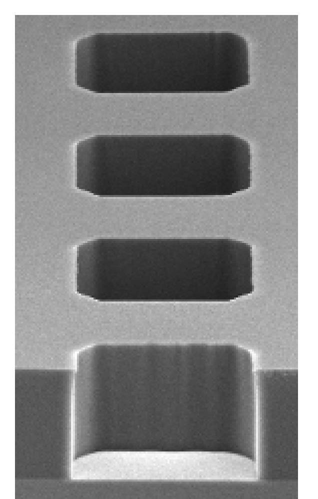
# AZ® 40XT-11D
## Performance on Silicon at 40μm FT



**DTP = 250 mJ/cm²**



| | |
|---|---|
| Softbake: | 115°C/60sec @ 0.05” gap, + 60sec @ 0.025” gap, + 240sec @ 0.002” gap |
| EBR: | EBR 600 for 60 sec followed by bake 115°C/10sec @ 0.002” gap |
| Exposure: | Suss MA-200, Broadband, proximity exposure; Exposure gap: FT+30μm (70μm) |
| PEB: | 100°C/30sec @ 0.002” gap |
| Develop: | 3x60 sec puddle AZ 300 MIF Developer @23°C |

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# AZ® 40XT-11D Summary

- Chemically Amplified Platform
- Vertical profiles on aligners
- Excellent photospeed;  good develop time
- TMAH Developer compatible
- Superior overall throughput
- Superior adhesion on substrates
- Superior DRIE performance, ideal for MEMS
- Copper substrate compatible
- Good plating compatibility
- Standard wet strip process for removal

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# AZ 4500 Series

## Thick Film Photoresists

## GENERAL INFORMATION

This series of positive photoresists is intended for applications where coating thicknesses above 3 µm are required. When using a standard photoresist at film thicknesses above 3 µm, the necessary exposure energy drastically increases. This is due to the absorption of the photoactive compound (PAC) in the actinic range of the spectrum. So with increasing film thickness exposure dose has to be adjusted to provide sufficient energy also at the bottom of the photoresist, otherwise the pattern cannot be cleared. In extreme cases it becomes almost impossible to expose the resist properly and exposure doses above 1000 mJ/cm² have to be applied. Under these conditions unwanted side effects also appear: the dose at the surface of the photoresist becomes too high and induces crosslinking of the resist. This effect is similar to the well known deep-UV hardening used to preserve the resist profiles at postbake temperatures up to 200°C. Standard resist would also generate too much nitrogen during exposure which, trapped in the thick layer, cannot diffuse fast enough and may lead to lifting of the resist.

For AZ 4500-series photoresists we have chosen a special photoactive compound with low absorption and reduced nitrogen content which enables these resists to be used at thicknesses up to 50 µm. The highest viscosity product AZ 4562 allows to spin coat 10 µm in a single step (2000 rpm). For even higher thicknesses special coating techniques have to be applied:

1. The common spin time of about 30 - 40 seconds is reduced down to only 3 seconds. By this 20 µm are obtained, however the substrate has to be left on the spinner in a horizontal position for another minute to allow for drying.

2. AZ 4562 may be multiple coated with a bake cycle in-between. Due to the high solids content of this resist, which is close to the dissolution limit, the underlying coating will only be dissolved minor. The bake temperatures in-between should not exceed 90°C or the final prebake temperature.

When using high film thicknesses some special guidelines have to be observed: after coating the resist should be kept at room temperature for at least 15 minutes to allow most of the solvent to evaporate before it is put into an oven for prebake. Otherwise the resist surface will dry quite fast and trapped solvent remaining in the bulk may form bubbles and lift the resist film. Adhesion failure is the result. Using a hotplate instead of an oven is the better choice, especially when the temperature is ramped to the final value.

The development process also has to be adopted to the high film thickness: Background for this is the fact that even heavily overexposed positive photoresists only have limited dissolution rates. There is a saturation at values in the order of 100 nm/s. For this it is recommended to operate at development rates of about 2 µm/min. and adjust the exposure dose for proper clearing and feature size.

This resist series is designed for use with any common sodium and potassium based developer. AZ 351B, 1:4 diluted with water is a good choice, AZ 400K may be used as well.

## PHYSICAL and CHEMICAL PROPERTIES

| | AZ 4533 | AZ 4562 |
|---|---|---|
| **Solids content [%]** | 34.5 | 39.5 |
| **Viscosity [cSt at 25°C]** | 125 | 440 |
| **Absorptivity [l/g*cm] at 398nm** | 0.86 | 1.01 |
| **Solvent** | methoxy-propyl acetate (PGMEA) | |
| **Max. water content [%]** | 0.50 | |
| **Spectral sensitivity** | 310 - 440 nm | |
| **Coating characteristic** | striation free | |
| **Filtration [µm absolute]** | 0.2 | |

## FILM THICKNESS [µm] as FUNCTION of SPIN SPEED (characteristically)

| **spin speed [rpm]** | 2000 | 3000 | **4000** | 5000 | 6000 |
|---|---|---|---|---|---|
| **AZ 4533** | 4.67 | 3.81 | **3.30** | 2.95 | 2.69 |
| **AZ 4562** | 8.77 | 7.16 | **6.20** | 5.55 | 5.06 |

## PROCESSING GUIDELINES

| | |
|---|---|
| **Dilution and edge bead removal** | AZ EBR Solvent |
| **Prebake** | 100°C, 50", hotplate |
| **Exposure** | broadband and monochromatic |
| **PEB** | not required, optional with monochromatic exposure |
| **Development** | AZ 351B, 1:4, 30"/µm film thickness |
| **Postbake** | 115°C, 50s hotplate or 60 min. oven |
| **Removal** | AZ 100 Remover, conc. |

## HANDLING ADVISES

Consult the **Material Safety Data Sheets** provided by us or your local agent!
This AZ Photoresists are made up with our patented safer solvent PGMEA. They are **flammable liquids** and should be kept away from oxidants, sparks and open flames.
**Protect from light and heat and store** in sealed original containers between 0°C and 25°C, exceeding this range to -5°C or +30°C for 1 week does not adversely affect the properties.
**Shelf life** is limited and depends on the resist series. The **expiration date** is printed on the label of every bottle below the batch number and coded as **[year/month/day]**.
AZ Photoresists are compatible with most commercially available wafer processing equipment. **Recommended materials** include PTFE, stainless steel and high-density poly-ethylene and -propylene.

# AZ® 4999 Photoresist

## Spray Coating Photoresist

## GENERAL INFORMATION

AZ® 4999 is a spray coating dedicated highly transparent photoresist tailored to excel on special spray coating equipment (e.g. SUSS Delta AltaSpray) where it provides defect free and conformal coatings on devices with severe topography. Thick (several to several tens of microns) and uniform resist coatings are obtained on topography such as V-grooves and trenches with optimum coverage of sharp edges. There is no accumulation of resist in trenches. The use of AZ® 4999 photoresist enables high reproducibility in volume production applications.

## RECOMMENDED PROCESS

| | |
|---|---|
| Softbake: | 100°C, 60 sec, hotplate |
| | or 80°C – 115°C, 30 min, oven |
| | or follow spray coater instructions |
| Exposure: | i-, h-, g-line, broadband and monochromatic |
| Post Exposure Bake (PEB): | not required, optional with monochromatic exposure |
| Developer: | AZ 400K Developer 1:4 |
| | AZ 826 MIF Developer |
| | AZ 351B Developer 1:4 |
| Development Time: | ~ 30 sec per micron resist thickness |

## SUITABLE ANCILLARIES

AZ® EBR 70/30 Edge Bead Remover

AZ® 400T Stripper / AZ® 100 Remover

## PHYSICAL AND CHEMICAL PROPERTIES

| | |
|---|---|
| Viscosity [cSt at 25°C]: | 0.52 |
| Solids content [%]: | 4 |
| Absorptivity [l/(g*cm)] at 398 nm: | 0.1 |
| Spectral sensitivity: | 310 nm – 440 nm |

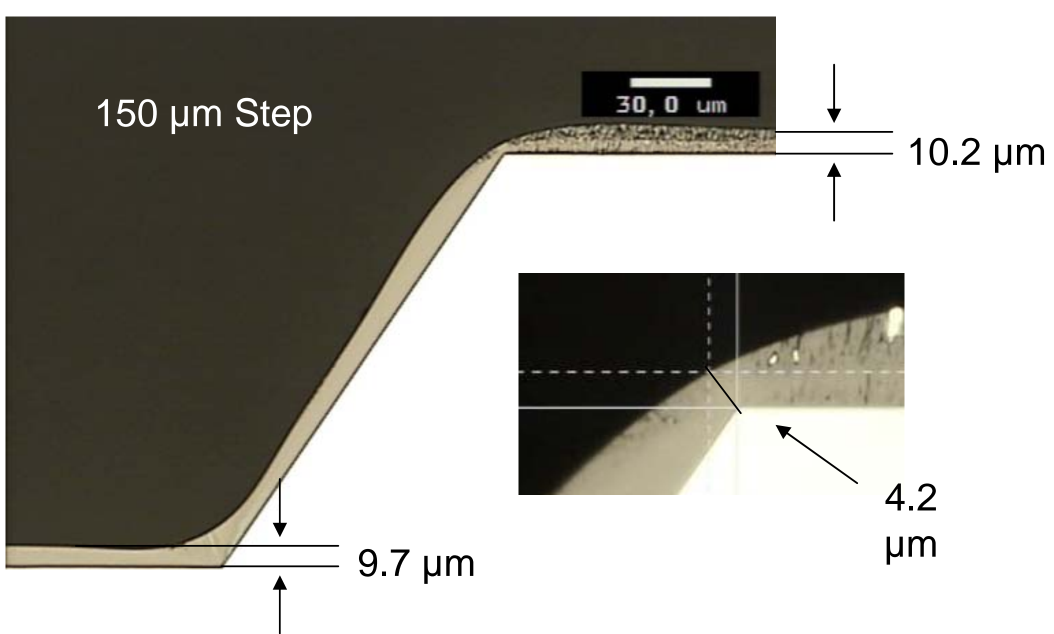
## CAUCHY COEFFICIENTS

| | A | B | C |
|---|---|---|---|
| Unbleached | 1.6154 | 0.010349 µm² | 0.000816 µm⁴ |
| | 1.6154 | 1.0349 x $10^6$ Å² | 8.16 x $10^{12}$ Å⁴ |

## REFRACTIVE INDEX

| | | 633 nm |
|---|---|---|
| Unbleached | n | 1.6463 |
| | k | 0 |

## COATING ON TOPOGRAPHY



# AZ 5214 E

## Image Reversal Photoresist

## GENERAL INFORMATION

This special photoresist is intended for lift-off-techniques which call for a negative wall profile. Although they are positive photoresists (and may even be used in that way) comprised of a novolak resin and naphthoquinone diazide as photoactive compound (PAC) they are capable of image reversal (IR) resulting in a negative pattern of the mask. In fact AZ 5214E is almost exclusively used in the IR-mode.

The image reversal capability is obtained by a special crosslinking agent in the resist formulation which becomes active at temperatures above 110°C and - what is even more important - only in exposed areas of the resist. The crosslinking agent together with exposed PAC leads to an almost insoluble (in developer) and no longer light sensitive substance, while the unexposed areas still behave like a normal unexposed positive photoresist. After a flood exposure (no mask required) this areas are dissolved in standard developer for positive photoresist, the crosslinked areas remain. The overall result is a negative image of the mask pattern.

As everybody knows a positive photoresist profile has a positive slope of 75 - 85° depending on the process conditions and the performance of the exposure equipment (only submicron-resists get close to 90°). This is mainly due to the absorption of the PAC which attenuates the light when penetrating through the resist layer (so called bulk effect). The result is a higher dissolution rate at the top and a lower rate at the bottom of the resist. When AZ 5214E is processed in the IR-mode this is reversed as higher exposed areas will be crosslinked to a higher degree than those with lower dose, dissolution rates accordingly. The final result will be a negative wall profile ideally suited for lift-off.

The most critical parameter of the IR-process is reversal-bake temperature, once optimised it must be kept constant within ± 1°C to maintain a consistent process. This temperature also has to be optimised individually. In any case it will fall within the range from 115 to 125°C. If IR-temperature is chosen too high (>130°C) the resist will thermally crosslink also in the unexposed areas, giving no pattern. To find out the suitable temperature following procedure is suggested:

Coat and prebake a few substrates with resist. Without exposing them to UV-light subject them to different reversal-bake temperatures, i.e. 115°, 120°, 125° and 130°C. Now apply a flood exposure of > 200mJ/cm² and afterwards immerse them into a standard developer make up, i.e. AZ 351B, 1:4 diluted, or AZ 726 MIF for 1 minute. From a part of the substrates the resist will be removed, another part (those exposed to a too high temperature) will remain with the resist thermally crosslinked on it. Optimum RB-temperature now is 5° to 10°C below the temperature where crosslinking starts.

The flood exposure is absolutely uncritical as long as sufficient energy is applied to make the unexposed areas soluble. 200 mJ/cm² is a good choice, but 150 - 500 mJ/cm² will have no major influence on the performance.

Finally it should be noted that the imagewise exposure energy is lower than with normal positive processes, generally only half of that. So a good rule of thumb is: compared to a standard positive resist process, imagewise exposure dose should be half of that, flood exposure energy double of that for AZ 5214E IR-processing.

Once understanding and being familiar with this IR-procedure it is quite simple to set up a different process for lift-off. A T-shaped profile can be achieved by the following process sequence:

The prebaked AZ 5214E photoresist is flood exposed (no mask) with a small amount of UV energy, just to generate some exposed PAC at the surface. Now the reversal-bake is performed to partially crosslink this top areas. By this treatment a top layer with a lowered dissolution rate compared to the bulk material is generated. After this the resist is treated like a normal positive photoresist (imagewise exposure and development) to generate a positive image! Due to the lower dissolution rate in the top layer a T-shaped profile with overhanging lips will be the result.

## PHYSICAL and CHEMICAL PROPERTIES

| | | AZ 5214E | |
|---|---|---|---|
| **Solids content [%]** | | 28.3 | |
| **Viscosity [cSt at 25°C]** | | 24.0 | |
| **Absorptivity [l/g*cm] at 377nm** | | 0.76 | |
| **Solvent** | methoxy-propyl acetate (PGMEA) | | |
| **Max. water content [%]** | 0.50 | | |
| **Spectral sensitivity** | 310 - 420 nm | | |
| **Coating characteristic** | striation free | | |
| **Filtration [µm absolute]** | 0.1 | | |

## FILM THICKNESS [µm] as FUNCTION of SPIN SPEED (characteristically)

| spin speed [rpm] | 2000 | 3000 | **4000** | 5000 | 6000 |
|---|---|---|---|---|---|
| | | | | | |
| **AZ 5214E** | 1.98 | 1.62 | **1.40** | 1.25 | 1.14 |
| | | | | | |

## PROCESSING GUIDELINES

| | |
|---|---|
| **Dilution and edge bead removal** | AZ EBR Solvent |
| **Prebake** | 110°C, 50", hotplate |
| **Exposure** | broadband and monochromatic h- and i-line |
| **Reversal bake** | 120°C, 2 min., hotplate (most critical step) |
| **Flood exposure** | > 200 mJ/cm$^2$ (uncritical) |
| **Development** | AZ 351B, 1:4 (tank, spray) or AZ 726 (puddle) |
| **Postbake** | 120°C, 50s hotplate (optional) |
| **Removal** | AZ 100 Remover, conc. |

## HANDLING ADVISES

Consult the **Material Safety Data Sheets** provided by us or your local agent!
This AZ Photoresists are made up with our patented safer solvent PGMEA. They are **flammable liquids** and should be kept away from oxidants, sparks and open flames.
**Protect from light and heat and store** in sealed original containers between 0°C and 25°C, exceeding this range to -5°C or +30°C for 24 hours does not adversely affect the properties.
**Shelf life** is limited and depends on the resist series. The **expiration date** is printed on the label of every bottle below the batch number and coded as **[year/month/day]**.
AZ Photoresists are compatible with most commercially available wafer processing equipment. **Recommended materials** include PTFE, stainless steel and high-density poly-ethylene and -propylene.

# AZ 6600 Series

General-Purpose
Photoresists

## GENERAL INFORMATION

This series of positive photoresists belongs to the group of ADVANCED PHOTORESISTS. It represents the latest state of the art photoresist series for wet- and dry-etching applications. It is designed for broadband UV4 exposure like projection printers and Ultratech steppers. It may be used on g- or h-line steppers as well providing excellent process latitude. On i-line steppers these resists are extremely fast (only 50 mJ/cm² exposure dose) causing reduced process latitude.
AZ 6600-series gives optimum process latitude at an isofocal bias of 0.2 µm, however zero-bias can be obtained at slightly reduced focus latitude. This lithographic performance was one issue when this series was designed. The background for this is that - especially in Europe - still a lot of semiconductor manufacturers are making discrete semiconductors and bipolar IC's (linear and digital) which for historical reasons have design rules > 1µm. For this kind of processes masks with litho-bias do already exist. Considering this situation we felt it worth do develop a new state-of the-art "general purpose resist". During the last two decades AZ 111-, AZ 1300-, AZ 1400- and AZ 1500-series resists have been the workhorses in this field. They all have certain properties which make them suitable for one or several layers. As a result thereof at least two different types were used. With AZ 6600-series there now is available a single resist family for all applications.
When designing these resists in 1992 we focused on following properties to be a must: **safer solvent**, **excellent adhesion** for wet-etch, **high thermal stability** for dry-etch, compatible with modern **MIF (metal ion free) developers** and **high process latitude**. Our experience of more than 20 years in developing and manufacturing of positive photoresists gave us the basis to achieve this goal.

**Adhesion**
is a very critical, but important parameter for wet-etching. First of all it requires a clean and dry surface. This generally is provided by subjecting the freshly prepared or dehydrated (bake at > 200°C) surface to a priming step with HMDS. By this procedure a hydrophobic surface is generated which prevents absorption of moisture for several days and which is ideally suited for the resist. Unfortunately HMDS is not very effective for aluminium, here a pretreatment with fuming nitric acid is recommended, which optionally may be followed by a HMDS treatment. If prepared in that way AZ 6600 will show excellent adhesion on all surfaces used in semiconductor manufacturing. Meanwhile these resists have proven in several production lines their superior adhesion in wet-etch including aluminium resulting in less undercut, better etch profiles and solving the mouse bite problems.

**Thermal stability**
is required for modern dry-etch equipment where the resist is subjected to reasonably high temperatures. A general solution is to perform a deep-UV hardening cycle before plasma etch. This of course is time consuming (cycle time 2 - 3 min.) and requires special equipment. In many cases it is sufficient to apply a postbake of 130 - 140°C, however the resist should maintain its profile to hit CD's after etch. AZ 6600 does withstand a 130°C bake on a hotplate and up to 140°C in an oven without major degradation of its profile. This is 20°C more than AZ 1500HS-series and often makes a DUV-cure obsolete.

**Lithographic performance**
is of importance for wide process windows. Our experience from developing sub micron resists also helped us to implement a good process latitude into AZ 6600. On a 0.35 NA g-line stepper 1.0 µm features can be printed with 20% exposure margin and 4 µm focus latitude (10% CD tolerance). Like any modern photoresist they are compatible with MIF developers, for best uniformity and fast wetting **AZ 726 MIF** is recommended. Especially for use on aluminium the dyed type **AZ 6618-2DG** is available to suppress reflective notching and to improve focus latitude.

## PHYSICAL and CHEMICAL PROPERTIES

| | AZ 6612 | AZ 6615 | AZ 6618-2DG | AZ 6624 | AZ 6632 |
|---|---|---|---|---|---|
| **Solids content [%]** | 26.5 | 29.0 | 30.1 | 32.0 | 35.0 |
| **Viscosity [cSt at 25°C]** | 19.0 | 27.7 | 34.3 | 58.5 | 82.0 |
| **Absorptivity [l/g*cm] at 398nm** | 1.20 | 1.29 | 1.52 | 1.42 | 1.52 |
| **Solvent** | methoxy-propyl-acetate (PGMEA) | | | | |
| **Max. water content [%]** | 0.50 | | | | |
| **Spectral sensitivity** | 310 - 440 nm | | | | |
| **Coating characteristic** | striation free | | | | |
| **Filtration [µm absolute]** | 0.1 | | | 0.1 | 0.2 |
| **Na, K, Cu, Fe-content** | ≤ 1 ppm | | | | |

## FILM THICKNESS [µm] as FUNCTION of SPIN SPEED (characteristically)

| **spin speed [rpm]** | 2000 | 3000 | **4000** | 5000 | 6000 |
|---|---|---|---|---|---|
| **AZ 6612** | 1.70 | 1.39 | **1.20** | 1.07 | 0.98 |
| **AZ 6615** | 2.12 | 1.73 | **1.50** | 1.34 | 1.22 |
| **AZ 6618-2DG** | 2.55 | 2.08 | **1.80** | 1.61 | 1.47 |
| **AZ 6624** | 3.39 | 2.77 | **2.40** | 2.15 | 1.96 |
| **AZ 6632** | 4.53 | 3.70 | **3.20** | 2.86 | 2.61 |

## PROCESSING GUIDELINES

| **Dilution and edge bead removal** | AZ EBR Solvent |
|---|---|
| **Prebake** | 110°C, 50s, hotplate |
| **Exposure** | broadband, g- and h-line |
| **PEB** | not required, optional with monochromatic exposure |
| **Development** | AZ 726 MIF, stream-puddle, 30 - 50s |
| **Postbake** | 125°C, 50s hotplate or 30 min. oven |
| **Removal** | AZ 100 Remover, conc. |

## HANDLING ADVISES

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**Protect from light and heat and store** in sealed original containers between 0°C and 25°C, exceeding this range to -5°C or +30°C for 1 week does not adversely affect the properties.
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AZ Photoresists are compatible with most commercially available wafer processing equipment. **Recommended materials** include PTFE, stainless steel and high-density poly-ethylene and -propylene.

Product Data Sheet

# PL 177

## General-Purpose Positive Resist

## General

*PL 177* is a positive tone liquid resist for the application in various coating techniques. *PL 177* can be used in all those places, where layouts are directly to be copied onto and subsequently transferred into a substrate by etching, plating, sputtering and related processes. The essential features of **PL 177** include:

- high resolution potential
- good drying behaviour
- aqueous-alkaline processability
- halogen free coating solvent
- possibility of multiple exposure (selective plating process) light or bright day light should be avoided.
- storability of coated substrates
- blue coloured for easy inspection

*PL 177* can be applied by dip coating. By dilution with suitable solvents *PL 177* can be adjusted to also meet the viscosity and drying requirements of other coating techniques (spray coating, roller coating, spin coating). *PL 177* is resistant towards acidic and ammoniacal etchants as well as acidic and neutral plating baths. The final removal of the temporary resist layer, the stripping, is done with low concentrated bases. *PL 177* is used in the manufacturing of printed circuit boards, multilayer inner flexible boards and in chemical milling.

## Physical properties

| | |
|---|---|
| Solid content | 36 % |
| Viscosity at 25°C | l35 $mm^2/s$ |
| Absorptivity at 398 nm | 0.92 l/g·cm |
| Water content | max. 0.5% |

## Storage Conditions

Liquid Resist *PL 177* is to be stored in sealed original containers at temperatures below 25°C. The shelf life under these conditions is a minimum of 1 year from date of manufacturing. *PL177* contains inflammable solvents. Respective safety measures are to be regarded when handling *PL177*.

## Illumination of working areas

Because of its light sensitivity *PL177* and *PL 177* coated substrates should be handled under yellow safety lights. Direct exposure to sun light or bright day light should be avoided. For the illumination of working areas yellow fluorescent lamps are recommended, e.g. Philips 1.2 m TL-D 36 W-1 6, the emission of which does not affect dry film performance. Windows are to be coated by a non-bleachable yellow film which has to be in-transparent for light of wave length below 450 nm. Instead yellow plexi glass plates like Röhm's type Yellow 303 can be used.

## Clean Room Facilities

In general the application of resists of lower thickness results in a more pronounced influence of contaminating particles on the production yield as compared with standard 38 µm dry film resist technology. Especially critical with respect to particle or dust inclusion in the resist are the process steps of coating and drying. A reduction of particle concentration at reasonable cost can be achieved by application of clean room technology in an object scale, just limited to the respective equipment. Depending on technological requirements a clean room class 100 to 10.000 area is suggested.

## Pre-treatment of Surfaces

To assure optimum adhesion on metallic surfaces these have to be free of grease and oxides. This can be assured by mechanical or chemical means.

## Coating

For typical applications *PL 177* is applied in film thicknesses between 3 and 10 µm. For these thicknesses commercial equipment is available for the following coating technologies:

- spray coating
- dip coating
- roller coating
- spin coating

*PL 177* can be adjusted in concentration and viscosity to meet the requirements of all of the above techniques.

## General Remarks to Viscosity Adjustment

It is advisable to dilute the liquid resists immediately before application. In the simple case this is done by vigorous shaking of resist concentrate and thinner in a closed bottle, which should not be filled by more than 75 % of its volume. In any case dilution must result in a homogenous solution. Air bubbles thus included in the liquid normally are easily removed and do not lead to any coating failure.

The replenishing of diluted resist into the coating equipment must be done with a thoroughly homogenated material of well-adjusted viscosity. Dilution must not be done within the coating equipment (dipping vessel, spraying tank) but rather in a separate vessel. The degree of dilution and the choice of thinner depend on the coating technique and the desired resist thickness. Solvent losses due to evaporation are to be compensated with the thinner in use.

When using higher boiling thinners the drying process has to be adjusted depending an the extent of dilution and the resist thickness. The parameters are to be checked by pre tests for the respective case.

## Storage of coated substrates

Coated substrates are to be stored in the dark and - especially for long term storage – at reduced temperature. Under these conditions storage over several weeks has proved to be uncritical with respect to resist performance.

## Viscosity Control, Filtration, Selection of Equipment and Material

Since *PL 177* contains low boiling solvents, it is recommended - especially for dip coating - to keep the coating vessels closed when not in use. A regular control of the viscosity of the resist is recommended. Characteristic data for the dilution of *PL 177* with *AZ EBR Solvent* and the respective viscosity values are given below.

Viscosity reduction of *PL 177* by dilution with *AZ EBR Solvent*

| Dilution by volume (resist : solvent) | 1 : 0.0 | 1 : 0.1 | 1 : 0.2 | 1 : 0.3 | 1 : 0.4 | 1 : 0.5 |
|---|---|---|---|---|---|---|
| Viscosity [mm²/sec] | 135 | 70 | 45 | 30 | 20 | 16 |

When controlling viscosity it has to be considered that it is strongly dependent with temperature. The table below gives the viscosity of undiluted *PL 177* in the temperature range from 20 to 35°C.

Temperature dependence of the viscosity of *PL 177*

| Temperature [°C] | 20 | 22 | 25 | 27 | 30 | 33 | 35 |
|---|---|---|---|---|---|---|---|
| Viscosity [mm²/sec] | 177 | 155 | 135 | 118 | 100 | 84 | 75 |

In practice viscosity control by measuring the drain time of standardised cups has proven useful. For the viscosity range of interest *Zahn Cup 2* or *Zahn Cup 4* is recommended.
Especially in continuously working production facilities increasing contamination of the liquid resist mainly by particles from the substrate material is observed. It therefore is recommended to slowly pump the liquid resist through an appropriate filtration module. The filter size depends on the product specification, good results have been obtained using a 10 µm curled filter.
All equipment and material used in production must withstand the used solvents. Appropriate materials include glass, stainless steel and polytetrafluoro ethylene. The coating rollers should not consist of Viton or EPDM rubber, while the use of butyl rubber offers advantages. In case of doubt the resistance of the material is to be checked in a pre test.

| Resist thickness [µm] | 4 | 6 | 8 | 10 |
|---|---|---|---|---|
| Yield [m²/litre] | 90 | 60 | 45 | 36 |

These calculated values refer to coated area and are to be halved for double sided coating of the substrate.

## Coating

In the following suggestions are given on how to dilute for the various coating techniques. Depending on the specific application the indicated parameters can differ reasonably from the given values. It is therefore recommended to countercheck the optimum dilution conditions prior to running the process.

## Spraying

For cylinder and flat panel coating a fast drying formulation has proved useful, which is obtained from

1.0 volume part *PL 177*
1.0 volume part Methylethylketone (MEK) and
1.0 volume part *AZ EBR Solvent*

Alternatively dilution with pure medium boiling solvent is possible, like:

1.0 volume parts *PL 177*
2.5 volume parts butyl acetate.

The use of solvents with low MAK value (high toxicity) is to be avoided, especially considering dip coating. The spraying process (spray nozzle diameter, spraying air pressure and distance spraying head to substrate) is to be optimised for any specific situation.

## Dip Coating

can be used for the coating of single or double sided copperclad material without metallized through holes. Good results are obtained with the following formulations:

for higher lifting speeds (resist thickness 5.0 µm at 40 cm/min.):
    1.0 volume part *PL 177* and 0.5 volume parts of Methylethylketone (MEK)
for lower lifting speeds (resist thickness 3.0 µm at 20 cm/min):
    1.0 volume part *PL 177* and 0.7 volume parts of Methylethylketone (MEK)

For printed circuit boards with through holes, dip coating is not suitable. To avoid any coating failure the dip coating equipment must be installed shock free. The lifting of the substrate should be performed pneumatically.

## Roller Coating

*PL 177* can be used on all commercial roller coaters with ungravured rollers, using the original concentration.

## Spin Coating

For spin coating of *PL 177* on commercial spin coating equipment the following minimum dilution is suggested:

1.0 volume parts *PL 177*
0.5 volume parts *AZ EBR Solvent*

The desired resist thickness is obtained by adjustment of the rotational speed. Spinning is to be continued until the resist is sufficiently dried to avoid drawing back of the resist to the centre of the substrate.

## Drying

The coated substrates can be dried in IR-, hot air or combination ovens, both of stand-alone or conveyorised type. For resist thicknesses of 3 to 6 um, drying times of 10 to 20 min at 70 to 90°C are recommended. For other thicknesses and in dependence on the dilution by higher or lower boiling solvents other drying parameters have to be used, which are to be determined by test runs.

Not sufficiently dried resist layers can result in sticking of the phototool in the subsequent exposure step or in bubble formation during the evacuation of the exposure frame. During development this can result in partial or overall loss of image. Over dried layers result in prolonged development times.

## Exposure

Before exposure the substrates have to cool down to room temperature. *PL 177* has a maximum photo sensitivity in the spectral range between 340 and 420 nm. Good exposure results are obtained with iron doped or undoped mercury lamps as installed in almost all commercial exposure equipment. The values given in the table below can be considered as a guide line for the exposure of *PL 177* of thickness 7 µm with 5 kW lamps.

Guidelines for exposure of *PL 177*

| Step Wedge BK01: Cu-free | 1 - 2 |
|---|---|
| Stouffer (21 Step): Cu-free | 2 – 3 |
| Exposure Energy (ORC-probe UV 350, through tool) | Approx. 100 mJ/cm² |
| Exposure time (iron doped, 5 kW, MO61 Sylvania) | Approx. 10 sec. |
| HI at 2.5 kW | 8 sec. |
| POK at 2 kW | 20 sec. |

The sensitivity of *PL 177* (for the given optimum step wedge reproduction) depends on resist thickness and drying. The exposure time is to be determined in test runs to include the specific parameters of resist thickness, phototool and exposure equipment. We recommend the use of step wedge BK01 for this purpose. To avoid deviations due to the UV transparency of the applied phototool this is to be placed above the step wedge during the test exposure. Too short exposure times result in resist residues after development, which in subsequent process steps (etching, plating) result in failure.

## Development

Exposed *PL 177* is developed with *AZ 351B Developer*, diluted 1:4 with water in an appropriate vessel (vertically or horizontally). The development time can be reduced by slightly wiping with a wad or a non-fraying cloth or by spraying with the developer solution. Any movement of the developer or the substrate will speed up the development. After development the image must be clean and free of resist residues, since otherwise subsequent etching or plating will result in failure.

Instead of *AZ 351B Developer* (1:4), pure diluted sodium hydroxide solution of 1 wt.% can be used. In this case the optimisation of the parameters for drying, exposure and kind and duration of development have to be done more thoroughly. When using commercial conveyorized equipment the use of NaOH is recommended.

The temperature of the developer should be between 20 and 25°C. Lower temperatures retard development, too high temperatures increase the loss of fine patterns. Underexposed layers result in slower development rate or even in residues which remain in the exposed areas.

The development has to be followed by a thorough water rinse (temp. > 18°C, nozzle pressure 1.0 - 1.5 bar) and subsequent drying. The pH value of the rinsing water should not be below 6.8 to avoid redepositing of dissolved resist components. The calcium and magnesium content ('hardness') of the water should be in a medium range (5 to 10°dH). Good drying after the development offers advantages in subsequent process steps.

It is of particular importance that no developer solution is allowed to dry on the substrate between development and rinsing. Testing for shadow free development can be carried out with sodium persulfate solution, with pre etch solution or with a chemically reductive tin bath.

For correctly exposed resist of a thickness of 4 to 6 µm, the development time in unloaded developer is between 30 and 60 sec. Thinner layers develop at much faster rate, while thicker resist requires longer development.
The aqueous alkaline developer is consumed by the up-take of carbon dioxide from the air. It is therefore recommended to close the development vessels after use or to place the developer in closed bottles.

The table below gives recommendations for a typical development process for *PL 177*.

| Developer type and make-up (7 µm thick *PL 177*) | 1.0% NaOH or alternatively<br>*AZ 351B Developer* 1:4 diluted with D.I. water |
|---|---|
| Developer temperature | 20 – 25 °C |
| Nozzle pressure | 1 – 2 bar |
| Development time (1% NaOH, 25 °C) | Approximately 60 sec. |

Should foaming occur during development with sodium hydroxide, a suitable anti foam agent can be added at a ratio of 0.2 to 1.0 ml per litre. To assure even distribution of the anti foam agent it should be added continuously to the tank by means of a feeding pump. Best results are obtained when the surface active agent is added to the backflow of the developer. Since the developer is free of organic solvents processors made of both stainless steel and plastic (PVC, PP) are suitable.

## Thermal Cure

For the uncritical requirements of the resist in etching of easily etched materials in typical acidic or ammoniacal etchants no additional curing step is required. However, for etching of difficult to etch materials (like steel or steel alloys) requiring in general rather long etching times, an additional thermal cure of the resist is recommended. This also applies for subsequent plating processes in critical plating baths.

For difficult to etch metals a thermal cure of 10 to 30 min. at 160 to 190° C is suggested. Fine tuning of both curing time and temperature mainly depends on the etchability and the thickness of the metal. For critical plating processes curing of 10 to 30 min. at 120°C normally is sufficient.

## Retouch

As the resist is non-soluble in pure aliphatic and aromatic hydrocarbons they can be retouched before etching, plating or sputtering. Retouch can be done with benzene based varnishes, like asphalt varnish. Deletions can be done with *PL 177* resist.

## Etching

The residual resist after development is resistant towards all common etchants, thus yielding well defined images, conductor patterns or milled parts. Sufficient resistance is also obtained for ammoniacal etchants as long as the residual resist is protected from light. Concentration and type of etchant are to be chosen as to assure minimum undercutting in the etching step, while keeping etch times as short as possible. Etching can be performed at increased temperatures. Towards weakly alkaline or buffered alkaline solutions up to pH 9, *PL 177* shows limited or short-term resistance.

## Plating

The residual resist after development is sufficiently resistant towards all common acidic and neutral plating baths as long as proper pre-treatment of the metal surface is assured. The recommendations of the bath supplier, especially in terms of current density, are to be followed. A further requirement for accurate plating is a uniform coating. Film thickness not below 8 µm are therefore suggested. For non-critical baths (like nickel sulfamate or brilliant tin) a thermal cure of the sufficiently thick resist layer is not necessary. Due to the variety of commercial plating baths general recommendations are difficult to be given. In case of doubt a test run is suggested.

## Stripping

Positive liquid resists can be removed:

- by flood exposure and subsequent development
- by rinsing with polar solvents like acetone
- by rinsing with 4 to 30 % sodium hydroxide or
- potassium hydroxide at elevated temperature (ref.: 50°C)

Resist, which has been cured at temperatures above 120°C is to be removed by 10 to 30% alkali at elevated temperature. An increase in stripping speed is obtained by mechanical aid of the stripping process by spraying or wiping or by addition of solvent. In case of doubt, especially with roughened surfaces, a test run is suggested.

## Waste Disposal and Environmental Aspects

The working up of resist loaded developer solutions and rinsing waters can be done in neutralisation equipment by addition of acid. The pH value of the used developer solution is about 13. By acidification to pH 3 most of the dissolved organic material is precipitated and can be removed by filtration. The waste water loading is thus reasonably reduced. Before draining the solution is to be adjusted to pH 6.5 to 9. The regulations of the local water authorities are to be observed.

The pH value of loaded aqueous alkaline stripper solutions is about 13.5. Working up follows the process outlined above. The so obtained solid waste and solvent containing stripper solutions are to be deposited or alternatively incinerated in locally authorised sites.

## Safety informations

Skin contact with uncovered resist as well as with the processed developer is to be avoided to prevent allergic reactions particularly of people with sensitive skin. It is suggested to coat in a well-ventilated room. Preferably the coater should be installed under a hood. The exhaust air from the drying unit is to be removed in suitable form.

All directions contained in our material safety data sheets must be adhered to.

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**Clariant GmbH**
Business Unit
Electronic Materials
Rheingaustrasse 190
D-65203 Wiesbaden
**Germany**
Tel. +49 (611) 962-6867
Fax +49 (611) 962-9207

**Clariant Corporation**
Business Unit
Electronic Materials
70 Meister Avenue
Somerville, NJ 08876-1252
**USA**
Tel. +1 (908) 429-3500
Fax +1 (908) 429-3631

**Clariant (Japan) K.K.**
Business Unit
Electronic Materials
9F Bunkyo Green Court Center
2-28-8 Honkomagome Bunkyo-Ku
**Tokyo 113, Japan**
Tel. +81 (3) 5977-7973
Fax +81 (3) 5977-7894

**Clariant Industries Ltd.**
Business Unit
Electronic Materials
84-7, Chungdam-dong,
Kangnam-ku
**Seoul Republic of Korea**
Tel. +82 (2) 510-8000/8442
Fax +82 (2) 514-5918

# AZ® MiR™ 701 Photoresist



## Product Description

AZ® MiR™ Series photoresists are fast, cost effective resists designed for replacement of older mid-range production resists. The AZ MiR series resists work well in both surfactated and non-surfactated TMAH developers using standard process conditions.

AZ MiR 701 photoresist is designed for production use at 0.30µm to 0.40µm CDs.

| Features | Benefits |
|---|---|
| • High Throughput | i-line DTP ~ 190mJ/cm$^2$ |
| • Cross over Exposure Capable | Mix/match with i-line, g-line, or broadband |
| • Wide process latitude | Production processing 0.30µm - 0.40µm features |
| | 1.4µm DOF @ 0.35µm |
| | 1.4µm DOF @ 0.30µm |
| • Thermal Stability | >125°C dependent on process conditions |

### Standard Process Conditions

Coat : 0.974µm Emax thickness

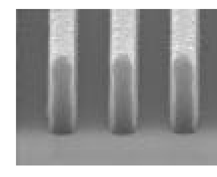
SB : 90°C for 60sec (proximity)

Expo : ASML/250 @ NA=0.60

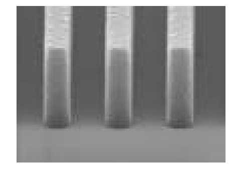
PEB : 110°C for 60sec (proximity)

Develop : AZ® 300MIF for 60sec
single puddle @ 23°C

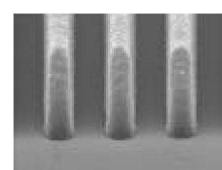
DOF @ 0.35µm Feature



-0.8µm

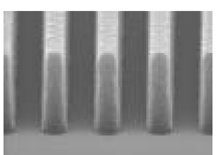


0.0µm



+0.6µm

0.30µm Features @ 180mJ



### Modelling Parameters

Refractive Index

| | 365nm | 436nm |
|---|---|---|
| n | 1.7039 | 1.6917 |
| k | 0.0214 | 0.0189 |

Dills :

A = 0.7090 B = 0.0342 C = 0.0220

Cauchies :

unbleached

A = 1.6104 B = 0.00505µm$^2$ C = 0.00171µm$^4$

bleached

A = 1.6057 B = 0.00673µm$^2$ C = 0.00094µm$^4$

Thermal Stability 1µm Features

115°C

130°C

# AZ® MiR™ 701 Photoresist



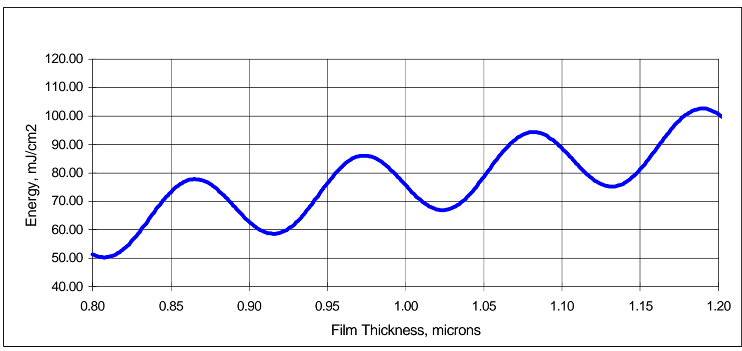
**Storage**
Keep in sealed original containers away from oxidants, sparks, and open flame. Protect from light and heat. Keep refrigerated. Recommended storage temperature of 45°F. Empty container may contain harmful residue and/or vapors. Dispose of appropriately.

**Equipment Compatibility**
AZ MiR 701 photoresist is compatible with all commercially available wafer and photomask processing equipment. Recommended materials of construction include stainless steel, glass, ceramic, PTFE, polypropylene, and HDPE.

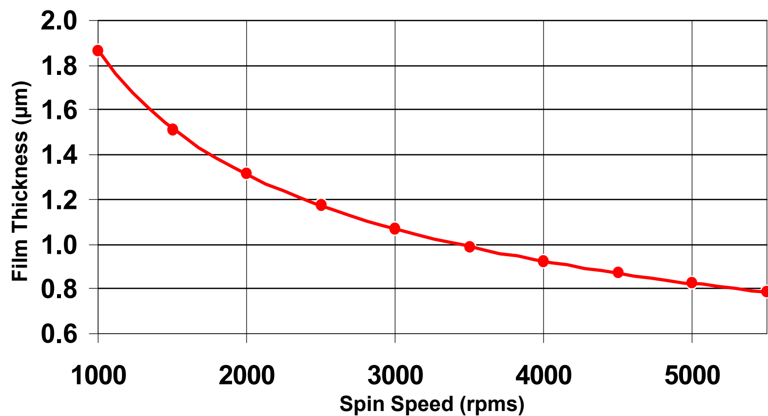
**Solvent Safety**
AZ MiR 701 photoresist is formulated with a mixture of PGMEA and EL safer solvents. We recommend AZ EBR 70/30 as a compatible solvent for EBR processing, resist cleaning, basic resist stripping and re-work.

**Handling Precautions / First Aid**
Refer to current Material Safety Data Sheet (MSDS) for detailed information prior to handling.

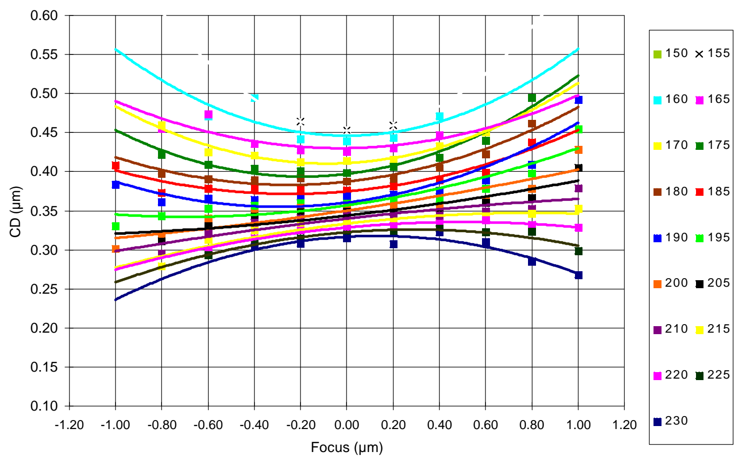
i-line Swing Curve



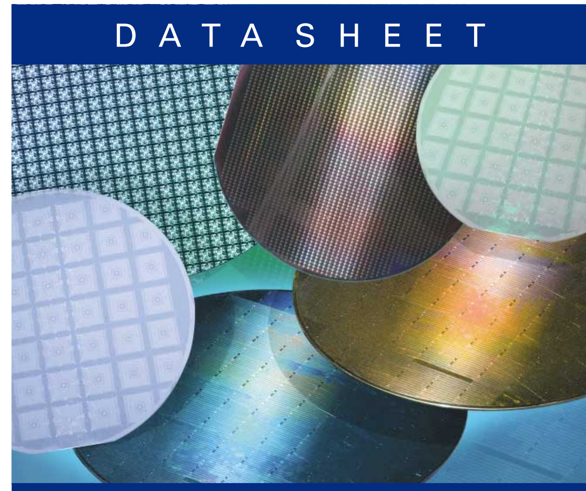

Spin Speed Curve on 150mm wafer




Bossung plot 0.35µm isolated lines




Contact your local **Clariant-*AZ* Electronic Materials** Representative for further information at the following locations:
Somerville, NJ: 800.515.4164
Dallas, TX: 800.422.3884
San Jose, CA: 408.616.2100



DATA SHEET

# AZ® nLOF™ 2000 Series i-Line Photoresists

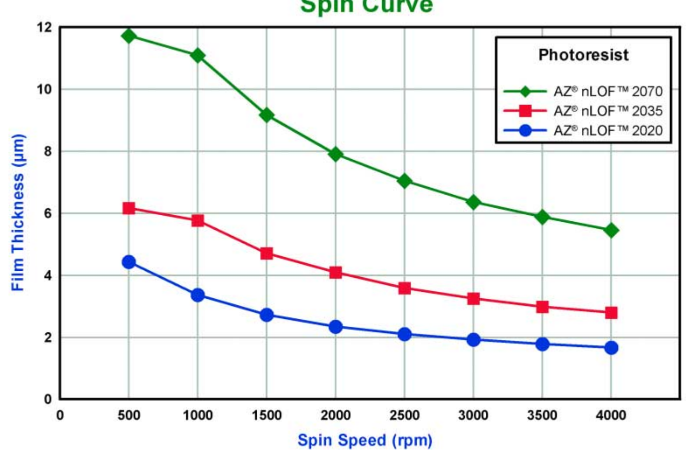
## Description

AZ® nLOF™ 2000 series i-line photoresists are uniquely formulated to simplify the historically complex lift-off lithography process. They make it possible to run a standard lithography process to get the desired lift-off profiles. The nLOF 2000 series photoresists work well in both surfactant and non-surfactant containing tetramethylammonium hydroxide (TMAH) developers using standard conditions. The nLOF 2000 series photoresists can be used for coating thicknesses beyond 7.0 µm, achieving aspect ratios of up to 4:1.

| Features | Benefits |
|---|---|
| High throughput | • i-line dose to print < 100 mJ/cm² for film thicknesses 2.0 to 3.5 µm |
| Streamlined lift-off process | • Standard single-layer lithography process to achieve lift-off profiles; no extra process steps required |
| Process compatibility | • Easy integration into an existing process with standard processing conditions |
| Process versatility | • Obtain lift-off profiles with resist thickness > 7.0 µm, with uniform profiles up to 4:1 aspect ratios |

## Recommended Process

| | |
|---|---|
| Coat: | 2.0 µm resist thickness |
| Softbake: | 110°C, 60 sec, contact |
| Exposure: | Nikon, 0.54 NA, 65 mJ/cm² |
| Post-Exposure Bake: | 110°C, 60 sec, contact |
| Develop: | AZ® 300 MIF Developer, 23°C |
| Develop Cycle: | 120 sec, single puddle |

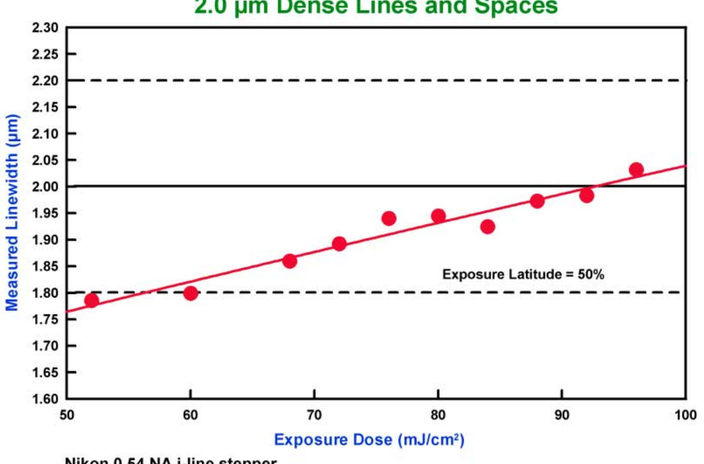


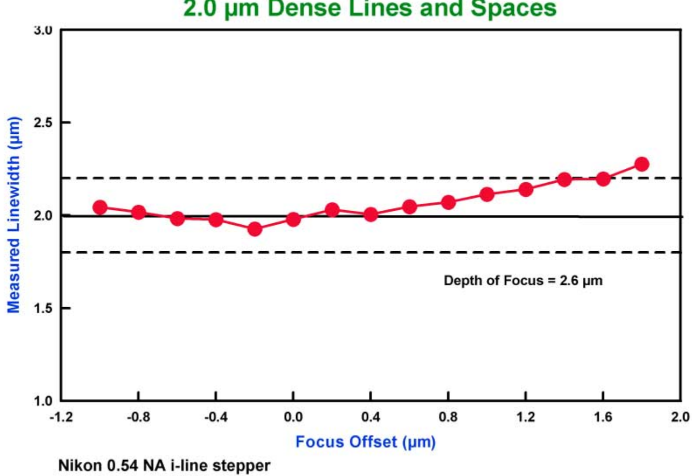

## Performance Summary

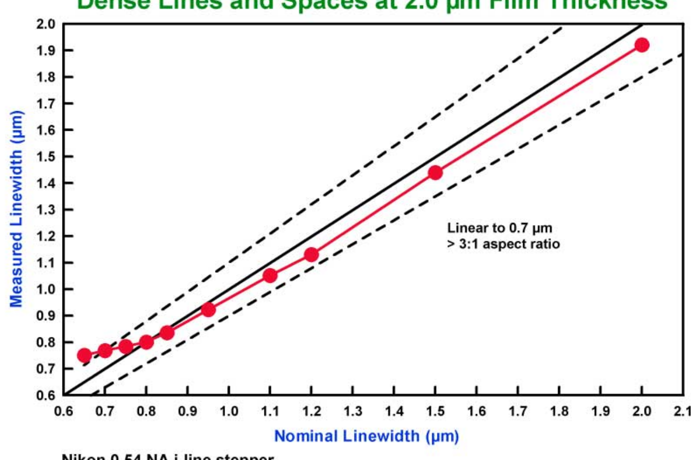
| | Nominal Film Thickness at 3000 rpm | Process Capability | Photospeed |
|---|---|---|---|
| AZ® nLOF™ 2020 Photoresist | 2.0 µm | 0.7 µm CD | 66 mJ/cm² |
| AZ® nLOF™ 2035 Photoresist | 3.5 µm | 0.9 µm CD | 80 mJ/cm² |
| AZ® nLOF™ 2070 Photoresist | 7.0 µm | 1.5 µm CD | 180 mJ/cm² |

# AZ® nLOF™ 2000 Series i-Line Photoresists

## Performance

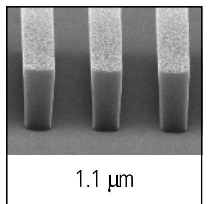


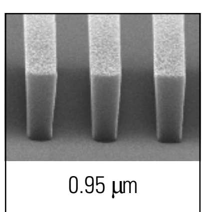



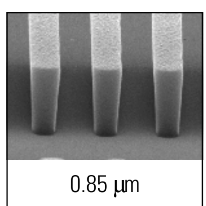



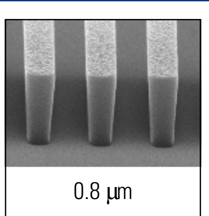
## Performance *(continued)*

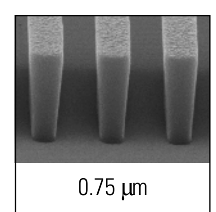
**Resolution** AZ® nLOF™ 2020 Photoresist, 66 $mJ/cm^2$, 0.54 NA i-line stepper, 2.0 µm film thickness, 60 sec single puddle develop

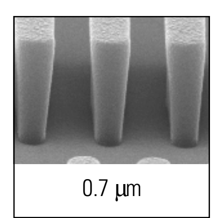

1.1 µm


0.95 µm

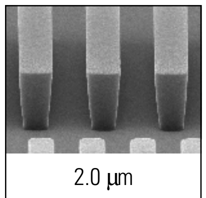

0.85 µm

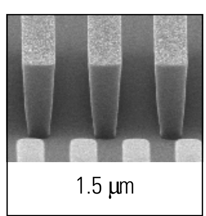

0.8 µm

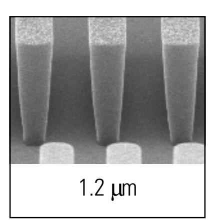

0.75 µm

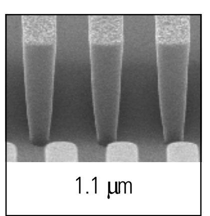

0.7 µm

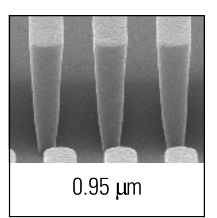
**Resolution** AZ® nLOF™ 2035 Photoresist, 80 $mJ/cm^2$, 0.54 NA i-line stepper, 3.5 µm film thickness

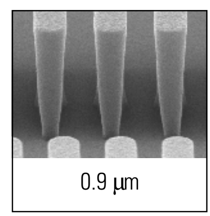

2.0 µm


1.5 µm

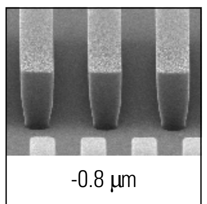

1.2 µm

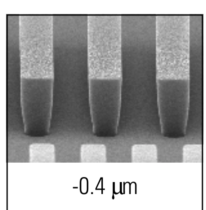

1.1 µm

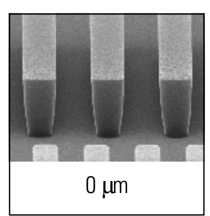

0.95 µm

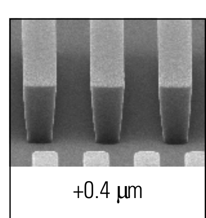

0.9 µm

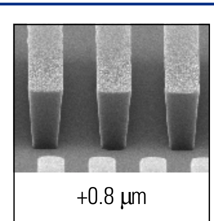
**Focus Latitude** AZ® nLOF™ 2035 Photoresist, 2.0 µm dense lines, 80 $mJ/cm^2$, 0.54 NA i-line stepper, 3.5 µm film thickness

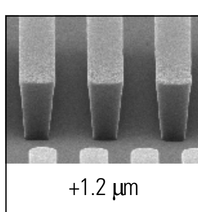

-0.8 µm


-0.4 µm


0 µm


+0.4 µm


+0.8 µm


+1.2 µm

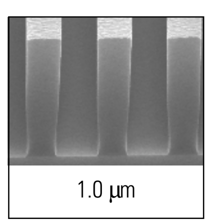
**Metal Lift-Off** AZ® nLOF™ 2035 Photoresist, 98 $mJ/cm^2$, 0.60 NA i-line stepper, 3.5 µm film thickness

### *Dense Lines and Spaces*

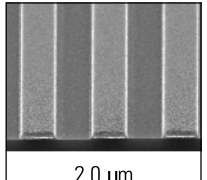
before

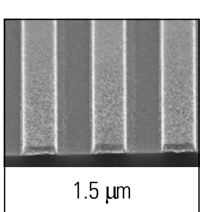
2.0 µm

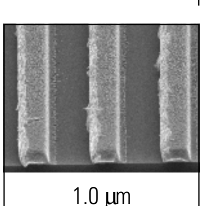
1.5 µm


1.0 µm

after

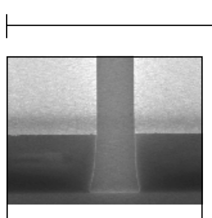

2.0 µm

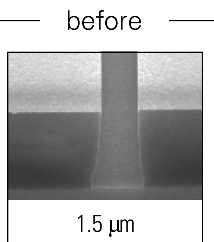

1.5 µm

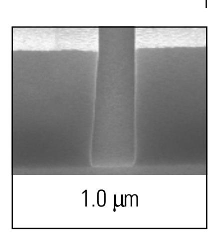

1.0 µm

### *Trenches*

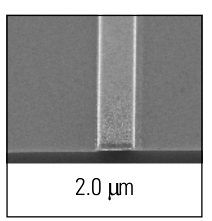
before

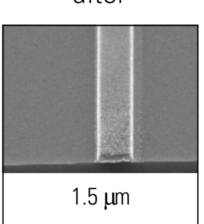

2.0 µm

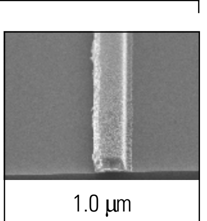

1.5 µm


1.0 µm

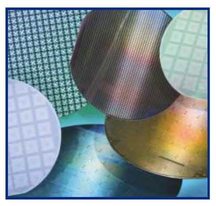
after


2.0 µm


1.5 µm


1.0 µm

Using recommended process unless otherwise noted.



# AZ® nLOF™ 2000 Series i-Line Photoresists

## Companion Products

| | |
|---|---|
| Wafer Prime: | AZ® Adhesion Promoter |
| Edge Bead Process: | AZ® EBR 70/30 Edge Bead Remover |
| Develop Cycle: | AZ® 300 MIF Developer |
| Stripping: | AZ® Kwik Strip™ Remover, AZ® 300T and 400T Strippers |

## Solvent Safety

AZ® nLOF™ 2000 series photoresists are formulated using 100% propylene glycol monomethyl ether acetate (PGMEA), which is patented for use in photoresists by Clariant AG (U.S. patent number 4,550,069).

## Equipment Compatibility

AZ nLOF 2000 series photoresists are compatible with all commercially available wafer and photomask processing equipment. Recommended materials of construction include stainless steel, glass, ceramic, PTFE, polypropylene, and high density polyethylene.

## Storage

Keep in sealed original containers away from oxidants, sparks, and open flame. Protect from light and heat. Keep refrigerated. Empty container may contain harmful residue and/or vapors.

## Handling Precautions/First Aid

Refer to the current Material Safety Data Sheet (MSDS) for detailed information prior to handling.


**U.S. Headquarters Office:**

Clariant Corporation
AZ Electronic Materials
70 Meister Avenue
P.O. Box 3700
Somerville, NJ 08876
(908) 429-3500
(908) 429-3631 fax
**www.azresist.com**

**Regional Sales and Service Offices:**

United States and Canada:

Clariant Corporation
AZ Electronic Materials
Somerville, NJ (800) 259-9160
San Jose, CA (408) 501-3940
Dallas, TX (214) 570-4320

Europe and Far East:

Clariant GmbH
Wiesbaden 49 (611) 962-6867

Clariant (Japan) K.K.
Tokyo 81-3-5977-7937

Clariant Industries Limited (Korea)
Seoul 82-2-510-8000

Clariant (Taiwan) Co., Ltd.
Taipei 886-2-2516-6886

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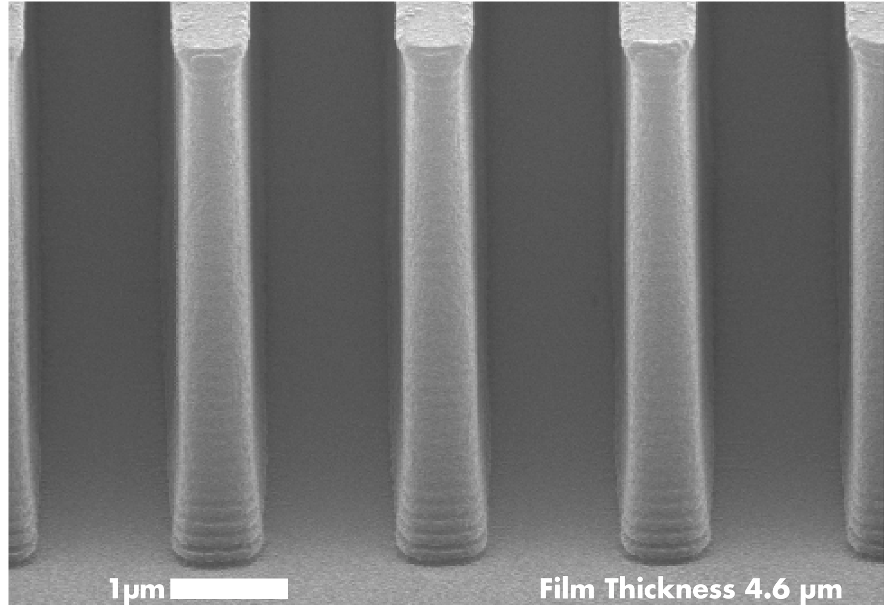
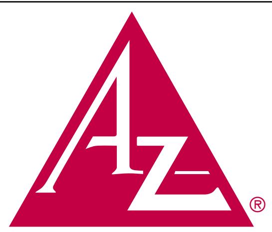


# AZ® 9200 Photoresist

## High-Resolution Thick Resist

AZ® 9200 thick film photoresist is designed for the more demanding higher-resolution thick resist requirements. It provides high resolution with superior aspect ratios, as well as wide focus and exposure latitude and good sidewall profiles. AZ® 9200 photoresist is available in two viscosity grades for film thicknesses of 4 to 24 µm. Critical dimension resolutions range from < 1 µm lines and spaces at a film thickness of 4.6 µm, to 3.5 µm lines and spaces at a film thickness of 24 µm on silicon using today's standard broadband exposure tools. Aspect ratios of 5 – 7 can be achieved.

Under the guidance of leading thin film recording head manufacturers, AZ® 9200 photoresist is optimized for both coil plating and top pole recording head applications.

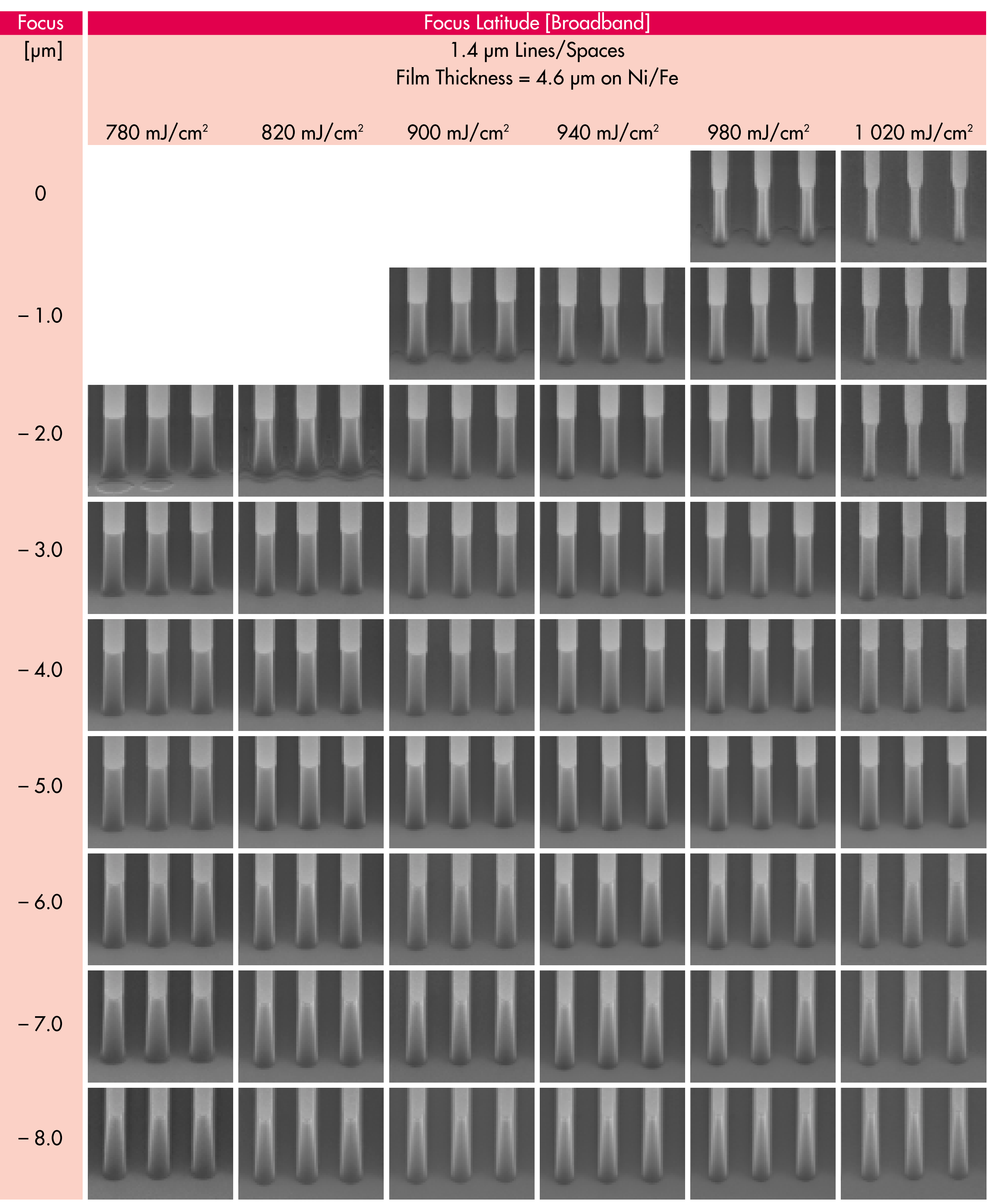
AZ® 9200 photoresist can be used as a higher resolution replacement for AZ® P4000 photoresist. It can be processed on the same exposure tools using similar processing conditions; it is developed from the same chemistry and has similar curing, electrical and thermal properties.

Sensitivity to both h- and i-line makes AZ® 9200 photoresist capable for both broadband and i-line steppers.

Recommended developers are inorganic based upon potassium hydroxide. The preferred developer is AZ® 400K Developer 1:4, a buffered developer designed to maximize bath life and process stability. For integrated circuit applications, TMAH developers such as AZ® 300 MIF developer can be used.

| Linewidth [μm] | Linearity [Broadband] Film Thickness = 4.6 μm on Ni/Fe | | | | | |
|---|---|---|---|---|---|---|
| | 780 mJ/cm² | 820 mJ/cm² | 900 mJ/cm² | 940 mJ/cm² | 980 mJ/cm² | 1 020 mJ/cm² |
| 2.0 | | | | | | |
| 1.40 | | | | | | |
| 1.20 | | | | | | |
| 1.10 | | | | | | |
| 1.0 | | | | | | |
| 0.95 | | | | | | |
| 0.90 | | | | | | |
| 0.80 | | | | | | |

Softbake Hotplate 110°C, 120 sec
Exposure Ultratech Model 1500 stepper, 0.315 NA
Focus = –5 μm
AZ® 400K Developer 1:4, 180 sec spray at 27°C




Softbake Hotplate 110°C, 120 sec
Exposure Ultratech Model 1500 stepper, 0.315 NA
AZ® 400K Developer 1:4, 180 sec spray at 27°C

## Linearity and Latitude [Broadband]

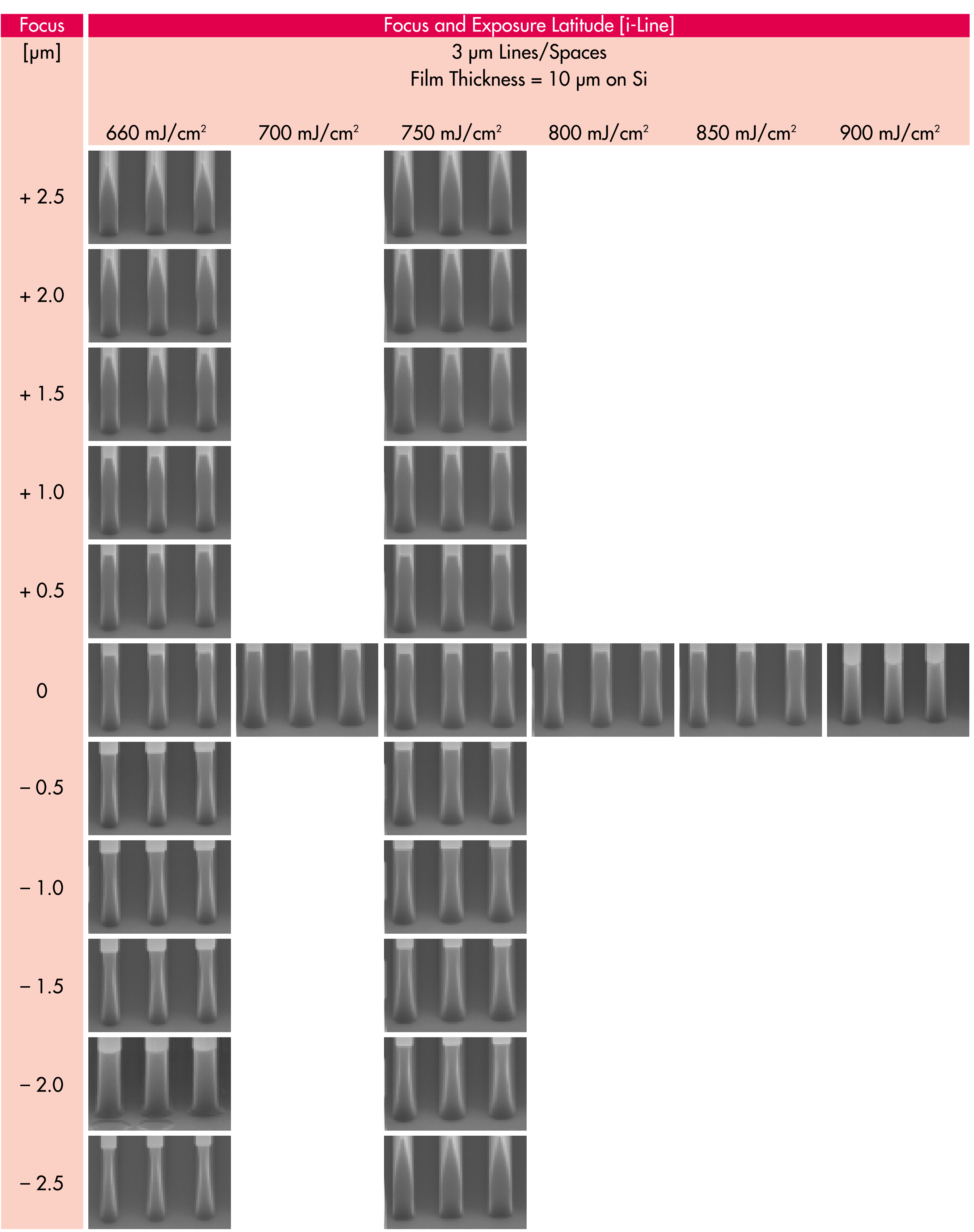
6 µm Lines/Spaces

Film Thickness = 24 µm on Si

| Linewidth [µm] | 1 850 mJ/cm² |
|---|---|
| 8.0 | |
| 7.0 | |
| 6.0 | |
| 5.0 | |
| 4.0 | |
| 3.5 | |

| Focus [µm] | 1 850 mJ/cm² | 2 030 mJ/cm² | 2 210 mJ/cm² |
|---|---|---|---|
| + 1 | | | |
| – 1 | | | |
| – 3 | | | |
| – 5 | | | |
| – 7 | | | |
| – 9 | | | |
| – 11 | | | |
| – 13 | | | |

Softbake Hotplate 110°C, 240 sec
Exposure Ultratech Model 1500 stepper, 0.315 NA
AZ® 400K Developer 1:4, 260 sec spray at 27°C




Softbake Hotplate 90°C, 155 sec
Exposure NIKON® i-line stepper, 0.54 NA
AZ® 300 MIF Developer, 360 sec spray at 22°C

| Typical Process for 4.6 µm Film Thickness [AZ® 9245 Photoresist (220 CPS)] | |
|---|---|
| Coat | Dispense: static or dynamic @ 300 rpm<br>Spin: 3 800 rpm, 60 sec |
| Softbake | 110 °C, 120 sec hotplate |
| Edge Bead Removal | Rinse: 500 rpm, 10 sec<br>Dry: 1 000 rpm, 10 sec |
| Exposure (10% bias) | 900 mJ/cm², broadband stepper |
| Post Exposure Bake | not recommended in most applications |
| Development | AZ® 400K Developer 1:4, 120 sec spray<br>Dispense temp. 27 °C<br>Rinse: 300 rpm, 20 sec.<br>Dry: 4 000 rpm, 15 sec. |

| Typical Process for 10 µm Film Thickness [AZ® 9260 Photoresist (520 CPS)] | |
|---|---|
| Coat | Dispense: static or dynamic @ 300 rpm<br>Spin: 2 400 rpm, 60 sec |
| Softbake | 110 °C, 165 sec hotplate |
| Edge Bead Removal | Rinse: 500 rpm, 10 sec<br>Dry: 1 000 rpm, 10 sec |
| Exposure (10% bias) | 1 500 mJ/cm², broadband stepper |
| Post Exposure Bake | not recommended in most applications |
| Development | AZ® 400K Developer 1:4, 180 sec spray<br>Dispense temp. 27°C<br>Rinse: 300 rpm, 20 sec.<br>Dry: 4 000 rpm, 15 sec. |

| Typical Process for 24 µm Film Thickness [AZ® 9260 Photoresist (520 CPS)] | |
|---|---|
| First Coat | Target: 10 µm film thickness<br>Dispense: static or dynamic @ 300 rpm<br>Spin: 2 400 rpm, 60 sec |
| Edge Bead Removal | Rinse: 500 rpm, 10 sec<br>Dry: 1 000 rpm, 10 sec |
| First Softbake | 110 °C, 80 sec hotplate |
| Second Coat | Target: 24 µm total film thickness<br>Dispense: static or dynamic @ 300 rpm<br>Spin: 2 100 rpm, 60 sec |
| Edge Bead Removal | Rinse: 500 rpm, 10 sec<br>Dry: 1 000 rpm, 10 sec |
| Second Softbake | 110 °C, 160 sec hotplate |
| Exposure Dose (10% bias) | 2 100 mJ/cm², broadband stepper |
| Post Exposure Bake | not recommended in most applications |
| Development | AZ® 400K Developer 1:4, 260 sec spray<br>Dispense temp. 27°C<br>Rinse: 300 rpm, 20 sec.<br>Dry: 4 000 rpm, 15 sec. |

Note: Recommendations on single-coat 24 µm processes are also available

## Thermal Comparison

Results after 2 Minutes at Temperature

Vacuum Chuck Hotplate

| | AZ® 9260 Photoresist | AZ® P4620 Photoresist |
|---|---|---|
| No Bake | | |
| 110°C | | |
| 115°C | | |
| 120°C | | |
| 125°C | | |

Film Thickness = 24 μm on Si

Softbake Hotplate 110 °C, 120 sec

| Film Thickness | 2 000 rpm | 2 500 rpm | 3 000 rpm | 3 500 rpm |
|---|---|---|---|---|
| AZ® 9245 Photoresist 220 cP | 6 600 Å | 5 800 Å | 5 200 Å | 4 800 Å |
| AZ® 9260 Photoresist 520 cP | 11 400 Å | 9 600 Å | 8 800 Å | 7 900 Å |

| Electrical Properties | 200 °C | 225 °C | 250 °C |
|---|---|---|---|
| Dielectric Constant | 4.03 | 4.37 | 4.90 |
| Breakdown Voltage (v/μm) | 694 | 642 | 600 |

| Modeling Parameters | | | |
|---|---|---|---|
| Cauchy Coefficients (unexposed) | $N_1 = 1.61406$ | $N_2 = -0.00087\ \mu m^2$ | $N_3 = -0.00196\ \mu m^4$ |
| Cauchy Coefficients (exposed) | $N_{1'} = 1.60843$ | $N_{2'} = 0.00994\ \mu m^2$ | $N_{3'} = -0.00165\ \mu m^4$ |

## Companion Products

**Developers:** AZ® 400K Developer 1:4 is the recommended developer for thick films of AZ® 9200 photoresist. This developer may be used for both spray and immersion development processes. AZ® 400K is a buffered potassium-based developer that provides the process latitude associated with inorganic developers while minimizing the risk associated with mobile ion contamination.

AZ® 300 MIF Developer, a standard non-surfactant TMAH developer, can be used with AZ® 9200 photoresist for high resolution IC applications.

**Strippers:** AZ® 400T and 300T strippers are recommended for removal of AZ® 9200 photoresist. AZ® S-46 stripper is a non-NMP sovent stripper particularly suited to thin film recording head applications.

**Edge Bead Removers:** AZ® EBR 70/30 and AZ® EBR solvent are recommended for AZ® 9200 photoresist for both front- and back-side edge bead removal.

## Solvent Safety

AZ® 9200 photoresist is formulated with propylene glycol monomethyl ether acetate (PGMEA), a safer solvent patented by Hoechst Celanese Corp. for use in photoresists (U.S. patent number 4,550,069). This is one of the safest and most thoroughly tested solvents in the industry.

## Equipment Compatibility

AZ® 9200 photoresist is compatible with all commercially available wafer and photomask processing equipment. Recommended materials of construction include stainless steel, glass, ceramic, PTFE, polypropylene, and high-density polyethylene.

## Storage

Keep in sealed original container. Protect from light and heat. Store between 30 and 70°F (–1 to 24°C). Refrigerate whenever possible. Refrigeration may extend shelf life. Empty container may contain harmful residue and vapors.

## Handling Precautions
### First Aid

Refer to the current Material Safety Data Sheet (MSDS) for detailed information prior to handling.

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Clariant GmbH
Business Unit Electronic Materials
D-65174 Wiesbaden
Germany
Tel. +49 (611) 962 - 6867
Fax +49 (611) 962 - 9207

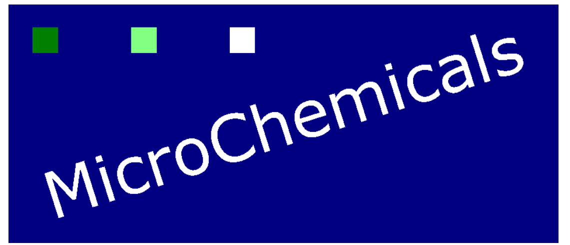
Clariant Corporation
Business Unit Electronic Materials
70 Meister Avenue
Somerville, NJ 08876-1252
USA
Tel. +1 (908) 429 - 3500
Fax +1 (908) 429 - 3631

Clariant (Japan) K.K.
Business Unit Electronic Materials
10-16 Akasaka 8-chome,
Minato-ku, Tokyo 107
Japan
Tel. +81 (3) 3479 - 5120
Fax +81 (3) 3479 - 4770

Clariant Industries Ltd. (Korea)
Business Unit Electronic Materials
84-7, Chungdam-dong,
Kangnam-ku
Seoul, Rep. of Korea
Tel. +82 (2) 510 - 8000/8442
Fax +82 (2) 514 - 5918

# TI 35E
# image reversal resist

## Technical Data Sheet
revised 09/2002




MicroChemicals GmbH
Schillerstrasse 18
D-89077 Ulm
Fon +49 (0) 731 36080409
Mobil +49 (0) 177 3332453
Fax +49 (0) 731 1517024
Email info@MicroChemicals.com
Internet www.microchemicals.com

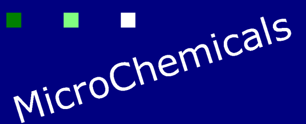
## General Information

The TI 35E resist is specially designed for the application in the so called "image reversal technology" for:

- subsequent **lift-off** of deposited layers
- **wet chemical** treatment in HF containing etching solutions
- direct **mesa grooving**.

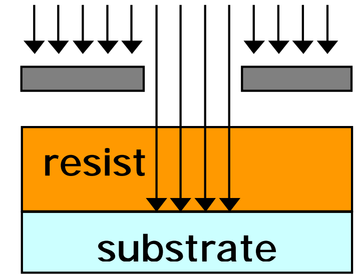
The viscosity of the resist leads to a thickness range depending on the spin-speed from 3.0-4.5 µm. With spin-speed of 3000 rpm a resist thickness of 3.6 µm will be achieved that enables lift-off of evaporated solids up to a thickness of 6 µm. The typical aspect ratio of the structured features achievable is in the range of 1.6 .. 2.0.

This technical data sheet intends to give you a guide-line for process parameters for various applications. However, the optimum values for e.g. spin profile, exposure dose, or development depend on the individual equipment and need to be adjusted on each individual demand.

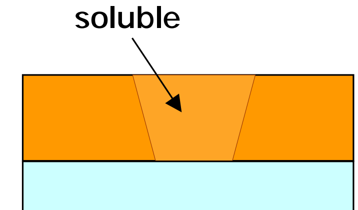



# 'Image Reversal' – A Short Introduction

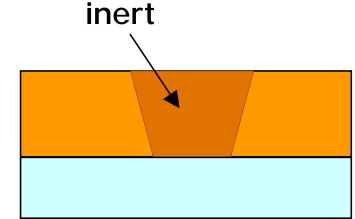
## What 'image reversal' generally means



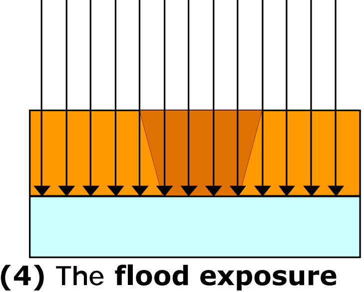

**(1) Exposure** using an inverted mask (the exposed areas finally remain)



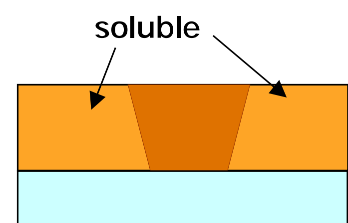

**(2)** The resist now would behaves like an exposed positive resist.



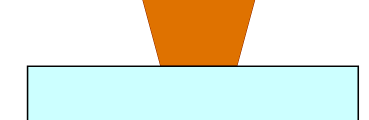

**(3)** The **reversal bake** cross-links the exposed area, while the unexposed area remains photo-active



**(4)** The **flood exposure** (without mask) …




… **(5)** makes the resists, which was not exposed in the first step, soluble in developer



**(6)** After developing, the areas exposed in the first step now remain

## … and for what image reversal is good for:

® High **stability** for wet-chemical etching allows the usage of the inverted TI 35E as mask for **wet-chemical etching under harsh conditions**

## TI 35E – Fields of Application

### Lift-off of PECVD layers

- Amorphous Si layer deposited in device quality at 110°C
- Amorphous $SiN_x$

### Lift-off of sputtered layers

- Due to non-directional deposition, lower thickness achievable (approx. 1 µm)
- Possibly ultra sonic treatment necessary
- Liftability dependent on operating pressure

### Etching of $SiN_x$ in BHF (12.5%HF)

- $SiN_x$ deposited at 400 °C with PECVD
- Hardbake at 125°C (Hotplate) for two minutes
- No visible degradation of resist after 10 min etching time
- Enables structuring of SiN up to at least 100 nm (tested)
- Use ammonia during $SiN_x$ deposition to increase adhesion of the resist on the surface
  (For harsh chemical attack prefer the use of TI 35E)

### Etching of thick thermal $SiO_2$ with 20 % HF

- No visible degradation of the resist after 10 min
- Possible etching in HF conc. (50%) for several minutes
  (For harsh chemical attack prefer the use of TI 35E)

### Direct mesa grooving

- TI series resists allow direct Si etching without $SiO_2$ masking
- Hardbake at 120-145°C for 2 min necessary
- Use **$HNO_3$** (70%) : **HF** (50 %) : **$H_2O$** = **75 : 10 : 25** as etching solution and TI 35E resist **in reversal mode**, groove up to 4 µm in 45s

## Technological Requirements

Since the TI 35E yields an inverted structure in the image reversal mode, an inverted exposure mask is needed. Beyond this, compared to standard positive resist processing, **no further upgrade** in existing technological infrastructure is necessary.

Also compared to standard positive resist processing, applying the TI 35E implements just two further process steps: The **reversal bake** and the **flood exposure** without mask, both very easy to be performed and explained in the following.

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## Processing the TI 35E

(in chronological order)

- **Substrate preparation:** Put the substrate on the hotplate at a minimum temperature of 120 °C for 10 minutes to remove adsorbed water from the substrates surface. Alternatively, you can use a furnace at same temperature for 30 min. Of course standard HMDS procedure (only from vapor phase at an optimum substrate temperature of 125°C!) is also an adequate preparation.

- **Spin-coat** the resist after cooling down the substrates, spin at the final speed level for at least 30-40 seconds.

- **Softbake** the coated substrate at 95°C for 2 minutes on the hotplate (when using a furnace, 95°C for 20 min is recommended)

- **Exposure** the coated substrate (with the mask) at a dose of 140 mJ/cm$^2$. This first exposure dose adjusts the negative wall profile the so called "undercut". Lower the 1$^{st}$ exposure dose to increase the undercut. 140 mJ/cm$^2$ will be a good choice for most applications. A too low 1st exposure dose will dramatically increase the erosion of the resist not to be cleared (see appendix). Note: Exposure dose holds for calibration on i-line (365nm). A standard mask aligner with a 350W Hg lamp has approx. 10 mW/cm$^2$ i-line intensity.

- Keep the coated substrate at room temperature after the exposure for at least **10 minutes**. In this delay time nitrogen, generated during exposure, will diffuse out the resist. If you use square shaped substrates the resist thickness on the edges is significant thicker than 3-4 µm. In this case the nitrogen needs more time to diffuse out. In this case double the **delay time**.

- **After the delay** bake the coated substrate on the hotplate at a temperature of 115 .. 120°C on the hotplate for two minutes (when using furnace try 20 minutes at 115°C. Because this step is very temperature critical furnace baking is not recommended). This step is the *reversal bake* where the image is reversed due to cross link the exposed areas making them insoluble in the developer.

- Exposure the coated substrate for the second time **without a mask (flood exposure).** Use a dose (very uncritical) of 540 mJ/cm$^2$ (200-800 has not a dominant effect). When, during a subsequent deposition, the temperature will raise over 80°C use high exposure doses to avoid nitrogen bubbles in the resist during the deposition. Especially when UV-light is present during deposition (plasma coating).

- **Develop** in AZ developer such as 826MIF (metal ion free) or potassium or sodium based developer (AZ 400K 1:4). When the structure is through-developed (cleared), add another 10-30% in the bath of the total development time to finalize the side wall profile.

- **Hardbake** the coated substrate only when using the resist as an etching mask under harsh conditions. When using it for mesa grooving hardbake at 140°C to 145°C for 2 minutes on the hotplate. The side-wall profile will loose the undercut during this step, lift-off processes become more problematic. If you need a hardbake and lift-off or very high temperatures during deposition, make a UV-curing to harden the resist after development (or contact us for further information).

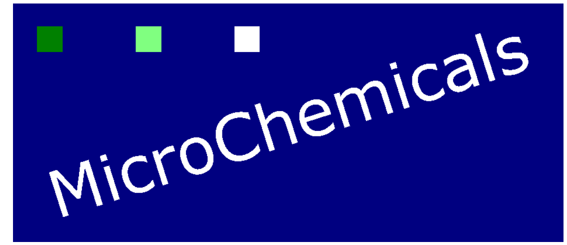
# Processing the TI 35E - Overview

| | |
|---|---|
| Resist thickness (µm) | 3.0... 4.5 |
| Exposure Broadband or g, h, i (mJ/cm$^{-2}$)<br>Typical Exposure time (sec)* | 100 .. 250, 140 (typ.)<br>10-25, 14 (typ.) |
| Reversal Bake Time (Hot plate Temperature) | 2 min (115-120°C) |
| Flood exposure (mJ/cm$^{-2}$) (without any mask) | 540 (typ.) 200-800 |
| Developer | Clariant AZ 351B, MIF Developers e.g. AZ 826 |
| Hardbake 140 ... 145°C (only for hard etching, avoid it for lift-off ) | 2 min |
| Lift off media | PGMEA, NMP, MMP, EEP, DMF, Acetone, ethyl lactate |
| Remover (Stripper) | AZ 100 remover, acetone |

*Exposure dose as calibrated on i-line (365nm). A standard mask aligner with a 350W Hg lamp has approx. 10 mW/cm$^2$ i-line intensity

# TI Plating
## Spray coating resist

### Technical Data Sheet
Revised 10/2002

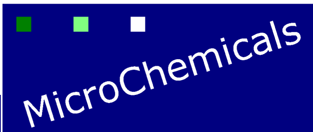



MicroChemicals GmbH
Schillerstrasse 18
D-89077 Ulm
phone +49 (0) 731 36080409
mobile +49 (0) 177 3332453
fax +49 (0) 731 1517024
email info@MicroChemicals.com
internet www.microchemicals.com

## General Information

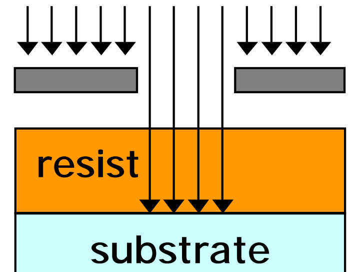
The **TI Plating** resist is optimized for spray coating of thin (2 µm) to very thick (20 µm) films. TI Plating can either be processed in **positive** mode or negative (**image reversal**) mode

This technical data sheet intends to give you a guideline for process parameters for various applications. However, the optimum values for e.g. dilution, exposure dose, or development depend on the individual equipment and need to be adjusted on each individual demand.

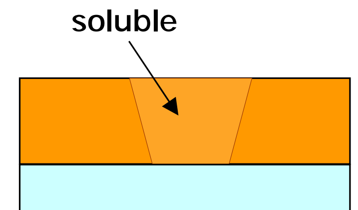



# 'Image Reversal' – A Short Introduction

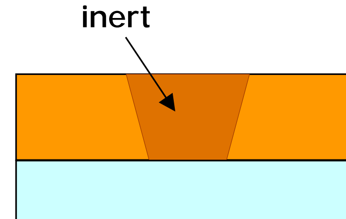
## What 'image reversal' generally means



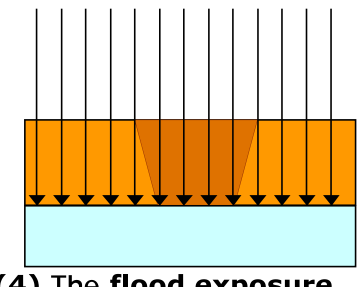

**(1) Exposure** using an inverted mask (the exposed areas finally remain)



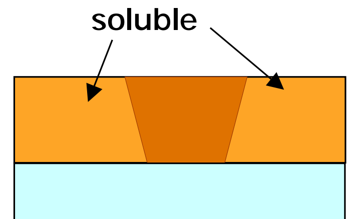

**(2)** The resist now would behave like an exposed positive resist.



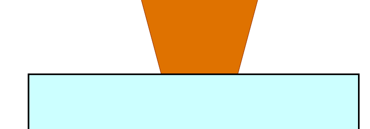

**(3)** The **reversal bake** cross-links the exposed area, while the unexposed area remains photo-active



**(4)** The **flood exposure** (without mask) …



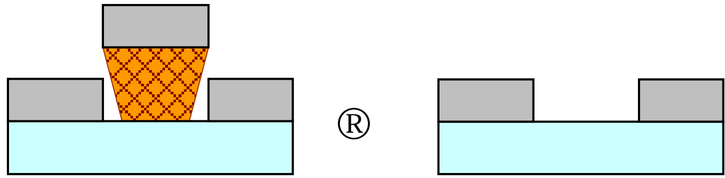

… **(5)** makes the resists, which was not exposed in the first step, soluble in developer

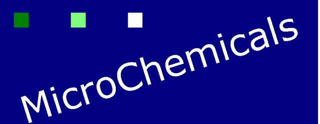


**(6)** After developing, the areas exposed in the first step now remain

## … and for what image reversal is good for:

Adjustable undercut for lift-off of thin and thick sputtered, CVD, and evaporated films like metals, a-Si:H, a-SiN:H etc.






# Processing the TI Plating (positive mode)

## In chronological order:

- **Resist dilution**: To optimize spray coating processes for uniform film thicknesses and excellent step coverage, aliphatic or aromatic ketones or aliphatic esters could be used in certain dilutions. For detailed information please consult your spray coating equipment manufacturer.

- After **cleaning** the **substrate**, put the substrate on the hotplate at minimum 120 °C for 10 minutes to remove adsorbed water from the substrate surface. Alternatively, you can use a furnace at same temperature for 30 min. Standard HMDS procedure (only from vapor phase with an optimum substrate temperature of 125°C !) is also an adequate preparation.

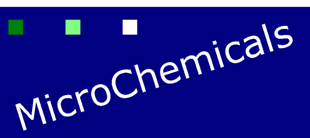
- **Soft-bake** at 95°C on a hot-plate for:

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm |
|---|---|---|---|
| time (min) | 10 | 20 | 30 |

- **Exposure** (with the mask) broadband or monochromatic at a dose (calibrated on **i-line** = 365 nm) of approximately:

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm | 25 .. 32 µm |
|---|---|---|---|---|
| exposure dose (mJ/cm$^2$) | 500 .. 800 | 700 .. 1000 | 900 .. 1200 | 1000-1600 |
| = exposure time (sec.) (holds for all standard mask aligners with a 350W Hg-lamp) | 50 .. 80 | 70 .. 100 | 90 .. 120 | 100 .. 160 |

- **Develop** in e.g. AZ 826MIF. After development, it is **very important** to flush the wafer with **plenty of water** to remove traces of residual developer. Otherwise, even very small amounts of developer on/in the resist will concentrate when drying the wafer and cause strong local concentrations of developer, which might deteriorate the resist during subsequent processing steps in aqueous solutions.




## Processing the TI Plating (negative mode)

In chronological order:

- **Resist dilution**: To optimize spray coating processes for uniform film thicknesses and excellent step coverage, aliphatic or aromatic ketones or aliphatic esters could be used in certain dilutions. For detailed information please consult your spray coating equipment manufacturer.
- After **cleaning** the **substrate**, put the substrate on the hotplate at minimum 120 °C for 10 minutes to remove adsorbed water from the substrate surface. Alternatively, you can use a furnace at same temperature for 30 min. Standard HMDS procedure (only from vapor phase with an optimum substrate temperature of 125°C !) is also an adequate preparation.
- **Soft-bake** at 95°C on a hot-plate for:

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm |
|---|---|---|---|
| time (min) | 10 | 20 | 30 |

- **Exposure** (with the mask) broadband or monochromatic at a dose (calibrated on **i-line** = 365 nm) of approximately:

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm | 25 .. 32 µm |
|---|---|---|---|---|
| exposure dose (mJ/cm²) | 150 .. 250 | 200 .. 400 | 200 .. 400 | 200-500 |
| = exposure time (sec.) (holds for all standard mask aligners with a 350W Hg-lamp) | 15 .. 25 | 20 .. 40 | 20 .. 40 | 20 .. 50 |

- **post-exposure delay time:**

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm |
|---|---|---|---|
| Room temperature 20° (min) … | 120 | 240 | 480 |
| … subsequent hot-plate 50°C (min) | 60 | 120 | 120 |

In this delay time, $N_2$, generated during exposure, will diffuse out the resist. If the resist foams on the hot-plate, next time increase the delay time at room temperature.

- **Reversal Bake:** After the delay bake the substrate at a temperature of 125°C on the hotplate for 2 minutes (when using furnace try 20 minutes at 120°C-130°C. Because this step is very temperature critical furnace baking is not recommended). This step is the reversal bake where the image is reversed due to cross link the exposed areas making them insoluble in the developer. If the resist foams, next time increase the delay time at 50°C (see previous point)
- **Flood Exposure:** Exposure the substrate for the second time **without a mask** (flood exposure).

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm |
|---|---|---|---|
| dose (mJ/cm²) | ≈ 1.200 | ≈ 1.800 | ≈ 1.800 |

When, during a subsequent deposition, the temperature will raise over 80°C, use a high exposure dose to avoid nitrogen bubbles in the resist during the deposition.

- **Develop** in e.g. AZ 826MIF. After development, it is **very important** to flush the wafer with **plenty of water** to remove traces of residual developer. Otherwise, even very small amounts of developer on/in the resist will concentrate when drying the wafer and cause strong local concentrations of developer which might deteriorate the resist during subsequent processing steps in aqueous solutions.

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# Exposure dose and resist profile

## I) Positive mode: Varying the Exposure dose

Thickness 12 µm; Dev. AZ 826MIF

| 300 mJ/cm$^2$ | 400 mJ/cm$^2$ | 500 mJ/cm$^2$ | 800 mJ/cm$^2$ |
|---|---|---|---|
| 12 µm | | | |

## II) Positive mode: Varying the Exposure dose

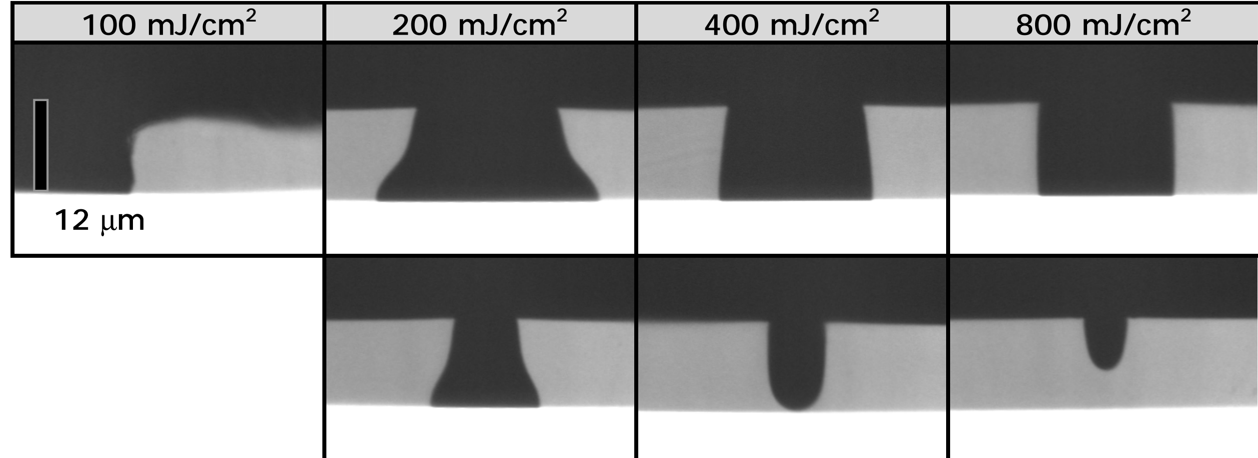
Thickness 5 µm; Dev. AZ 826MIF

| 200 mJ/cm$^2$ | 300 mJ/cm$^2$ |
|---|---|
| 12 µm | |

® **higher 1st exposure doses: resist profile improves**

### III) Image reversal mode: Varying the 1st Exposure dose

Thickness 12 µm; rev. bake 2min @ 125°C; flood exp. 1.800 mJ/cm$^2$
Dev. AZ 826MIF 7min (5min to clear)




(top row: 24µm lines; bottom row: 4 µm lines)

### IV) Image reversal mode: Varying the 1st Exposure dose

Thickness 5 µm; rev. bake 2min @ 125°C; flood exp. 1.800 mJ/cm$^2$
Dev. AZ 826MIF 7min (5min to clear)

100 mJ/cm$^2$ | 300 mJ/cm$^2$ | 500 mJ/cm$^2$

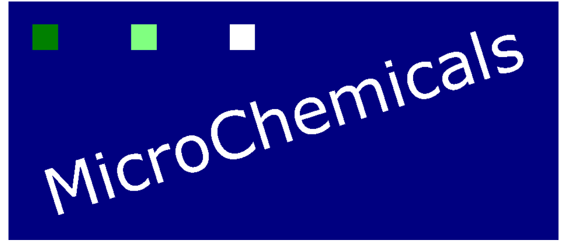
12 µm

(top row: 24µm lines; bottom row: 4 µm lines)

® **1st exposure dose too low: dark erosion**
® **1st exposure dose too high: undercut to low (no undercut for narrow spaces)**

# TI Spray
# image reversal resist

## Technical Data Sheet
revised 10/2002




MicroChemicals GmbH
Schillerstrasse 18
D-89077 Ulm
Fon +49 (0) 731 36080409
Mobil +49 (0) 177 3332453
Fax +49 (0) 731 1517024
Email info@MicroChemicals.com
Internet www.microchemicals.com

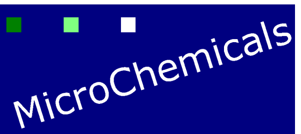
## General Information

The TI Spray resist is specially designed for the application in the so called "image reversal technology" for:

- subsequent **lift-off** of deposited layers
- **wet chemical** treatment in HF containing etching solutions
- direct **mesa grooving**.

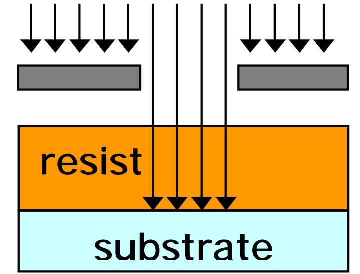
The viscosity enables a direct use in spray coating equipment for a target thickness of 1 to 10 µm. The typical aspect ratio of the structured features achievable is in the range of 1.6 .. 2.0.

This technical data sheet intends to give you a guide-line for process parameters for various applications. However, the optimum values for e.g. exposure dose, or development depend on the individual equipment and need to be adjusted on each individual demand.

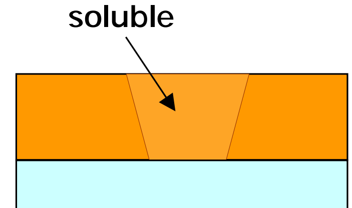


# 'Image Reversal' – A Short Introduction

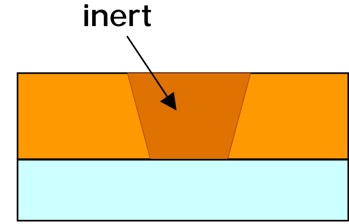
## What 'image reversal' generally means



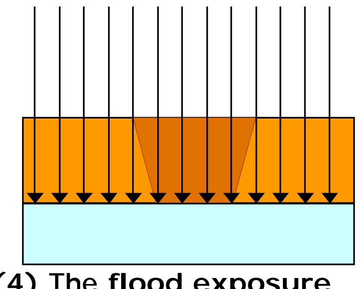

**(1) Exposure** using an inverted mask (the exposed areas finally remain)



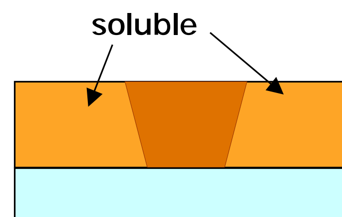

**(2)** The resist now would behaves like an exposed positive resist.



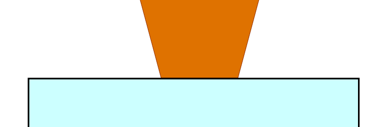

**(3) The reversal bake** cross-links the exposed area, while the unexposed area remains photo-active



**(4)** The **flood exposure** (without mask) …



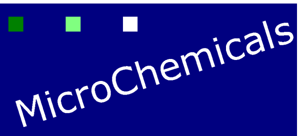

… **(5)** makes the resists, which was not exposed in the first step, soluble in developer



**(6)** After developing, the areas exposed in the first step now remain

## … and for what image reversal is good for:

® **High stability** for wet-chemical etching allows the usage of the inverted TI Spray as mask for **wet-chemical etching under harsh conditions**




## TI Spray – Fields of Application

### Lift-off of PECVD layers

- Amorphous Si layer deposited in device quality at 110°C
- Amorphous $SiN_x$

### Lift-off of sputtered layers

- Due to non-directional deposition, lower thickness achievable (approx. 1 µm)
- Possibly ultra sonic treatment necessary
- Liftability dependent on operating pressure

### Etching of $SiN_x$ in BHF (12.5%HF)

- $SiN_x$ deposited at 400 °C with PECVD
- Hardbake at 125°C (Hotplate) for two minutes
- No visible degradation of resist after 10 min etching time
- Enables structuring of SiN up to at least 100 nm (tested)
- Use ammonia during $SiN_X$ deposition to increase adhesion of the resist on the surface
  (For harsh chemical attack prefer the use of TI Spray)

### Etching of thick thermal $SiO_2$ with 20 % HF

- No visible degradation of the resist after 10 min
- Possible etching in HF conc. (50%) for several minutes
  (For harsh chemical attack prefer the use of TI Spray)

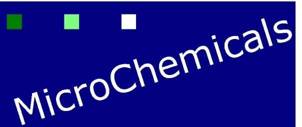
### Direct mesa grooving

- TI series resists allow direct Si etching without $SiO_2$ masking
- Hardbake at 120-145°C for 2 min necessary
- Use **$HNO_3$** (70%) : **HF** (50 %) : **$H_2O$** = **75 : 10 : 25** as etching solution and TI Spray resist **in reversal mode**, groove up to 4 µm in 45s

## Technological Requirements

Since the TI Spray yields an inverted structure in the image reversal mode, an inverted exposure mask is needed. Beyond this, compared to standard positive resist processing, **no further upgrade** in existing technological infrastructure is necessary.

Also compared to standard positive resist processing, applying the TI Spray implements just two further process steps: The **reversal bake** and the **flood exposure** without mask, both very easy to be performed and explained in the following.




## Processing the TI Spray

(in chronological order)

- **Substrate preparation:** Put the substrate on the hotplate at a minimum temperature of 120 °C for 10 minutes to remove adsorbed water from the substrates surface. Alternatively, you can use a furnace at same temperature for 30 min. Of course standard HMDS procedure (only from vapor phase at an optimum substrate temperature of 125°C!) is also an adequate preparation. Also recommended is the preparation with the solvent based TI-Prime.

- **Spray coat** the resist according to the guidelines given from the spray coat equipment manufacturer.

- **Softbake** the coated substrate at 95°C for 2 minutes on the hotplate (when using a furnace, 95°C for 20 min is recommended)

- **Exposure** the coated substrate (with the mask) at a dose of 140 mJ/cm$^2$. This first exposure dose adjusts the negative wall profile the so called "undercut". Lower the 1$^{st}$ exposure dose to increase the undercut. 140 mJ/cm$^2$ will be a good choice for most applications. A too low 1st exposure dose will dramatically increase the erosion of the resist not to be cleared (see appendix). Note: Exposure dose holds for calibration on i-line (365nm). A standard mask aligner with a 350W Hg lamp has approx. 10 mW/cm$^2$ i-line intensity.

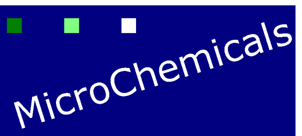
- Keep the coated substrate at room temperature after the exposure for at least **10 minutes**. In this delay time nitrogen, generated during exposure, will diffuse out the resist. If you use square shaped substrates the resist thickness on the edges is significant thicker than 3-4 µm. In this case the nitrogen needs more time to diffuse out. In this case double the **delay time**.

- **After the delay** bake the coated substrate on the hotplate at a temperature of 115 .. 120°C on the hotplate for two minutes (when using furnace try 20 minutes at 115°C. Because this step is very temperature critical furnace baking is not recommended). This step is the *reversal bake* where the image is reversed due to cross link the exposed areas making them insoluble in the developer.

- Exposure the coated substrate for the second time **without a mask (flood exposure)**. Use a dose (very uncritical) of 540 mJ/cm$^2$ (200-800 has not a dominant effect). When, during a subsequent deposition, the temperature will raise over 80°C use high exposure doses to avoid nitrogen bubbles in the resist during the deposition. Especially when UV-light is present during deposition (plasma coating).

- **Develop** in AZ developer such as 826MIF (metal ion free) or potassium or sodium based developer (AZ 400K 1:4). When the structure is through-developed (cleared), add another 10-30% in the bath of the total development time to finalize the side wall profile.

- **Hardbake** the coated substrate only when using the resist as an etching mask under harsh conditions. When using it for mesa grooving hardbake at 140°C to 145°C for 2 minutes on the hotplate. The side-wall profile will loose the undercut during this step, lift-off processes become more problematic. If you need a hardbake and lift-off or very high temperatures during deposition, make a UV-curing to harden the resist after development (or contact us for further information).



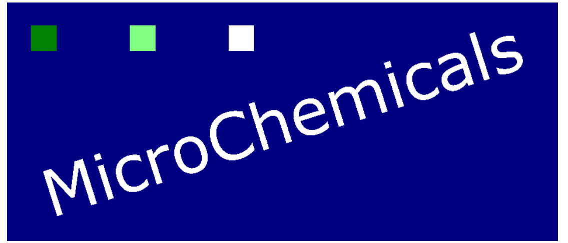

## Processing the TI Spray - Overview

| | |
|---|---|
| Resist thickness (µm) | 1-10µm (typ. 4µm) |
| Exposure Broadband or g, h, i (mJ/cm$^{-2}$) | 100 .. 250, 140 (typ.) |
| Typical Exposure time (sec)* | 10-25, 14 (typ.) |
| Reversal Bake Time (Hot plate Temperature) | 2 min (115-120°C) |
| Flood exposure (mJ/cm$^{-2}$) (without any mask) | 540 (typ.) 200-800 |
| Developer | Clariant AZ 400K, AZ 351B, MIF AZ 826 |
| Hardbake 140 ... 145°C (only for hard etching, avoid it for lift-off ) | 2 min |
| Lift off media | PGMEA, NMP, MMP, EEP, DMF, Acetone, ethyl lactate |
| Remover (Stripper) | AZ 100 remover, acetone |

*Exposure dose as calibrated on i-line (365nm). A standard mask aligner with a 350W Hg lamp has approx. 10 mW/cm$^2$ i-line intensity

# TI xLift
# image reversal resist

## Technical Data Sheet
revised 10/2002

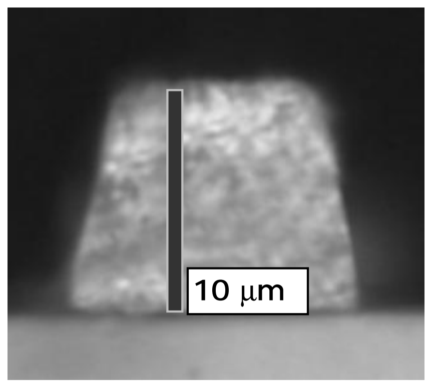



MicroChemicals GmbH
Schillerstrasse 18
D-89077 Ulm
Fon +49 (0) 731 36080409
Mobil +49 (0) 178 7825198
Fax +49 (0) 731 1517024
Email info@MicroChemicals.com
Internet www.microchemicals.com

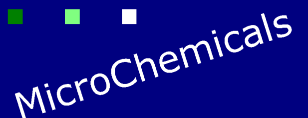
## General Information

The **TI xLift** image reversal resist is optimized for **lift-off** of thick to very thick (5 .. 20 µm) films.

This technical data sheet intends to give you a guide-line for process parameters for various applications. However, the optimum values for e.g. spin profile, exposure dose, or development depend on the individual equipment and need to be adjusted on each individual demand.

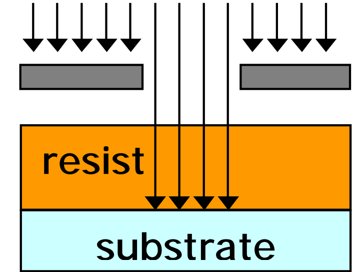



← *10.5 µm thick metal via lift-off with TI xLift*

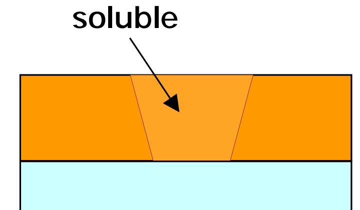



# 'Image Reversal' – A Short Introduction

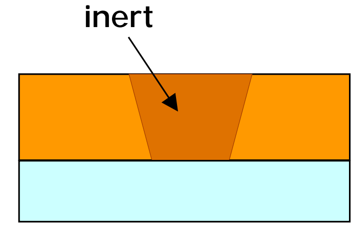
## What 'image reversal' generally means



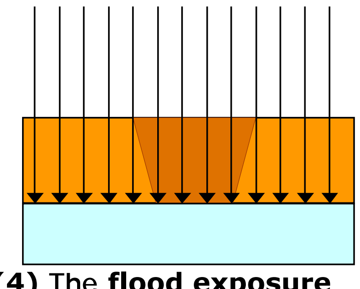

**(1) Exposure** using an inverted mask (the exposed areas finally remain)



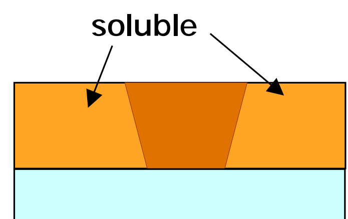

**(2)** The resist now would behaves like an exposed positive resist.



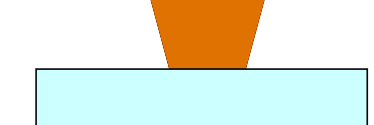

**(3)** The **reversal bake** cross-links the exposed area, while the unexposed area remains photo-active



**(4)** The **flood exposure** (without mask) …



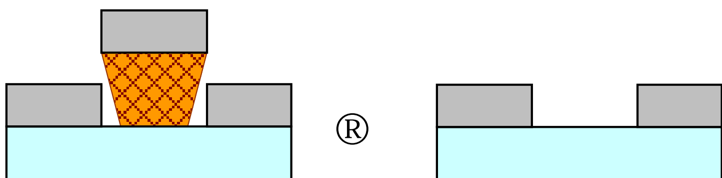

… **(5)** makes the resists, which was not exposed in the first step, soluble in developer

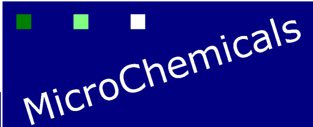


**(6)** After developing, the areas exposed in the first step now remain

## … and for what image reversal is good for:

Adjustable undercut for lift-off of thin and thick sputtered, CVD, and evaporated films like metals, a-Si:H, a-SiN:H etc.






# Processing the TI xlift

In chronological order:

- After **cleaning** the **substrate**, put the substrate on the hotplate at minimum 120 °C for 10 minutes to remove adsorbed water from the substrate surface. Alternatively, you can use a furnace at same temperature for 30 min. Standard HMDS procedure (only from vapor phase with an optimum substrate temperature of 125°C !) is also an adequate preparation.

- **Spin-coat** the resist immediately after cooling down the substrate at:

| resist thickness | 5.9 µm | 7.0 µm | 8.2 µm | 10.5 µm | 14.4 µm | 20.0 µm |
|---|---|---|---|---|---|---|
| final rpm | 2.200 | 1.600 | 1.400 | 1.200 | 900 | 600 |

with an acceleration of approx. 900 rpm/s and keep at **final spin speed for 5 seconds**. Then decelerate down to 0 rpm at approx. –900 rpm/sec. For 4 inch wafer, a minimum of 3.0 ml of resist is recommended.

- **Leave** the substrate on the spin-coater (or on any horizontal surface at room temperature) for at least 5 min (≈ 5 µm resist thickness) to 30 min (≈ 20 µm resist thickness). This will smooth the surface, reduce striations, and allow the edge bead near the substrate edge i) to flatten and ii) to contract to the outermost few mm of the wafer. If subsequent soft-bake causes foaming or patterning of the resist, increase the **delay**.

- **Soft-bake** at 95°C on a hot-plate or in an fufor:

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm |
|---|---|---|---|
| time (min) | 20 | 40 | 60 |

- **Remove** the **edge bead** on the edge of the substrate. We recommend giving a sharp stream of AZ EBR solvent (PGMEA) focused on the outer few mm of the substrate spinning at 1.000 rpm. Avoid spattering drops of EBR on the inner side of the substrate, this will cause spots with reduced resist thickness.

- **Exposure** broadband or i-line (with the mask) at a (as calibrated on **i-line**, 365 nm) dose of approximately:

| total resist thickness | 5.9 µm | 7.0 µm | 8.2 µm | 10.5 µm | 14.4 µm | 20.0 µm |
|---|---|---|---|---|---|---|
| first exposure dose (mJ/cm$^2$) | 40 .. 100 | 50 .. 140 | 80 .. 200 | 110 .. 280 | 150 .. 400 | 180 .. 500 |
| = exposure time (sec.) (holds for all standard mask aligners with a 350W Hg-lamp) | 4 .. 10 | 5 .. 14 | 8 .. 20 | 11 .. 28 | 15 .. 40 | 18 .. 50 |

This first exposure dose adjusts the final wall profile and can be increased/decreased by up to 50% for optimum results (see Appendix).

- **Post-exposure delay time:**

| total resist thickness | 5 .. 9 µm | 10 .. 16 µm | 17 .. 24 µm |
|---|---|---|---|
| Room temperature 20° (min) … | 5 | 5 | 10 |
| … subsequent hot-plate 50°C (min) | 0 | 15 | 30 |

In this delay time, $N_2$, generated during exposure, will diffuse out the resist. If the resist foams on the hot-plate, next time increase the delay time at room temperature.

- **Reversal Bake:** After the delay bake the substrate at a temperature of 130°C on the hotplate for 2 minutes (when using furnace try 20 minutes at 120°C-130°C. Because this step is very temperature critical furnace baking is not recommended). This step is the reversal bake where the image is reversed due to cross link the exposed areas making them insoluble in the developer. If the resist foams, next time increase the delay time at 50°C (see previous point)

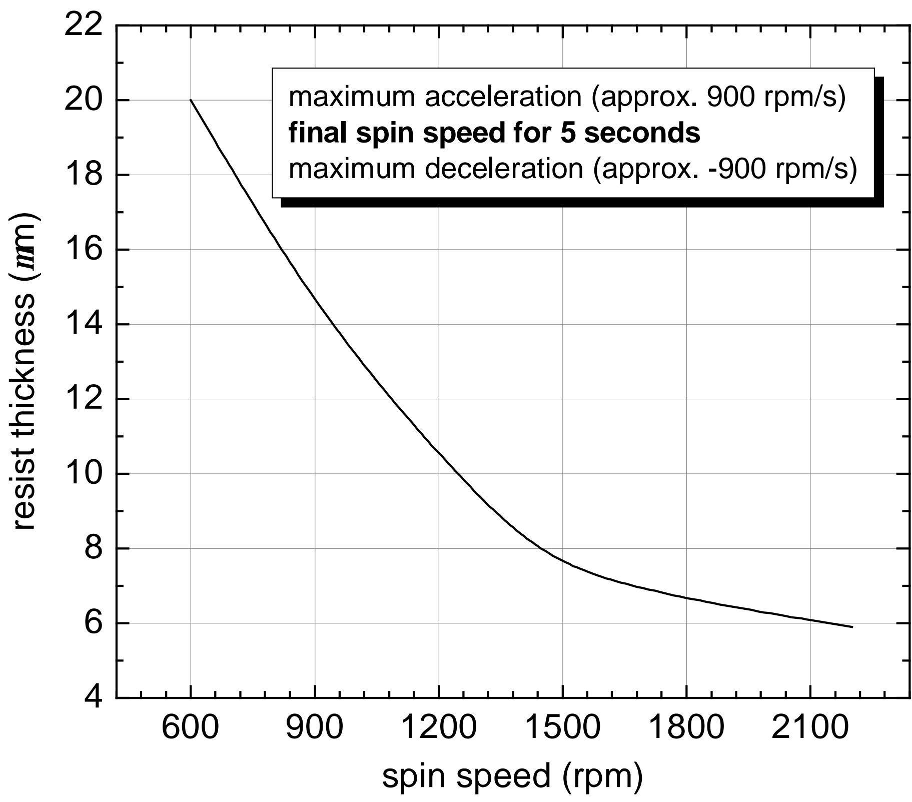
- **Flood Exposure:** Exposure the substrate for the second time **without a mask** (flood exposure).

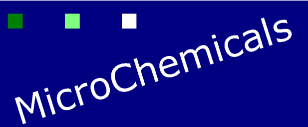
| total resist thickness | 5 .. 9 μm | 10 .. 16 μm | 17 .. 24 μm |
|---|---|---|---|
| dose (mJ/cm$^2$) | ≈ 800 | ≈ 1.000 | ≈ 1.200 |

When, during a subsequent deposition, the temperature will raise over 80°C, use a high exposure dose to avoid nitrogen bubbles in the resist during the deposition.

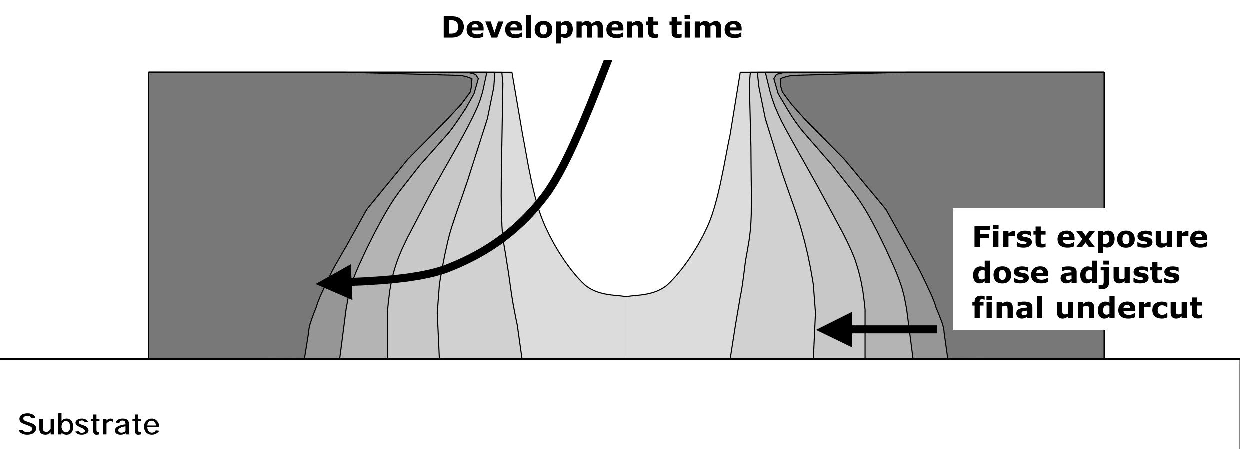
- **Develop** e.g. in AZ 826MIF. When the structures are through-developed, add another approx. 10-30% of the time in the bath of development time to finalize the side wall profile (see appendix). Beside the used developer, development time depends on resist thickness and strongly on reversal bake temperature.

  If shorter development times are important, use AZ 400K 1:3.5 (e.g. 100 ml AZ 400K and 350 ml DI-water). Resist dark erosion might slightly increase.






## Appendix A: Adjusting the undercut




### Undercut depends on:

#### 1. First exposure dose

At low 1st exposure doses, only the upper part of the resist is exposed. Only this region will subsequently be 'reversed' during image reversal bake. The substrate-near resist now is still unchanged and will be exposed (and made soluble) in the subsequent flood exposure. If the first exposure dose is too low, development will lift the upper resist layer, or/and the dark erosion is too high.
® **High 1st exposure dose: Reduced undercut**

#### 2. Reversal bake temperature and reversal bake time

If the reversal bake temperature- and time is too low, the image reversal process will not be completed. As a consequence, the resist exposed during the 1st exposure shows a high 'dark erosion' during development, sometimes appearing as holes or bubbles in the resist. With increasing reversal bake temperature/-time, the reversal process improves, and dark erosion is reduced.
At reversal bake temperatures/-times chosen to high, even the parts of the resists exposed by scattered light during the 1st exposure (in regions where no light should be) are reversed. As a consequence, the profile might change from the desired undercut to a typical positive profile.
® **High reversal bake temperature/-time: Reduced undercut**

#### 3. Developer/Development time

With increased developing time, or by the usage of strong developers (like AZ 400K in dilutions of 1:3.5 and stronger), also the parts of the resist are developed, where the image reversal process has been performed.
® **High developing time: Increased undercut**

# Appendix B: Parameters and profile

**Example I:** Varying the **first exposure dose** at 30% 'over-developing'
(Thickness 12 µm; Rev. bake 130°C 2min; Flood exp. 1.000 mJ; Dev. AZ400K 1:3, 8 min)

| 1st exp. 85 mJ/cm$^2$ | 170 mJ | 260 mJ | 430 mJ |
|---|---|---|---|
| 12 mue | | | |

**Example II:** Varying the **development time** at low first exposure dose
(Thickness 15 µm; 1st exp. 240 mJ, Rev. bake 130°C 2min; Flood exp. 1.200 mJ; Dev. AZ400K 1:2.5)

| Dev. time 5.0 min | 6.5 min | 8.5 min | 15 min |
|---|---|---|---|
| 15 mue | | | |

**Example III:** Varying the **development time** at high first exposure dose
(Thickness 13 µm; 1st exp. 310 mJ, Rev. bake 130°C 2min; Flood exp. 1.200 mJ; Dev. AZ400K 1:2.5)

| Dev. time 5.0 min | | 13 min |
|---|---|---|
| 13 mue | high 1st exposure<br>+<br>over-development<br>=<br>sharp profile near substrate | |

**Example IV:** Varying the **reversal bake**
(Thickness 11 µm; Rev. bake 130°C; Flood exp. 1.000 mJ; Dev. AZ 826MIF)

| rev. bake time 1 min | 3 min | 6 min |
|---|---|---|
| 11 mue | | |

http://www.kayakumicrochem.jp/

www.microchem.com

# KMPR® 1000

## Chemically Amplified Negative Photoresist

**KMPR® 1000** i-Line photoresist is a high contrast, epoxy based photoresist that can be developed in a conventional aqueous alkaline developer (TMAH) and readily stripped from the wafer. KMPR® is designed to coat 4 – 120 µm in a single step using the four standard viscosities. KMPR® 1000 has excellent adhesion, chemical and plasma resistance, making it ideal for many MEMS, Electrolytic Plating and DRIE applications.

## Features

- High aspect ratio imaging
- Vertical sidewalls
- Greater than 100 µm film thickness in a single coat
- Aqueous developer compatible (TMAH & KOH)
- Wet strips in conventional strippers
- Excellent dry etch resistance

## Processing Guidelines

KMPR® 1000 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-initiated, thermally driven 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 KMPR® 1000 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 $O_2$ gas. 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).

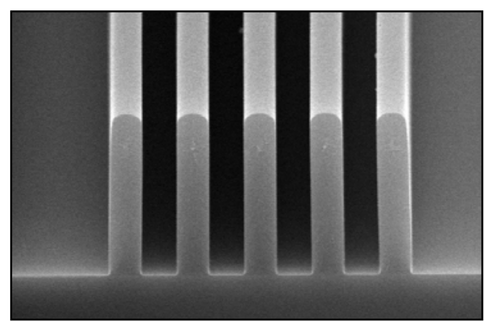
## Coat

KMPR® 1000 resists are available in four standard viscosities, shown in Table 1. Figures 1 and 2 provide the information required to select the appropriate KMPR® 1000 resist and spin conditions, to achieve the desired film thickness.

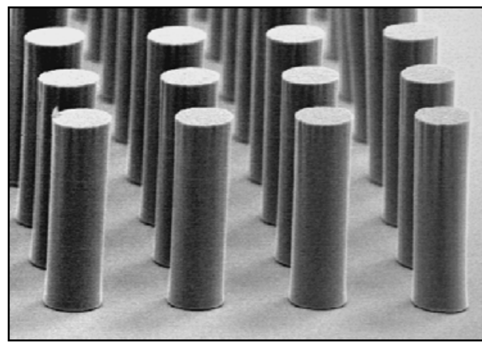
## Recommended Program

(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

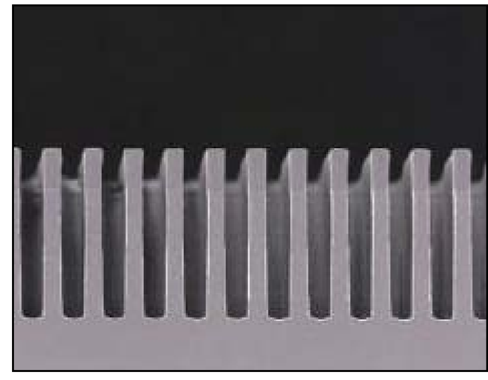
## Applications



i-Line stepper exposure
2 µm features, 10 µm KMPR coating



Copper Plated Deposit
10 µm features, 45 µm tall, KMPR® Removed



Etched Trenches
10 µm features, 65 µm deep
(Photo Courtesy of ULVAC)

Ver. 4.2a

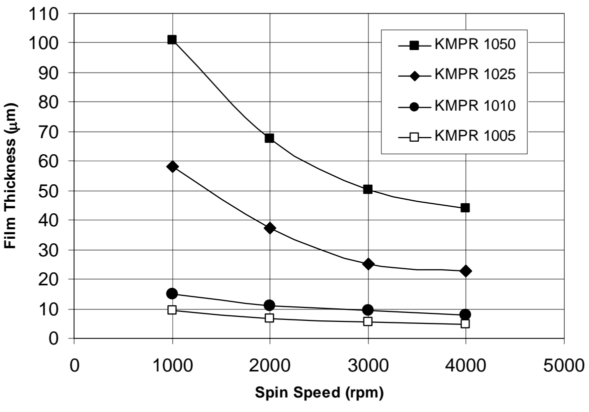



Figure 1. Spin speed vs. Thickness
for KMPR® 1000 resists (21ºC US & EU)

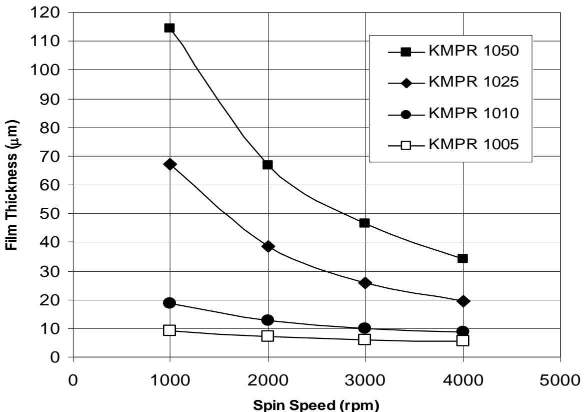



Figure 2. Spin speed vs. Thickness
for KMPR® 1000 resists (23ºC Japan & Asia)

Table 1. KMPR Viscosity

| KMPR | % Solids | Viscosity (cSt) |
|---|---|---|
| 1005 | 45 | 95 |
| 1010 | 55 | 600 |
| 1025 | 63.8 | 4800 |
| 1050 | 67.3 | 13000 |

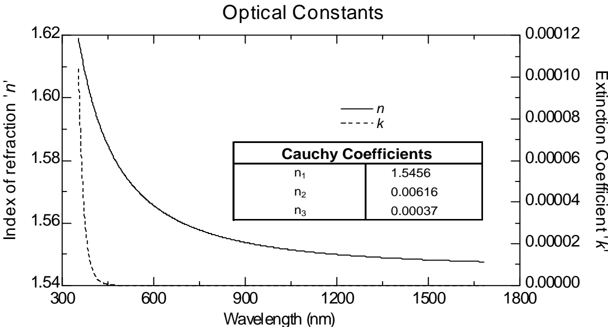



Figure 3. Cauchy Coefficients

## 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 KMPR® 1000 products at selected film thicknesses. The recommended bake temperature is 100ºC, however temperatures from 95-105ºC may also be used.

***Note:*** *In order 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 when the wafer is initially placed on the hotplate.*

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

| THICKNESS microns | SOFT BAKE TIME minutes @ 100°C |
|---|---|
| 5 - 11 | 5 |
| 12 - 20 | 7 |
| 21 - 30 | 12 |
| 31 - 55 | 15 |
| 56 - 80 | 20 |

Table 2. Soft Bake Times

## Exposure

To obtain vertical sidewalls in the KMPR® 1000 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 after being placed on the PEB hotplate and not before. A visible latent image before the PEB step indicates excessive exposure. An exposure matrix experiment should be performed to optimize the exposure dose*

| THICKNESS microns | EXPOSURE ENERGY $mJ/cm^2$ |
|---|---|
| 5 - 11 | 235 - 335 |
| 12 - 20 | 355 - 485 |
| 21 - 30 | 500 - 645 |
| 31 - 55 | 665 - 1055 |
| 56 - 80 | 1070 - 1465 |

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 and before development. For KMPR® 1000 film thicknesses of 25 µm or less, a PEB time of 2 minutes at 100ºC is sufficient. For film thickness greater than 25 µm, a PEB time of 3 minutes is recommended. For film thickness greater than 50 µm, a PEB time of 4 minutes is recommended. The recommended PEB temperature is 100ºC, however temperatures from 95-105ºC may also be used.

***Note:*** *After 1 minute of PEB, an image of the mask should be visible in the KMPR® photoresist coating. No visible latent image during or after PEB means that there was insufficient exposure, temperature or both.*

## Develop

KMPR® 1000 resist has been designed for use with 2.38% TMAH (0.26N) aqueous alkaline developer in immersion, spray or spray-puddle processes. Other solvent based developers such as SU-8 developer may also be used instead of TMAH. Strong agitation during development is recommended for high aspect ratio and/or thick film structures. Recommended develop times for immersion processes are given in Table 5 for TMAH and Table 6 for SU-8 developer. 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 | TMAH DEVELOPMENT TIME |
|---|---|
| microns | minutes |
| 5 - 11 | 3 |
| 12 - 20 | 5 |
| 21 - 30 | 6 |
| 31 - 55 | 6 |
| 56 - 80 | 8 |

Table 5. Development Times for 2.38% TMAH

| THICKNESS | SU-8 DEVELOPMENT TIME |
|---|---|
| microns | minutes |
| 5 - 11 | 2 |
| 12 - 20 | 2 |
| 21 - 30 | 2 |
| 31 - 55 | 3 |
| 56 - 80 | 4 |

Table 6. Development Times for SU-8 Developer

## Rinse and Dry

Following TMAH development, the substrate should be spray rinsed with de-ionized water for 20 seconds and then air dried with filtered, pressurized air or nitrogen.

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.*

## Plating

(1) HMDS
(2) Coat, Expose, PEB, Develop
(3) Descum: RIE 2 min, 100 W, 10 sccm $O_2$, 100 mTorr
(4) Electrolytic Copper: 60 min, 0.1 A/dm$^2$

***Note:*** *Hard bake is NOT REQUIRED OR RECOMMENDED for plating resistance.*

## Removal

KMPR® 1000 will swell and lift and readily strip using MicroChem's Remover PG (NMP). To remove KMPR® 1000 with Remover PG, heat the bath to 80°C and immerse the substrates for 10-20 minutes. Actual strip time will depend on resist thickness and agitation method (such as ultrasound).

For more information on MicroChem Remover PG please see the product data sheet.

## Process Recommendation

(1) Remover PG: 10 min, 80ºC
(2) DI water rinse
(3) Plasma removal if required

## Plasma Removal

RIE 200W, 80 sccm $O_2$, 8 sccm $CF_4$, 100mTorr, 10°C
See www.r3t.de or www.tepla.com for microwave plasma tools for high throughput without damaging other microstructures.

## Storage

Store KMPR® 1000 resists *frozen* in tightly closed, upright containers at 14°F(-10°C). Store away from light, heat, acids and sources of ignition. Shelf life is thirteen months from the date of manufacture for storage at 14°F(-10°C) and typically one to two months at room temperature. Defrost KMPR® 1000 at room temperature for 24 hours prior to use.

## Disposal

KMPR® 1000 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 KMPR® 1000 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 KMPR® 1000 resists. Handle with care. Wear chemical goggles, chemical gloves and suitable protective clothing when handling KMPR® 1000 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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# LOR and PMGI Resists

## DESCRIPTION

LOR and PMGI resists are based on polydimethylglutarimide. Its unique properties enable LOR and PMGI products to perform exceptionally well when used, either as a sacrificial layer, or as an undercut layer in bi-layer lift-off processing. LOR and PMGI resists are designed for applications requiring high resolution imaging, easy process tuning, high yields and superior deposition line width control. Mainstream applications utilizing LOR or PMGI resists include GMR & MR heads, wireless devices, opto-electronics, MEMs, and packaging.

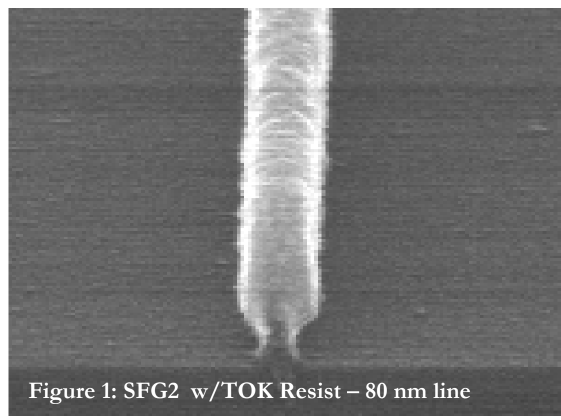


Figure 1: SFG2 w/TOK Resist – 80 nm line

## BENEFITS

- **Sub 0.25µm lift-off processing.**
- **Film thicknesses for depositions from <20nm - >5µm.**
- **Dissolution Rate optimized for maximum undercut control.**
- **Simple bi-layer processing without extra flood exposure, develop, amine treatment or toxic chemical soak steps required.**
- **Superior adhesion to Si, NiFe, GaAs, InP and many other III-V materials.**
- **Compatible with g-, h-, i-line, DUV, 193nm and E-beam resists.**
- **Compatible with TMAH and metal-ion bearing developers.**
- **High thermal stability.**
- **Excellent conformal and/or planarizing formulation's available.**
- **Optically transparent formulations available.**

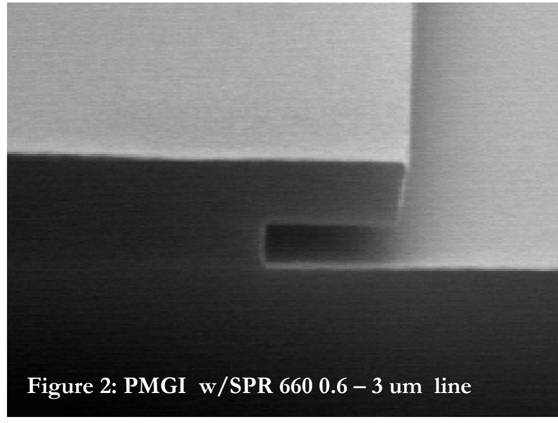


Figure 2: PMGI w/SPR 660 0.6 – 3 um line

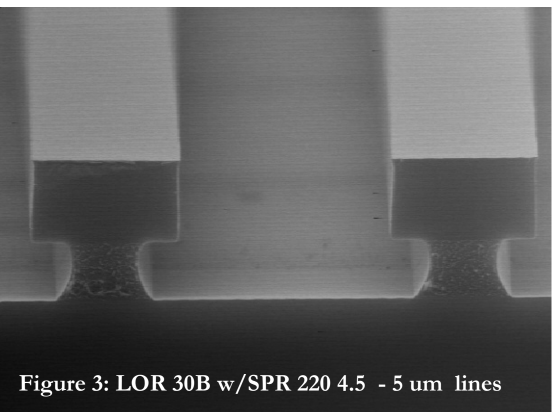
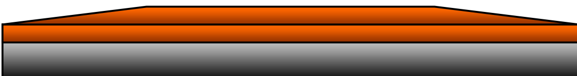
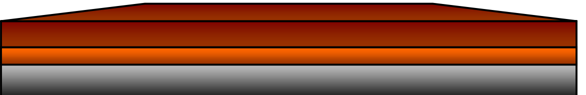


Figure 3: LOR 30B w/SPR 220 4.5 - 5 um lines

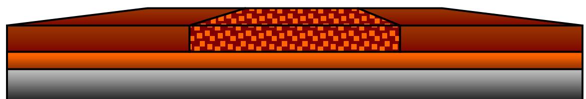
Figure 4:



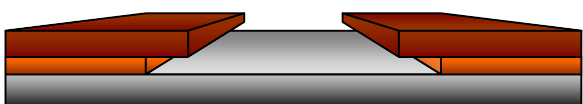
1. Coat and Soft-bake PMGI or LOR.



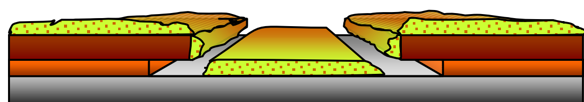
2. Coat and Soft-bake Imaging Resist.



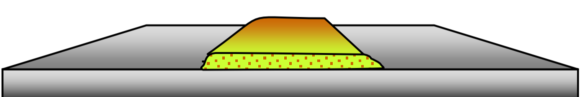
3. Expose Imaging Resist.



4. Develop resist and PMGI/LOR.



5. Deposit film.



6. Lift-off Bi-layer stack and residual deposition.

**Substrate preparation**

LOR/PMGI resists exhibit excellent adhesion to most semiconductor, GaAs, and thin-film head substrates. Primers such as HMDS (hexamethyldisilazane) are typically NOT required to promote adhesion with PMGI/LOR products when used as recommended.

To obtain maximum process reliability, substrates should be clean and dry prior to applying LOR resist. Start with solvent cleaning, or rinse with dilute acid, followed by DI water rinse. To dehydrate the surface, bake at 200°C for 5 minutes on a contact hot plate or 30 minutes in a convection oven.

**Coating process**

LOR and PMGI resists are designed to provide low defect level coatings over a broad film thickness range using a variety of spin-coat conditions. For clean lift-off processing, LOR/PMGI films should be thicker than the deposited metal film, typically by 25%.

Film thicknesses versus spin speed plots are included in the technical data section. Spin speeds between 2,500 and 4,500 rpm generate maximum coating uniformity. The Spin speed needs to be optimized for the substrate size and shape. Generally, higher speeds are used for smaller substrates and lower speeds for larger substrates. Substrates with deep topography or irregular shape will need to be spun slower for improved coverage.

Coating equipment should be compatible with cyclopentanone to minimize coater-bowl exhaust variability and drain-line clogging associated with mixing conventional and PMGI/LOR resists. A dedicated coat-bowl and drainage system is recommended but not mandatory.
When MicroChem EBR PG is used for clean up or edge bead removal, LOR/PMGI and conventional resists may be employed in the same system.

## Edge Bead Removal

MicroChem EBR PG effectively removes both edge-beads and whiskers, and is designed specifically for LOR/PMGI resists. EBR PG is compatible with most conventional positive resists and commercially available coating tracks. Acetone and conventional resist edge-bead removers are NOT recommended with LOR/PMGI products. See the EBR PG data sheet for more details

## Soft- bake/Prebake Process

The pre-bake process enables precise and reproducible control of undercut to provide maximum process windows. Pre-bake temperature shows the greatest influence on undercut rate, although pre-bake time, exposure dose for the patterning resist, choice of developer, develop mode and develop time are also influential. Refer to Figures 5a, 5b and 6.

Hot plates are the preferred tool for the pre-bake; however, LOR/PMGI resists are also compatible with convection oven processes. The recommended bake temperature range is 150°C - 200°C, although some PMGI products may be baked to 250°C. Ultimately, a matrix design varying pre-bake temperature and time is recommended for process fine-tuning.

## Application and Processing the Patterning Resist Layer

Refer to the patterning resist manufacturer process recommendations for specific processing directions. LOR/PMGI products are compatible with typical g-line, i-line, broadband, deep UV, 193nm, and e-beam photoresists. The resist can be applied and pre-baked directly over PMGI without need for barrier layers or plasma de-scum steps. LOR or PMGI does not require an exposure step when using the simple bi-layer lift-off process. PMGI can also be used in a Cap-On process in which the PMGI layer must be deep-UV (240-290nm) flood exposed. The Cap-On process is typically used to obtain straighter sidewall profiles in the PMGI resist layer. For more detailed information regarding the Cap-On process, please contact your MicroChem Technical Sales Representative, or refer to the PMGI Process Notes, which are available on our website. www.microchem.com

Figure 5a:

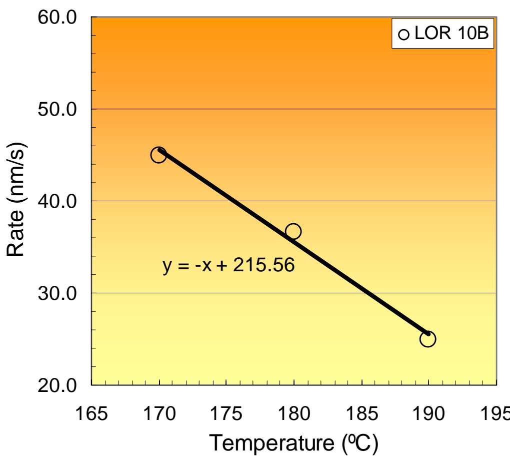



Figure 5b:

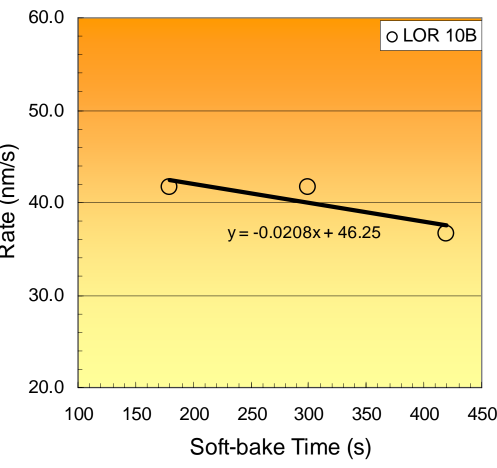
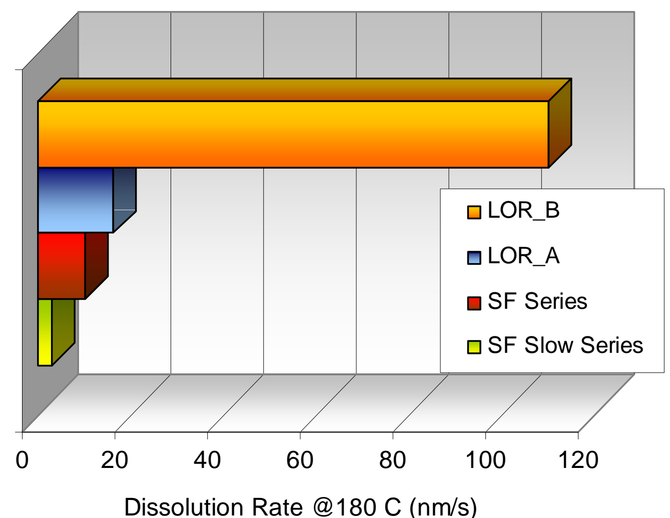



Figure 6:



## Post - Exposure (PEB) Process

LOR/PMGI does not require post-exposure baking. Refer to patterning resist manufacturer process recommendations to determine whether a PEB step is required.

## Development Process

LOR and PMGI resists are optimized for use with various metal ion free and metal ion containing developers. Thickness of both LOR/PMGI layer and patterning resist layer contribute ultimately to final develop time. Also, sidewall profile can be influenced by the development process. Straighter sidewalls with thick (>2 um) LOR/PMGI layers are obtained using spray development. Refer to the product selection guide to determine the best product to satisfy your application requirements. For more detailed information regarding processing needs, please contact a MicroChem Technical Sales Representative, or refer to the PMGI Process Notes, which are available on the website, www.microchem.com

## Deposition Process

PMGI is compatible with high temperature sputter, evaporative metal and dielectric deposition processes. The step coverage achieved in the deposition process will influence ultimate dimensional stability.

## Lift-Off Process

Use MicroChem's Remover PG to remove the bi-layer resist stack. Removal rate of LOR/PMGI is dependent upon soft-bake temperature of the LOR/PMGI product and remover bath temperature. As a baseline process, use Remover PG in two tanks: at 60ºC for 30 minutes in the first tank and rinse at 60ºC in the second tank. Ultrasonic action will improve the resist removal efficiency. Actual processing times will vary depending upon pre-bake conditions, step coverage and resist profiles. Figure 9 demonstrates the effect of temperature on the removal process. Consult the Remover PG technical data sheet for more information on this product.

Figure 7:
The Effect of Developer Type on Dissolution Rate

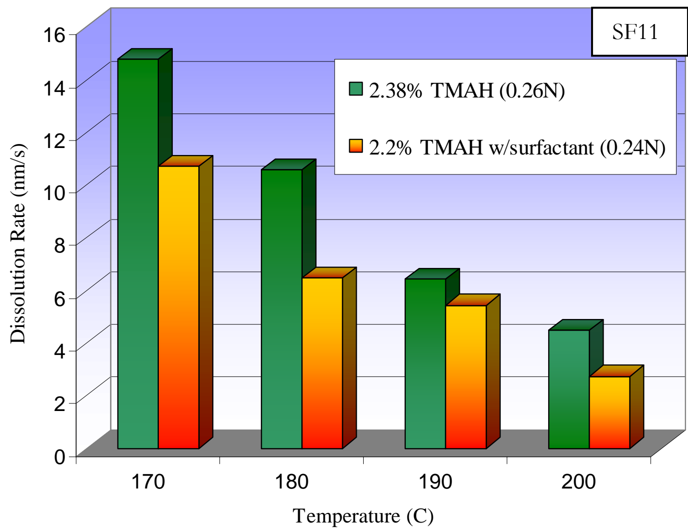
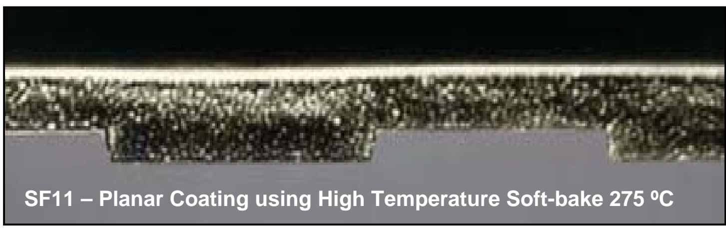



Figure 8:


SF11 – Planar Coating using High Temperature Soft-bake 275 ºC

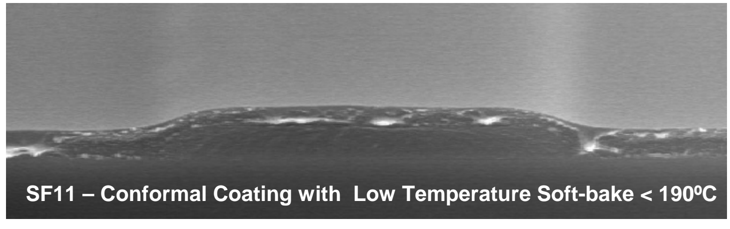
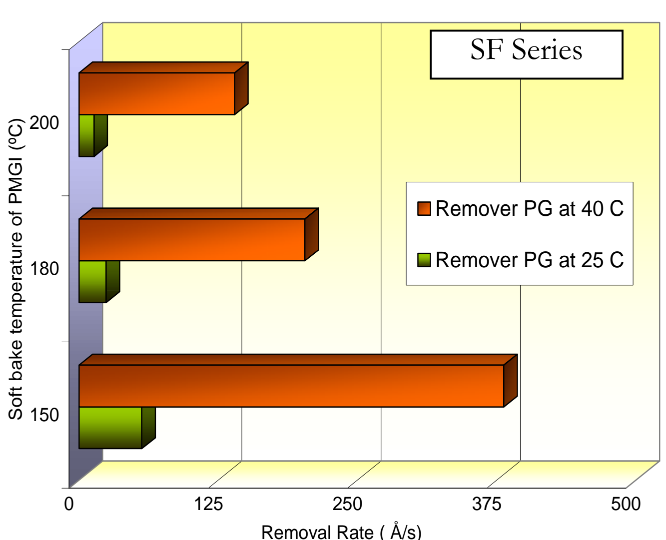
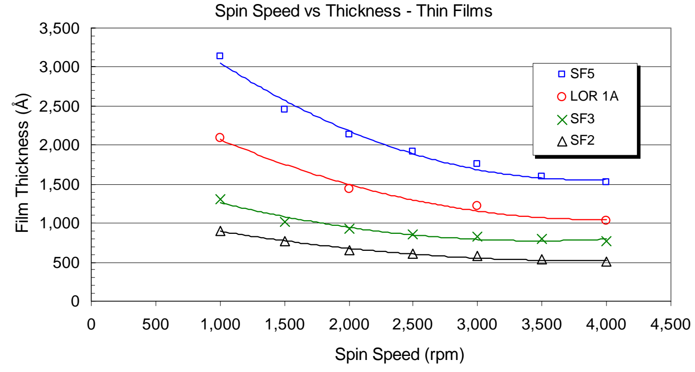
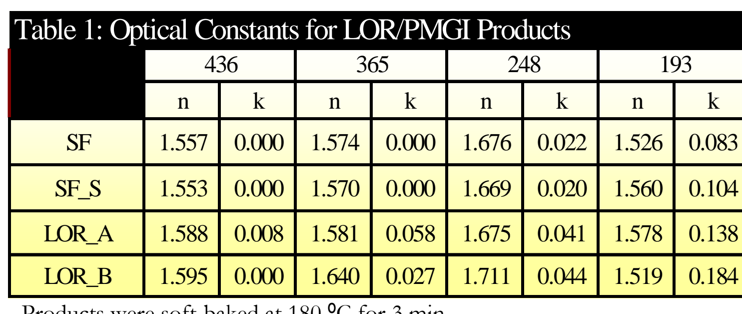

SF11 – Conformal Coating with Low Temperature Soft-bake < 190ºC

Figure 9:
Removal Rate of PMGI in Remover PG at 25 and 40 ºC



# Technical Data



| Table 1: Optical Constants for LOR/PMGI Products | 436 | | 365 | | 248 | | 193 | |
|---|---|---|---|---|---|---|---|---|
| | n | k | n | k | n | k | n | k |
| SF | 1.557 | 0.000 | 1.574 | 0.000 | 1.676 | 0.022 | 1.526 | 0.083 |
| SF_S | 1.553 | 0.000 | 1.570 | 0.000 | 1.669 | 0.020 | 1.560 | 0.104 |
| LOR_A | 1.588 | 0.008 | 1.581 | 0.058 | 1.675 | 0.041 | 1.578 | 0.138 |
| LOR_B | 1.595 | 0.000 | 1.640 | 0.027 | 1.711 | 0.044 | 1.519 | 0.184 |

- Products were soft-baked at 180 °C for 3 min

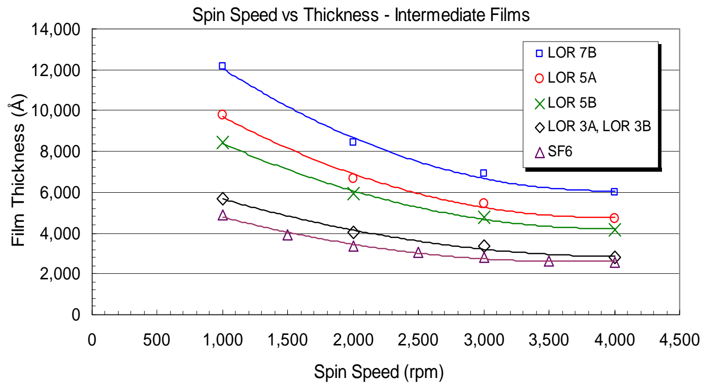
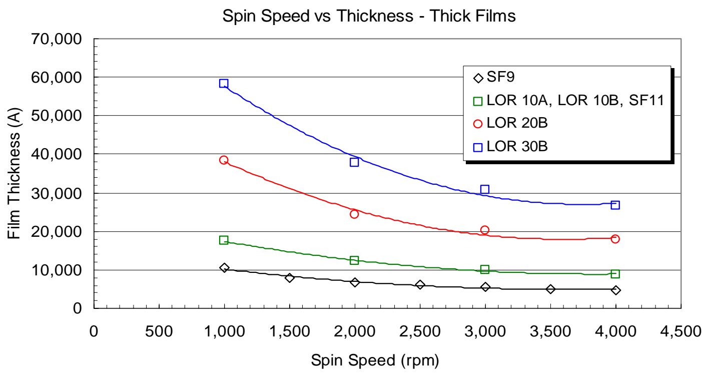



**Table 2: Cauchy Parameters for LOR/PMGI in the Transparent Region**

| Product | An | Bn | Cn | Wavelength Range (nm) |
|---|---|---|---|---|
| SF | 1.524 | 5.176E-03 | 2.105E-04 | 300 - 1700 |
| SF_S | 1.522 | 5.052E-03 | 2.113E-04 | 300 - 1700 |
| LOR_A | 1.537 | 5.636E-03 | 7.984E-04 | 500 - 1700 |
| LOR_B | 1.547 | 5.912E-03 | 6.190E-04 | 430 - 1700 |




Optical Constant n for PMGI Products

Index of Refraction, n

Wavelength (nm)

LOR_B
LOR_A
SF
SF_S

**RECOMMENDED COATING PARAMETERS**

| | |
|---|---|
| **Dispense volume** | **5 ml (150 mm Si wafer)** |
| **Dispense mode** | **Dynamic 3-5 seconds** |
| **Dispense spin speed** | **300-500 rpm** |
| **Acceleration** | **10,000 rpm/second** |
| **Terminal spin speed** | **3,000 rpm** |
| **Spin time** | **45 seconds** |
| **Edge bead remover** | **EBR PG** |

**Table 3: Viscosity and Density Data**

| Product Film Thickness @ 3000 rpm | Approximate Viscosity, cSt | Approximate Density, g/ml |
|---|---|---|
| 50 nm | 2 | 0.96 |
| 100 nm | 3 | 0.97 |
| 200 nm | 7 | 0.97 |
| 300 nm | 11 | 0.98 |
| 500 nm | 25 | 0.98 |
| 1 um | 115 | 0.99 |
| 2 um | 450 | 1.00 |
| 3 um | 750 | 1.00 |

## LOR/PMGI Product Selection Guide

| Attributes | | LOR A | LOR B | SF | SF Slow |
|---|---|---|---|---|---|
| Undercut Geometry | <0.35um | | | ☆ | ★ |
| | 0.35 - 0.5um | ★ | | ★ | |
| | 0.5 - 1um | ★ | ★ | | |
| | >1 um | | ★ | ☆ [3] | ☆ [3] |
| Thickness Range | <100nm | | | ★ | ★ |
| | 0.1um - 1um | ★ | ★ | ★ | ★ |
| | 1 - 5 um | ☆ [4] | ★ | ☆ [3] | ☆ [3] |
| Temperature Range | <150 C | | | | |
| | 150 - 190 C | ★ | ★ | ☆ [1,2] | ☆ [1,2] |
| | >190 C | | | ★ | ★ |
| Developer Compatibility | 0.26N MIF | ★ | | ★ | ★ |
| | 0.24N MIF | ★ | ★ | ★ | ★ |
| | MIB | | ★ | | |
| Resist Solvent Compatibility | Ethyl Lactate | ★ [2] | ★ [2] | ★ [2] | ★ [2] |
| | PGMEA | ★ | ★ | ★ | ★ |
| | 2-Heptanone | ★ | ★ | ★ | ★ |
| | Cyclohexanone | ★ | ★ | ★ | ★ |
| Substrate Compatibility | Si | ★ | ★ | ★ | ★ |
| | Glass | ★ | ★ | ★ | ★ |
| | NiFe | ★ | ★ | ★ | ★ |
| | III-V Metals | ★ | ★ | ★ | ★ |
| | Au | ★ | ★ | ★ | ★ |
| Coating | Conformal | ★ | ★ | ★ | ★ |
| | Planar & Via-fill | | | ☆ [5] | ☆ [5] |

★ Recommended ☆ Some Compatibility

1. Adhesion loss can occur with reworked substrates when soft-baking the PMGI with temperatures lower than 180 $^{o}$C.
2. Intermixing can occur with Ethyl Lactate based resists at temperatures below 180 $^{o}$C.
3. A Cap-On Process or an additional exposure of the PMGI layer can be used to achieve excellent results.
4. Compatible up to 3um in thickness.
5. High temperatures >250 $^{o}$C needed for reflow.

## Handling LOR/PMGI

Use precautions for combustible mixtures with cyclopentanone when handling LOR products. Avoid contact with eyes, skin, and clothing. Use with adequate ventilation and avoid breathing fumes. Wear chemical-resistant eye protection, chemical gloves, and protective clothing when handling LOR products.
LOR resists cause irritation in case of contact with eyes, skin, and mucous membranes. In case of eye contact, flush with water for 15 minutes and call a physician immediately. Review the current product Material Safety Data Sheet before using.

## LOR/PMGI Material and Equipment Handling

LOR/PMGI is compatible with glass, ceramic, unfilled polypropylene, high-density polyethylene, polytetrafluoroethylene, stainless steel, and equivalent materials. LOR/PMGI products are compatible with most commercial resist processing equipment.

## Processing Environment for LOR/PMGI

For optimum results, use LOR resists in a controlled environment.
20-25° ± 1°C (68-77° ± 2°F)
35-45% ± 2% relative humidity

## LOR/PMGI Storage

Store upright in original sealed containers in a dry area at 17 ± 7C (63 ± 13F).
.
Keep away from sources of ignition, light, heat, oxidants, acids, and reducers.
Do not use after the expiration date (13 months from date of manufacture).

## Disposing of LOR/PMGI

Each locality, state, and country invokes unique regulations regarding the disposal of organic solvents such as LOR resists. It is the user's responsibility to dispose of LOR/PMGI in compliance with all applicable codes and regulations. In most cases, LOR/PMGI may be included with other organic solvents for destruction or reclaim.
Ensure that acetone and resist waste are kept separate from LOR/PMGI waste streams. LOR/PMGI will precipitate in the presence of acetone, PGMEA, and ethyl lactate and may clog lines or form unwanted solids in the collection area.

## Disclaimer

Notwithstanding anything to the contrary contained in any sales documentation, e.g., purchase order forms, all sales are made on the following conditions:
All information contained in any MicroChem product literature reflects our current knowledge on the subject and is, we believe, reliable. It is offered solely to provide possible suggestions for customer's own experiments and is not a substitute for any testing by customer to determine the suitability of any of MicroChem products for any particular purpose. This information may be subject to revision as new knowledge and experience becomes available, but MicroChem assumes no obligation to update or revise any data previously furnished to a customer; and if currency of data becomes an issue, customer should contact MicroChem requesting updates. Since MicroChem cannot anticipate all variations in actual end uses or in actual end-use conditions, it makes no claims, representations or warranties, express or implied including, without limitation any warranty of merchantability or fitness for a particular purpose; and customer waives all of the same. MicroChem expressly disclaims any responsibility or liability and assumes no responsibility or liability in connection with any use of this information including, without limitation, any use, handling, storage or possession of any MicroChem products, or the application of any process described herein or the results desired or anything relating to the design of the customer's products. Nothing in this publication is to be considered as a license to operate under or a recommendation to infringe any patent right.

## Caution

This product is not designed or manufactured for any use, or intended use, in any medical device or for any other medical application. Do not use this product in any medical applications including, without limitation, any permanent implantation in the human body or any animals (other than laboratory animals used for experimental purposes), or contact with internal body fluids or tissues] unless otherwise expressly and specifically provided for in a written contract between MCC and the customer. The complete MicroChem Medical Disclaimer Statement is available upon request.

## PRODUCT ATTRIBUTES

- Submicron linewidth control
- Sub 0.1µm imaging
- E-beam, X-ray & deep UV imaging
- Broad range of molecular weights & dilutions
- Excellent adhesion to most substrates
- Compatible with multi-layer processes

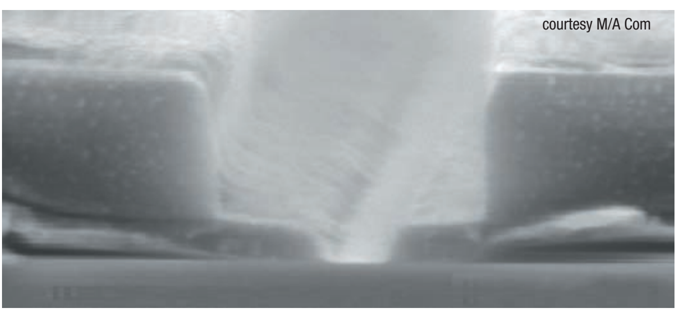
## APPLICATIONS

- Multi-layer T-gate processing
- Direct write e-beam lithography
- Protective coatings for wafer thinning
- Adhesive for X-ray LIGA processing
- Sacrificial layers

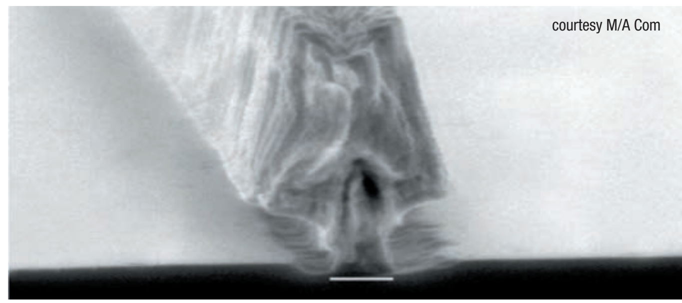
# NANO™ PMMA and Copolymer

PMMA (polymethyl methacrylate) is a versatile polymeric material that is well suited for many imaging and non-imaging microelectronic applications. PMMA is most commonly used as a high resolution positive resist for direct write e-beam as well as x-ray and deep UV microlithographic processes. PMMA is also used as a protective coating for wafer thinning, as a bonding adhesive and as a sacrificial layer.

Standard PMMA products cover a wide range of film thicknesses and are formulated with 495,000 & 950,000 molecular weight (MW) resins in either chlorobenzene or the safer solvent anisole. Custom MW products ranging from 50,000 - 2.2 million are available upon request. In addition, we offer copolymer (MMA (8.5) MAA) products formulated in the safer solvent ethyl lactate. All MCC PMMA and copolymer resists are available in package sizes from 500ml to 20 liters.




100nm gate profile imaged in 495K PMMA with 8.5 MAA Copolymer on top.




T-gate resulting from PMMA/Copolymer bilayer resist stack.

**Substrate Preparation**

The substrate should be clean and dry. Solvent, $O_2$ plasma, and $O_3$ cleans are commonly used and recommended.

**Coat**

MicroChem PMMA resists produce low defect coatings over a broad range of film thicknesses. The film thickness vs. spin-speed curves displayed in Fig. 1 through 8 provide the information required to select the appropriate PMMA dilution and spin speed needed to achieve the desired film thickness.

The recommended coating conditions are:

| | | |
|---|---|---|
| (1) Dispense: | STATIC | 5 - 8ml for a 150mm wafer |
| (2) Spread: | DYNAMIC | 500 rpm for 5 sec OR |
| | STATIC | 0 rpm for 10 sec |
| (3) Spin: | Ramp to final spin speed at a high acceleration rate and hold for a total of 45 seconds. | |

**Pre Bake**

**PMMA**

Hot plate: 180°C for 60 - 90 sec OR

Convection Oven: 170°C for 30 min

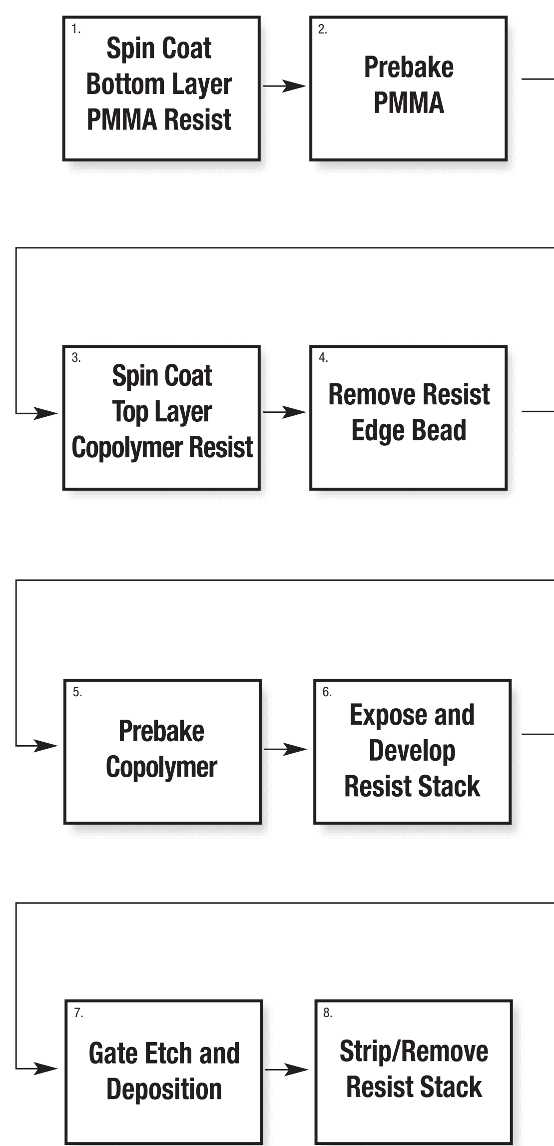
**Copolymer**

Hot plate: 150°C for 60 - 90 sec OR

Convection Oven: 140°C for 30 min

*Vacuum oven bake can also be used

**Typical process flow for bi-layer T-gate process**



### Expose

PMMA can be exposed with various parts of the electromagnetic spectrum.

e-beam: Dose - 50 - 500 $\mu C/cm^2$ depending on radiation source/equipment & developer used.

Energy – 20-50kV; higher kV for higher resolution, e.g. 50kV for 0.1mm images.

DUV(deep UV): Low sensitivity, requiring doses >500$mJ/cm^2$ at 248nm.

X-ray: Sensitivity of PMMA is low, ~1-2 J/cm2 at 8.3Å. The sensitivity increases at longer x-ray wavelengths. Features of <0.02µm can be fabricated.

### Develop

PMMA and copolymer resists are compatible with immersion (21$^{o}$C), spray puddle, and spray process modes. Process variables such as soft bake, exposure conditions, choice of resist and developer should be optimized to achieve desired results. For more process details see the PMMA and Copolymer DEVELOPER data sheet. Table 1 lists commonly used developers and their recommended usage.

NANO™ PMMA AND COPOLYMER DEVELOPERS ARE AVAILABLE IN THE FOLLOWING BLENDS

| PRODUCT | COMPOSITION | RESOLUTION | SENSITIVITY / THROUGHPUT |
|---|---|---|---|
| M/I 1:1 | 1:1 MIBK to IPA | high | high |
| M/I 1:2 | 1:2 MIBK to IPA | higher | medium |
| M/I 1:3 | 1:3 MIBK to IPA | very high | low |
| MIBK | MIBK | low | high |

**Table 1**

### Rinse and Dry

To terminate the develop process and prevent scumming, PMMA and copolymer should be immersed or sprayed with 1:3 or 1:4 MIBK:IPA, alcohol or DI water immediately following develop. Substrates are normally spin dried at 3000rpm for 20 seconds or $N_2$ blow dried.

Table 2 outlines helpful guidelines for a develop process.

TYPICAL DEVELOPMENT PROCESS

| ACTION | SPRAY** | SPRAY PUDDLE | IMMERSION (21$^{o}$C) |
|---|---|---|---|
| Dispense | 500 rpm for 30-45 secs | 500 rpm for 3-4 secs | |
| Dispense | | 0 rpm for 2 secs | |
| No Dispense | | 0 rpm for 25-40 secs | 30 secs |
| Rinse * | 500 rpm for 30-45 secs | 500 rpm for 3-4 secs | 30 secs |
| Dry | 500 rpm for 30 secs | 5000 rpm for 30 secs | Nitrogen blow dry |

* Recommended Rinse solution is MIBK to IPA 1:3 in order to reduce the possibility of scumming

** Variables such as developer pressure, nozzle type & position, spray pattern, etc. should be optimized

**Table 2**

### Postbake/Hardbake (optional)

To remove residual developer, rinse solvent, and moisture from the resist image.

| | |
|---|---|
| Hot Plate OR | 100$^{o}$C for 60 - 90 sec |
| Convection Oven | 95$^{o}$C for 30 min |

Note: PMMA images will round/flow above 125$^{o}$C.

### Remove

| | |
|---|---|
| Wet: | Remover PG or ACRYL STRIP |
| Bath: | time as required, ambient |
| Spray: | time as required, 500 - 1000 rpm |
| Dry: | plasma $O_2$ |

PMMA and copolymer resists can be removed by using MCC's Remover PG or standard cleanroom solvents, such as acetone, photoresist thinner, or positive photoresist removers.

Resists that have seen higher processing temperatures and/or hostile processes that have toughened the polymer will require ACRYL STRIP or a more aggressive removal process. This can include Remover PG at elevated temperature followed by cleaner baths to assure adequate material removal.

See appropriate product data sheet for specific process recommendations and safety precautions.

For additional questions or technical assistance please contact Technical Services.

# SPIN SPEED CURVES FOR PMMA AND COPOLYMER RESISTS

The spin speed versus film thickness curves displayed in figures 1-11 provide approximate information required to select the appropriate PMMA or copolymer resist and spin conditions needed to obtain the desired film thickness. Actual results will vary and are equipment, environment, process and application specific. Additional resist dilutions to obtain other film thicknesses are available upon request.

**495PMMA C Resists**
**Solids: 2% - 6% in Chlorobenzene**

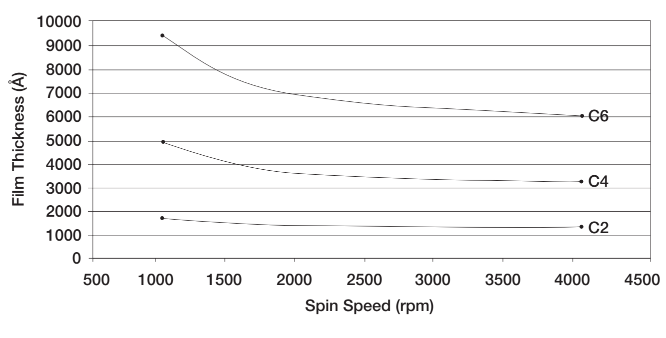



Figure 1

**495PMMA A Resists**
**Solids: 2% - 6% in Anisole**

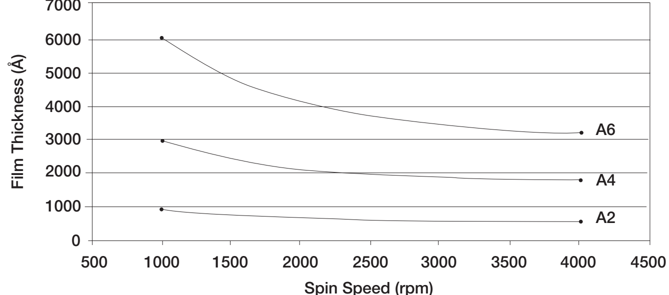



Figure 3

**495PMMA C Resists**
**Solids: 8% - 9% in Chlorobenzene**

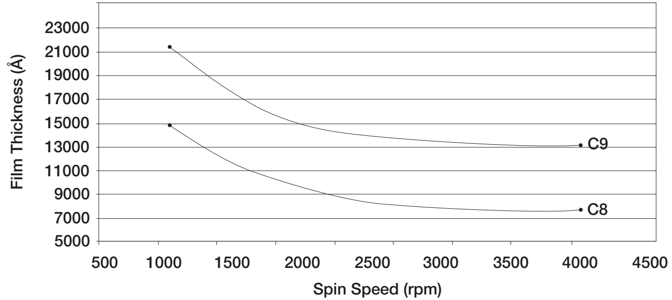



Figure 2

**495PMMA A Resists**
**Solids: 8% - 11% in Anisole**

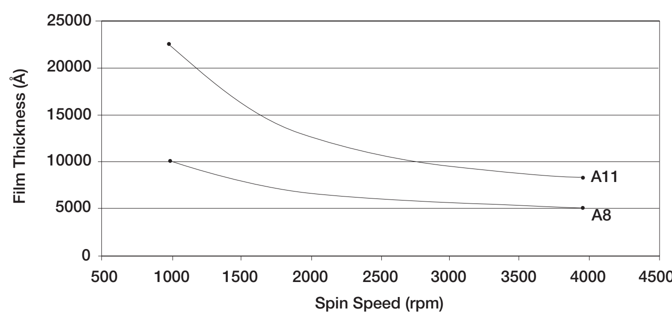



Figure 4

**Copolymer Resists**
**Solids: 6% - 11% in Ethyl Lactate**

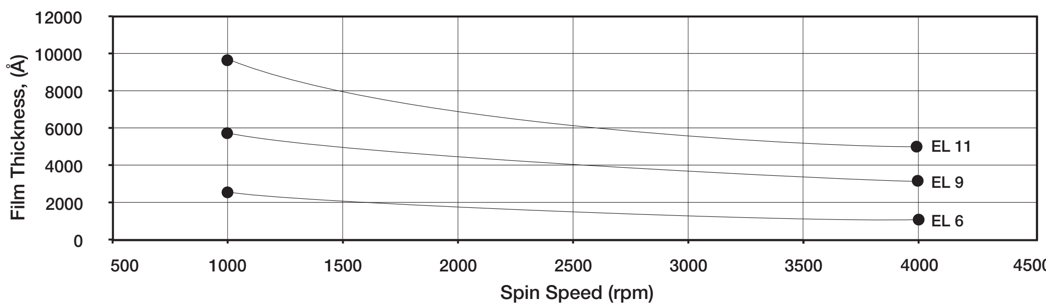



Figure 9

**950PMMA C Resists**
**Solids: 9% - 10% in Chlorobenzene**

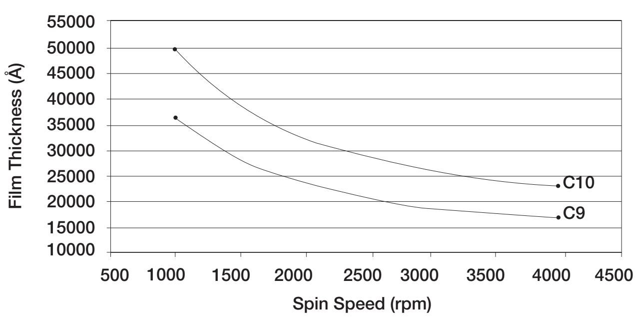



Figure 5

**950PMMA A Resists**
**Solids: 9% - 11% in Anisole**

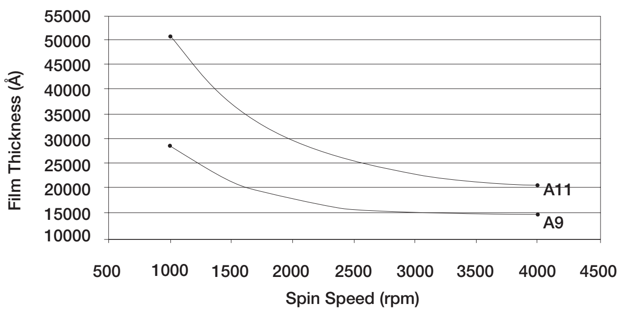



Figure 7

**950PMMA C Resists**
**Solids: 2% - 7% in Chlorobenzene**

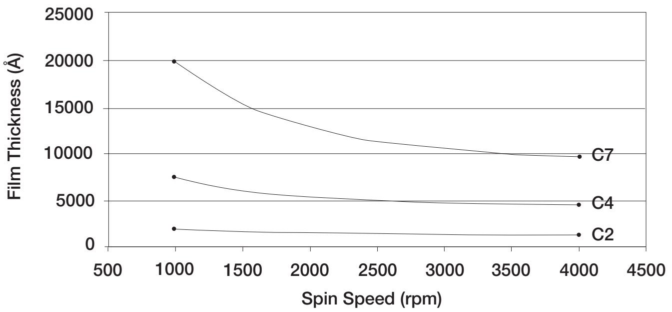



Figure 6

**950PMMA A Resists**
**Solids: 2% - 7% in Anisole**

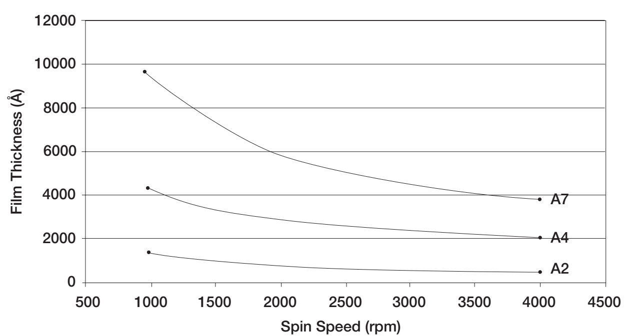



Figure 8

**Optical Properties**
**495 and 950 PMMA Resists**

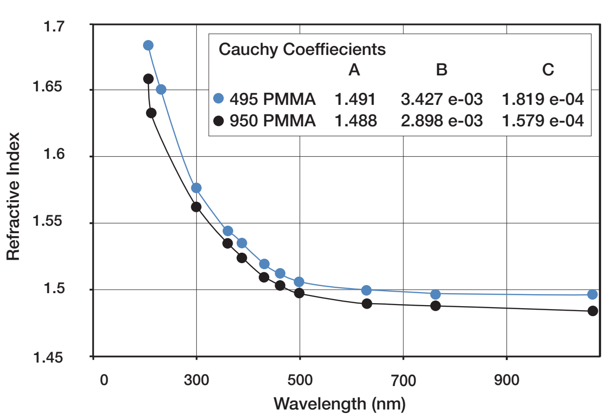



Figure 10

**Optical Properties**
**Copolymer Resists**

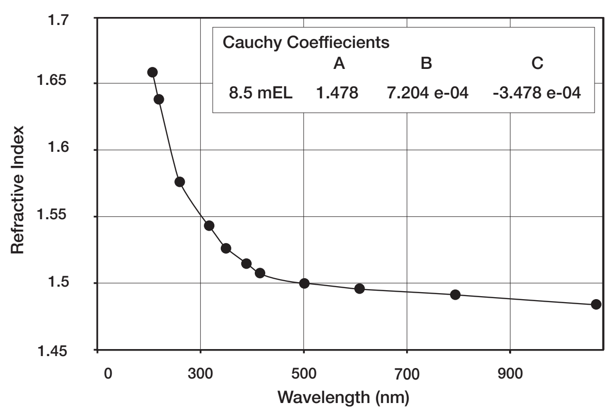
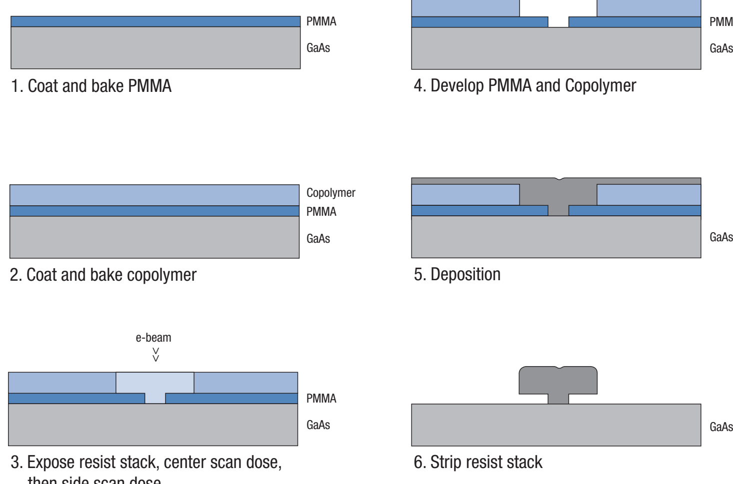



Figure 11

**PMMA resists for T-gate and other imaging processes**

PMMA is a high resolution positive tone resist for e-beam, deep UV (200-250nm) and X-ray lithographic processes. Although PMMA may be used in a single layer resist process, it is most commonly used in multi-layer processes such as in the fabrication of mushroom or T-gates. Images are formed through the photo scission of the polymer backbone and subsequent development process, which removes the exposed, lower molecular weight resist. Multi-layer, shaped resist profiles are realized and influenced through the careful choice of PMMA molecular weight, film thickness and other process set points.

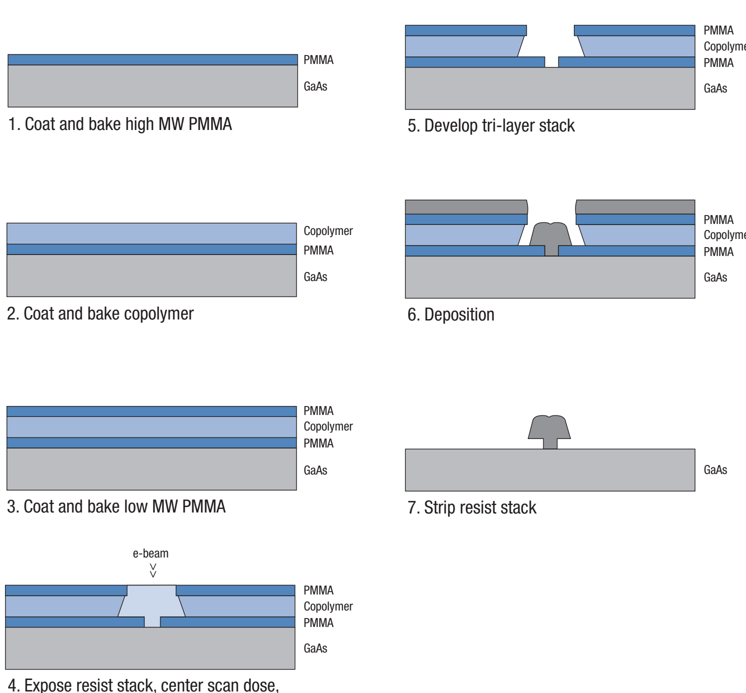
### Bi-Layer Process




In a typical bi-layer process, a combination of bottom and top layer resists are selected such that a large difference in dissolution rates of the layers at the developer step exists, leading to the desired resist sidewall profile. This contrast may be further influenced with a variety of process strategies. Generally, dissolution rate increases as molecular weight decreases. However, soft bake conditions, which affect residual solvent level and subsequent development rates will influence the bi-layer resist profile as will the exposure conditions.

Please refer to our web site, www.microchem.com for applications notes concerning non-imaging PMMA processes such as wafer thinning, bonding and sacrificial layers.

### Tri-Layer Process



## HANDLING NANO PMMA & COPOLYMER SERIES RESISTS (in Anisole or Chlorobenzene)

Use precautions in handling flammable PMMA solutions. Avoid contact with eyes, skin, and clothing. Use with adequate ventilation. Avoid breathing fumes. Wear chemical-resistant eye protection, chemical gloves (PVA for chlorobenzene solutions) and protective clothing when handling NANO PMMA & Copolymer Series Resist products. NANO PMMA & Copolymer Series Resists cause irritation in case of contact with eyes, skin, and mucous membranes. In case of eye contact, flush with water for 15 minutes and call a physician immediately. Review the current MSDS (Material Safety Data Sheet) before using.

## MATERIAL AND EQUIPMENT COMPATIBILITY

NANO PMMA & Copolymer Resists are compatible with glass, ceramic, unfilled polyethylene, high-density polyethylene, polytetrafluoroethylene, stainless steel, and equivalent materials.

Chlorobenzene is a powerful solvent and will attack various elastomers such as BUNA N, EPDM, HYPALON, and NEOPRENE. It will also attack PVC, CPVC and polyester. VITON A is recommended for both O-rings and tubing.

## PROCESSING ENVIRONMENT

For optimum results, use NANO PMMA & Copolymer Series Resists in a controlled environment. 20 - 25° ±1°C (68 - 77°F) is suggested.

## STORAGE

Store upright in original containers in a dry area 50 - 80°F (10 - 27°C). Do not refrigerate. Keepaway from sources of ignition, light, heat, oxidants, acids, and reducers. Shelf life is 13 months from date of manufacture.

## DISPOSAL

Each locality, state, and county has unique regulations regarding the disposal of organic solvents such as NANO PMMA Series Resists. It is the responsibility of the customer to dispose of NANO PMMA Series Resists in compliance with all applicable codes and regulations. See MSDS for additional information.

1254 Chestnut Street
Newton, MA 02464
Phone: 617.965.5511
Fax: 617.965.5818
Email: mcc@microchem.com
WWW.MICROCHEM.COM

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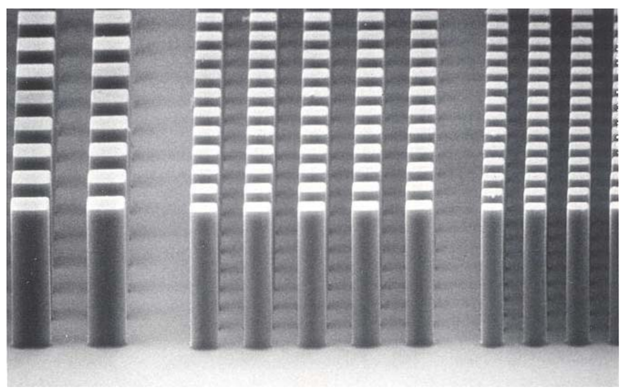
# SU-8 2000

## Permanent Epoxy Negative Photoresist

## PROCESSING GUIDELINES FOR:

## SU-8 2000.5, SU-8 2002, SU-8 2005, SU-8 2007, SU-8 2010 and SU-8 2015

**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. The use of a faster drying, more polar solvent system results in improved coating quality and increases process throughput. SU-8 2000 is available in twelve standard viscosities. Film thicknesses of 0.5 to >200 microns can be achieved with a single coat process. The exposed and subsequently thermally cross-linked portions of the film are rendered insoluble to liquid developers. SU-8 2000 has excellent imaging characteristics and is capable of producing very high aspect ratio structures. SU-8 2000 has very high optical transmission above 360 nm, 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 on the device.



10 um features, 50 um SU-8 2000 coating

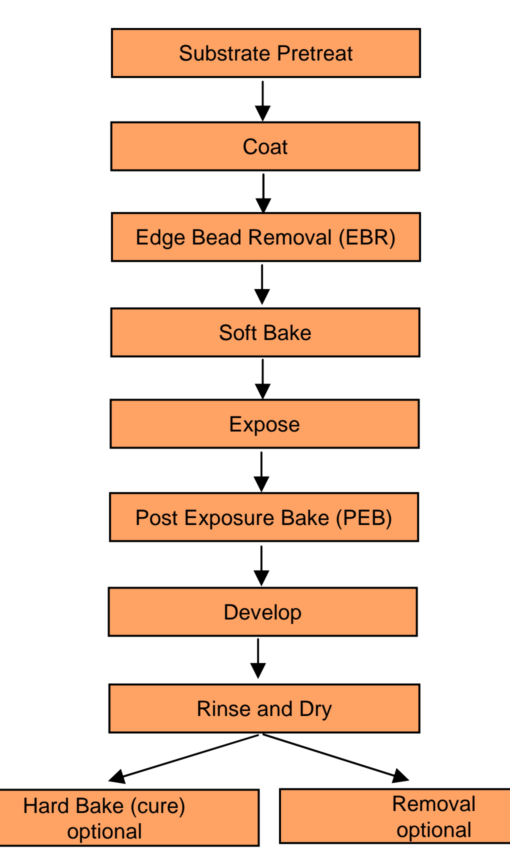
### SU-8 2000 Features

- High aspect ratio imaging
- 0.5 to > 200 μm film thickness in a single coat
- Improved coating properties
- Faster drying for increased throughput
- Near UV (350-400 nm) processing
- Vertical sidewalls

### Processing Guidelines

SU-8 2000 photoresist is most commonly exposed with conventional UV (350-400 nm) radiation, although i-line (365 nm) is the recommended wavelength. SU-8 2000 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. 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. The baseline information presented here is meant to be used as a starting point for determining a process.

### Process Flow



## Substrate Preparation

To obtain maximum process reliability, substrates should be clean and dry prior to applying SU-8 2000 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 oxygen. Adhesion promoters are typically not required. For applications that include electroplating, a pre-treatment of the substrate with MCC Primer 80/20 (HMDS) is recommended.

## Coat

SU-8 2000 resists are available in twelve standard viscosities. This processing guideline document addresses six products: SU-8 2000.5, SU-8 2002, SU-8 2005, SU-8 2007, SU-8 2010 and SU-8 2015. Figures 1.a. and 1.b. provide the information required to select the appropriate SU-8 2000 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 seconds with acceleration of 100 rpm/second.
3.) Spin at 2000 rpm for 30 seconds with acceleration of 300 rpm/second.

Figure 1.a. SU-8 2000 Spin Speed vs. Thickness

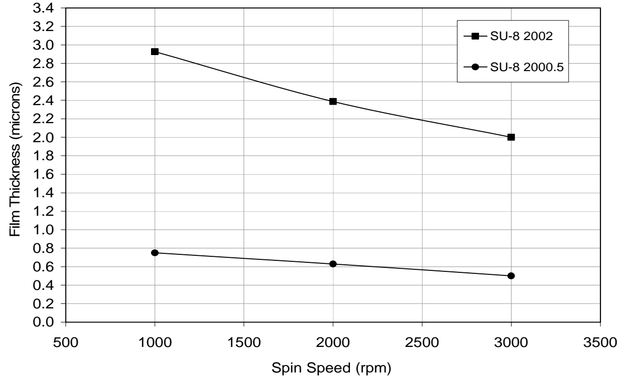



Figure 1.b. SU- 8 2000 Spin Speed vs. Thickness

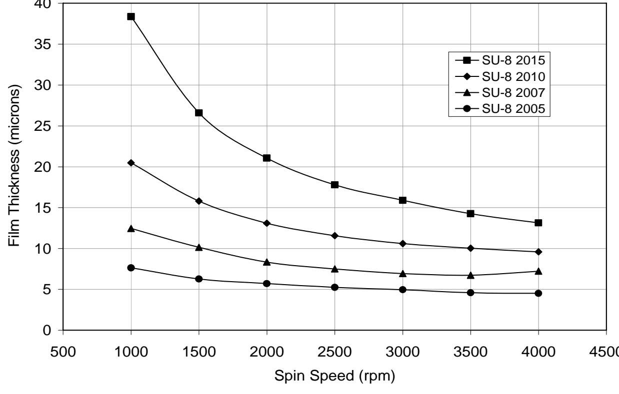



Table 1. SU-8 2000 Viscosity

| SU-8 2000 | % Solids | Viscosity (cSt) | Density (g/ml) |
|---|---|---|---|
| 2000.5 | 14.3 | 2.49 | 1.070 |
| 2002 | 29.00 | 7.5 | 1.123 |
| 2005 | 45.00 | 45 | 1.164 |
| 2007 | 52.50 | 140 | 1.175 |
| 2010 | 58.00 | 380 | 1.187 |
| 2015 | 63.45 | 1250 | 1.200 |

## Edge Bead Removal (EBR)

During the spin coat process step, a build up of photoresist may occur on the edge of the substrate. In order to minimize contamination of the hotplate, this thick bead should be removed. This can be accomplished by using a small stream of solvent (MicroChem's EBR PG) at the edge of the wafer either at the top or from the bottom. Most automated spin coaters now have this feature and can be programmed to do this automatically.

By removing any edge bead, the photomask can be placed into close contact with the wafer, resulting in improved resolution and aspect ratio.

## 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 2000 products at selected film thicknesses.

***Note:*** *To optimize the baking times/conditions, remove the wafer from the hotplate after the prescribed time and allow it 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.*

| THICKNESS | SOFT BAKE TIME |
|---|---|
| microns | minutes @ 95°C |
| 0.5 - 2 | 1 |
| 3 - 5 | 2 |
| 6 - 15 | 2 - 3 |
| 16 - 25 | 3 - 4 |
| 26 - 40 | 4 - 5 |

Table 2. Soft Bake Times

## Optical Parameters

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.

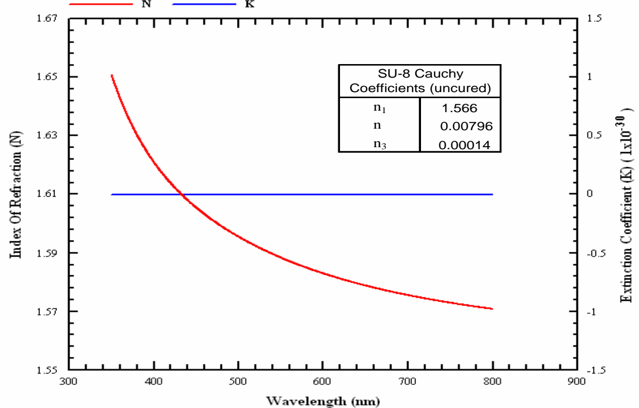



Figure 3. Cauchy Coefficients

## Exposure

To obtain vertical sidewalls in the SU-8 2000 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:*** *With optimal exposure, a visible latent image will be seen in the film within 5-15 seconds after being placed on the PEB hotplate and not before. An exposure matrix experiment should be performed to determine the optimum dosage.*

| THICKNESS microns | EXPOSURE ENERGY mJ/cm$^2$ |
|---|---|
| 0.5 - 2 | 60 - 80 |
| 3 - 5 | 90 - 105 |
| 6 - 15 | 110 - 140 |
| 16 - 25 | 140 - 150 |
| 26 - 40 | 150 - 160 |

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 Various Substrates

## Post Exposure Bake (PEB)

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 2000 photoresist coating. If no visible latent image is seen during or after PEB this means that there was insufficient exposure, heating or both.*

| THICKNESS microns | POST EXPOSURE BAKE TIME minutes @ 95°C |
|---|---|
| 0.5 - 2 | 1 - 2 |
| 3 - 5 | 2 - 3 |
| 6 - 15 | 3 - 4 |
| 16 - 25 | 4 - 5 |
| 26 - 40 | 5 - 6 |

Table 5. Post Exposure Bake Times

## Development

SU-8 2000 photoresist 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 recommended when developing high aspect ratio and/or thick film structures. The recommended development times for immersion processes are given in Table 6. These development times are approximate, since actual dissolution rates can vary widely as a function of agitation

***Note:*** *The use of an ultrasonic or megasonic bath may be helpful when developing out via or hole patterns or structures with tight pitch.*

| THICKNESS microns | DEVELOPMENT TIME minutes |
|---|---|
| 0.5 - 2 | 1 |
| 3 - 5 | 1 |
| 6 - 15 | 2 - 3 |
| 16 - 25 | 3 - 4 |
| 26 - 40 | 4 - 5 |

Table 6. Development Times for SU-8 Developer

## Rinse and Dry

When using SU-8 developer, spray and wash the developed image with fresh 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 is an indication of underdevelopment of the unexposed photoresist. Simply immerse or spray the substrate with additional SU-8 developer to remove the white film and complete the development process. Repeat the rinse step.*

*The use of an ultrasonic or megasonic bath will energize the solvent and allow for more effective development of the unexposed resist.*

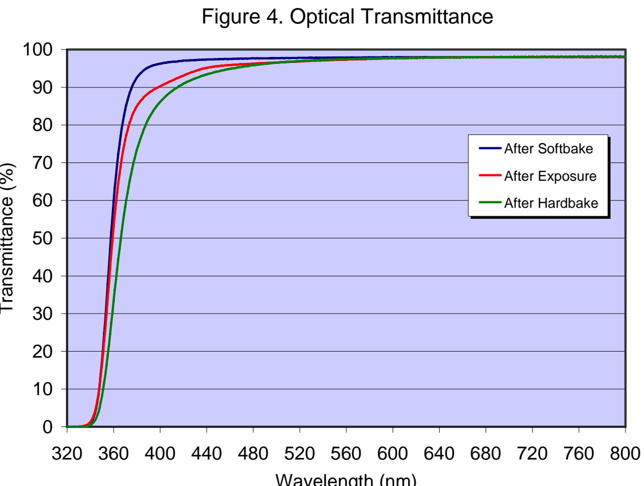
## Physical Properties

(Approximate values)

| Property | Value |
|---|---|
| Adhesion Strength (mPa) Silicon/Glass/Glass & HMDS | 38/35/35 |
| Glass Transition Temperature (Tg °C), tan δ peak | 210 |
| Thermal Stability (°C @ 5% wt. loss) | 315 |
| Thermal Conductivity (W/mK) | 0.3 |
| Coeff. of Thermal Expansion (CTE ppm) | 52 |
| Tensile Strength (Mpa) | 60 |
| Elongation at break (εb %) | 6.5 |
| Young's Modulus (Gpa) | 2.0 |
| Dielectric Constant @ 10MHz | 3.2 |
| Water Absorption (% 85°C/85 RH) | 0.65 |

Table 7. Physical Propeties

## Optical Properties




**Process conditions for Figure 4.**
Softbake: 5 minutes at 95°C
Exposure: 180 mJ/cm²
Hardbake: 30 minutes at 300°C

## Hard Bake (cure)

SU-8 2000 has good mechanical properties. However, for applications where the imaged resist is to be left as part of the final device, a hard bake can be incorporated into the process. This is generally only required if the final device or part is to be subject to thermal processing during regular operation. A hard bake or final cure step is added to ensure that SU-8 2000 properties do not change in actual use. SU-8 2000 is a thermal resin and as such its properties can continue to change when exposed to a higher temperature than previously encountered. We recommend using a final bake temperature 10°C higher than the maximum expected device operating temperature. Depending on the degree of cure required, a bake temperature in the range of 150°C to 250°C and for a time between 5 and 30 minutes is typically used.

***Note:*** *The hard bake step is also useful for annealing any surface cracks that may be evident after development. The recommended step is to bake at 150°C for a couple of minutes. This applies to all film thicknesses.*

## Removal

SU-8 2000 has been designed as a permanent, highly cross-linked epoxy material and it is extremely difficult to remove it with conventional solvent based resist strippers. MicroChem's Remover PG will swell and lift off minimally cross-linked SU-8 2000. 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 2000 material. Fully cured or hard baked SU-8 2000 cannot be removed without the use of OmniCoat.

To remove minimally cross-linked SU-8 2000, 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 2000: 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 2000 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 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 the 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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1254 Chestnut St.
Newton, MA 02464
PHONE: 617.965.5511
FAX: 617.965.5818
EMAIL: sales@ microchem.com
www.microchem.com

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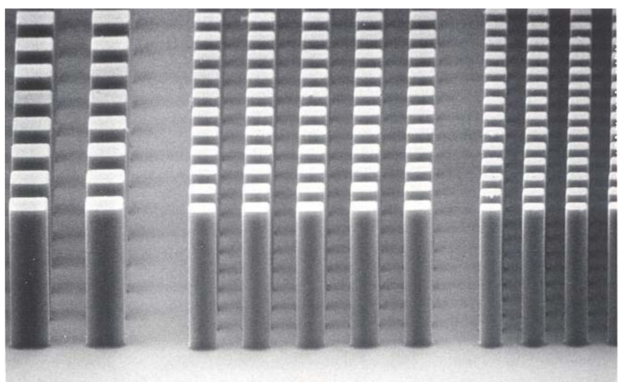
# SU-8 2000

## Permanent Epoxy Negative Photoresist

## PROCESSING GUIDELINES FOR:

## SU-8 2025, SU-8 2035, SU-8 2050 and SU-8 2075

**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. The use of a faster drying, more polar solvent system results in improved coating quality and increases process throughput. SU-8 2000 is available in twelve standard viscosities. Film thicknesses of 0.5 to >200 microns can be achieved with a single coat process. The exposed and subsequently thermally cross-linked portions of the film are rendered insoluble to liquid developers. SU-8 2000 has excellent imaging characteristics and is capable of producing very high aspect ratio structures. SU-8 2000 has very high optical transmission above 360 nm, 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 on the device.



10 um features, 50 um SU-8 2000 coating

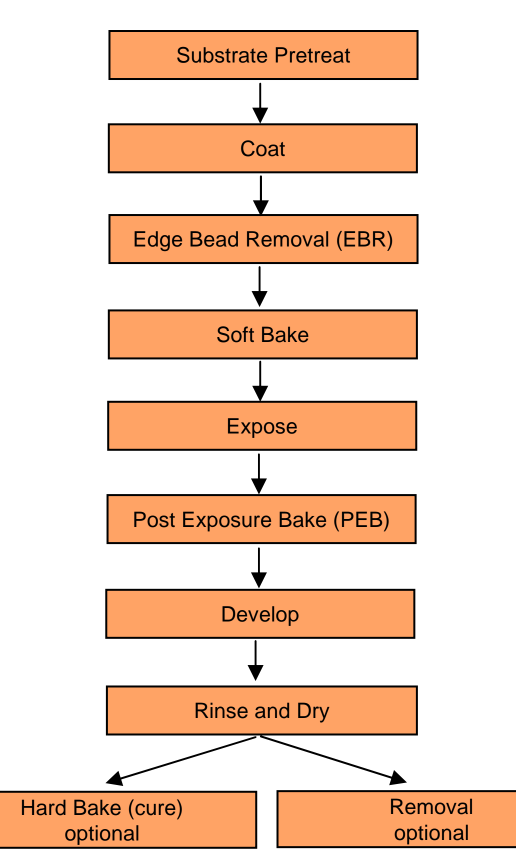
### SU-8 2000 Features

- High aspect ratio imaging
- 0.5 to > 200 μm film thickness in a single coat
- Improved coating properties
- Faster drying for increased throughput
- Near UV (350-400 nm) processing
- Vertical sidewalls

### Processing Guidelines

SU-8 2000 photoresist is most commonly exposed with conventional UV (350-400 nm) radiation, although i-line (365 nm) is the recommended wavelength. SU-8 2000 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. 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. The baseline information presented here is meant to be used as a starting point for determining a process.

### Process Flow



## Substrate Preparation

To obtain maximum process reliability, substrates should be clean and dry prior to applying SU-8 2000 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 oxygen. Adhesion promoters are typically not required. For applications that include electroplating, a pre-treatment of the substrate with MCC Primer 80/20 (HMDS) is recommended.

## Coat

SU-8 2000 resists are available in twelve standard viscosities. This processing guideline document addresses four products: SU-8 2025, SU-8 2035, SU-8 2050 and SU-8 2075. Figure 1. provides the information required to select the appropriate SU-8 2000 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 seconds with acceleration of 100 rpm/second.
3.) Spin at 2000 rpm for 30 seconds with acceleration of 300 rpm/second.

**Figure 1. SU-8 2000 Spin Speed versus Thickness**

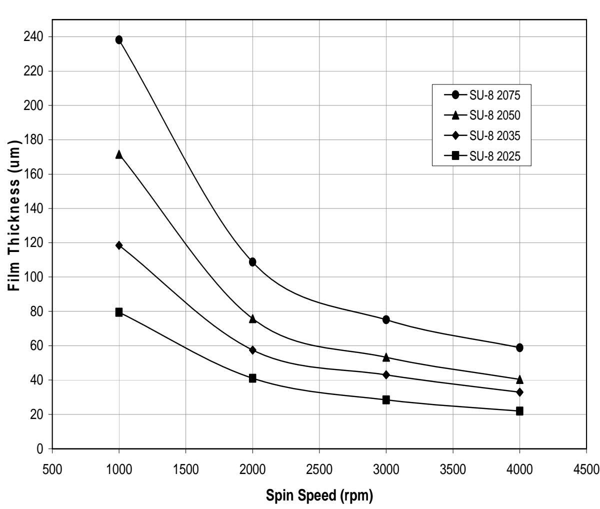



Table 1. SU-8 2000 Viscosity

| SU-8 2000 | % Solids | Viscosity (cSt) | Density (g/ml) |
|---|---|---|---|
| 2025 | 68.55 | 4500 | 1.219 |
| 2035 | 69.95 | 7000 | 1.227 |
| 2050 | 71.65 | 12900 | 1.233 |
| 2075 | 73.45 | 22000 | 1.236 |

## Edge Bead Removal (EBR)

During the spin coat process step, a build up of photoresist may occur on the edge of the substrate. In order to minimize contamination of the hotplate, this thick bead should be removed. This can be accomplished by using a small stream of solvent (MicroChem's EBR PG) at the edge of the wafer either at the top or from the bottom. Most automated spin coaters now have this feature and can be programmed to do this automatically.

By removing any edge bead, the photomask can be placed into close contact with the wafer, resulting in improved resolution and aspect ratio.

## 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 2000 products at selected film thicknesses.

***Note:*** *To optimize the baking times/conditions, remove the wafer from the hotplate after the prescribed time and allow it 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.*

| THICKNESS | SOFT BAKE TIMES | |
|---|---|---|
| | (65°C) | (95°C) |
| microns | minutes | minutes |
| 25 -40 | 0 - 3 | 5 - 6 |
| 45 - 80 | 0 - 3 | 6 - 9 |
| 85 - 110 | 5 | 10 - 20 |
| 115 - 150 | 5 | 20 - 30 |
| 160 - 225 | 7 | 30 - 45 |

Table 2. Soft Bake Times

## Optical Parameters

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.

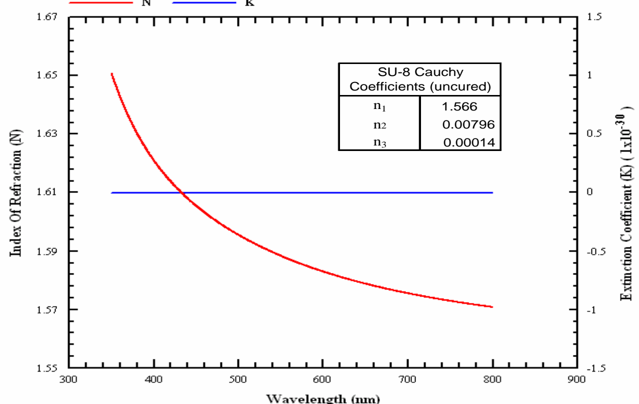



Figure 3. Cauchy Coefficients

## Exposure

To obtain vertical sidewalls in the SU-8 2000 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:*** *With optimal exposure, a visible latent image will be seen in the film within 5-15 seconds after being placed on the PEB hotplate and not before. An exposure matrix experiment should be performed to determine the optimum dosage.*

| THICKNESS microns | EXPOSURE ENERGY $mJ/cm^2$ |
|---|---|
| 25 - 40 | 150 - 160 |
| 45 - 80 | 150 - 215 |
| 85 - 110 | 215 - 240 |
| 115 - 150 | 240 - 260 |
| 160 - 225 | 260 - 350 |

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 Various Substrates

## Post Exposure Bake (PEB)

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 2000 photoresist coating. If no visible latent image is seen during or after PEB this means that there was insufficient exposure, heating or both.*

| THICKNESS microns | PEB TIME (65°C)* minutes | PEB TIME (95°C) minutes |
|---|---|---|
| 25 -40 | 1 | 5 - 6 |
| 45 - 80 | 1 - 2 | 6 - 7 |
| 85 - 110 | 2 - 5 | 8 - 10 |
| 115 - 150 | 5 | 10 - 12 |
| 160 - 225 | 5 | 12 - 15 |

* Optional step for stress reduction

Table 5. Post Exposure Bake Times

## Development

SU-8 2000 photoresist 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 recommended when developing high aspect ratio and/or thick film structures. The recommended development times for immersion processes are given in Table 6. These development times are approximate, since actual dissolution rates can vary widely as a function of agitation

***Note:*** *The use of an ultrasonic or megasonic bath may be helpful when developing out via or hole patterns or structures with tight pitch.*

| THICKNESS microns | DEVELOPMENT TIME minutes |
|---|---|
| 25 - 40 | 4 - 5 |
| 45 - 75 | 5 - 7 |
| 80 - 110 | 7 - 10 |
| 115 - 150 | 10 - 15 |
| 160 -225 | 15 - 17 |

Table 6. Development Times for SU-8 Developer

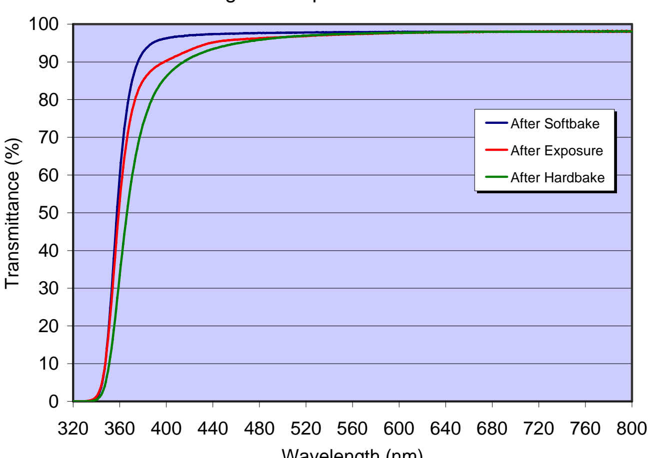
## Rinse and Dry

When using SU-8 developer, spray and wash the developed image with fresh 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 is an indication of underdevelopment of the unexposed photoresist. Simply immerse or spray the substrate with additional SU-8 developer to remove the white film and complete the development process. Repeat the rinse step.*

*The use of an ultrasonic or megasonic bath will energize the solvent and allow for more effective development of the unexposed resist.*

## Optical Properties




**Process conditions for Figure 4.**
Softbake: 5 minutes at 95°C
Exposure: 180 mJ/cm²
Hardbake: 30 minutes at 300°C

## Physical Properties

(Approximate values)

| Property | Value |
|---|---|
| Adhesion Strength (mPa) Silicon/Glass/Glass & HMDS | 38/35/35 |
| Glass Transition Temperature (Tg °C), tan δ peak | 210 |
| Thermal Stability (°C @ 5% wt. loss) | 315 |
| Thermal Conductivity (W/mK) | 0.3 |
| Coeff. of Thermal Expansion (CTE ppm) | 52 |
| Tensile Strength (Mpa) | 60 |
| Elongation at break (εb %) | 6.5 |
| Young's Modulus (Gpa) | 2.0 |
| Dielectric Constant @ 10MHz | 3.2 |
| Water Absorption (% 85°C/85 RH) | 0.65 |

Table 7. Physical Propeties

## Hard Bake (cure)

SU-8 2000 has good mechanical properties. However, for applications where the imaged resist is to be left as part of the final device, a hard bake can be incorporated into the process. This is generally only required if the final device or part is to be subject to thermal processing during regular operation. A hard bake or final cure step is added to ensure that SU-8 2000 properties do not change in actual use. SU-8 2000 is a thermal resin and as such its properties can continue to change when exposed to a higher temperature than previously encountered. We recommend using a final bake temperature 10°C higher than the maximum expected device operating temperature. Depending on the degree of cure required, a bake temperature in the range of 150°C to 250°C and for a time between 5 and 30 minutes is typically used.

***Note:*** *The hard bake step is also useful for annealing any surface cracks that may be evident after development. The recommended step is to bake at 150°C for a couple of minutes. This applies to all film thicknesses.*

www.microchem.com

## Removal

SU-8 2000 has been designed as a permanent, highly cross-linked epoxy material and it is extremely difficult to remove it with conventional solvent based resist strippers. MicroChem's Remover PG will swell and lift off minimally cross-linked SU-8 2000. 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 2000 material. Fully cured or hard baked SU-8 2000 cannot be removed without the use of OmniCoat.

To remove minimally cross-linked SU-8 2000, 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 2000: 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 2000 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 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 the 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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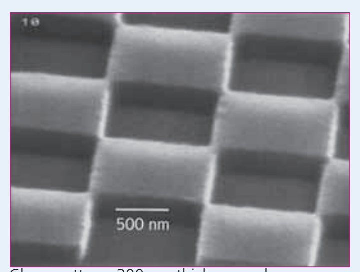
1254 Chestnut St.
Newton, MA 02464
PHONE: 617.965.5511
FAX: 617.965.5818
EMAIL: sales@ microchem.com
www.microchem.com

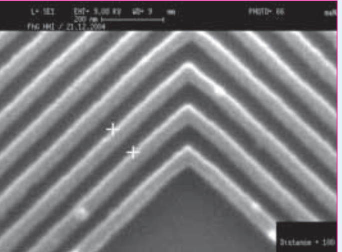
micro resist technology GmbH
Koepenicker Straße 325
12555 Berlin-Koepenick
Germany
Telephone +49 30 65762192
Fax +49 30 65762193
E-Mail mrt@microresist.de
www.microresist.de

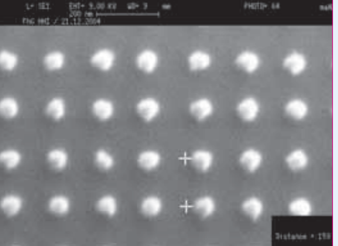
# ma-N 2400 — Negative Tone Photoresist Series

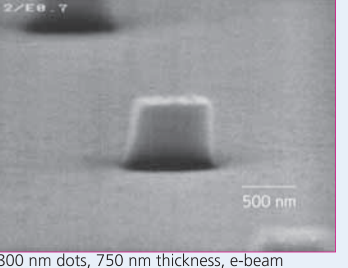
## E-Beam and Deep UV Sensitive



Chess pattern, 300 nm thickness, e-beam

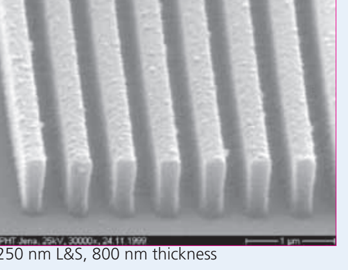

50 nm L&S, 100 nm thickness, e-beam


50 nm dots, 100 nm thickness, e-beam



800 nm dots, 750 nm thickness, e-beam

Dot after RIE with $CF_4$, (60 W)


250 nm L&S, 800 nm thickness

(Courtesy of FHG - HHI / IPHT Jena)

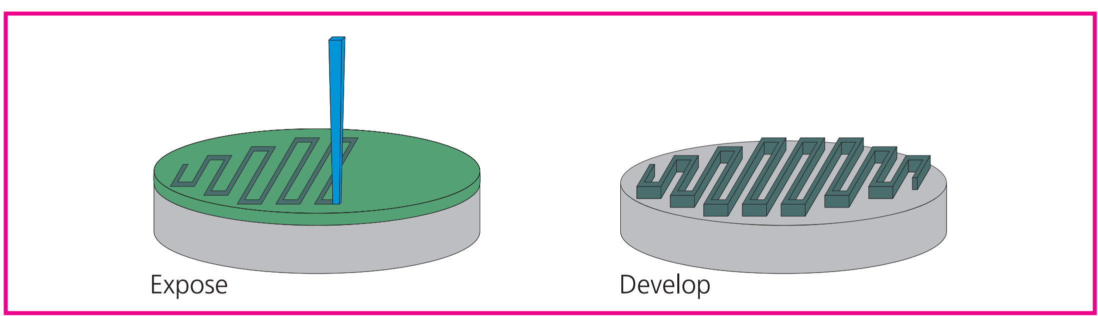
### Unique features

- High wet and dry etch resistance
- Good thermal stability
- Excellent pattern resolution - down to 30 nm
- Aqueous alkaline development
- Easy to remove
- Resists available in a variety of viscosities

### Applications

- Manufacturing of semiconductor devices
- Use in micro- and nanoelectronics
- Mask for etching, e.g. Si, $SiO_2$, $Si_3N_4$ or metals
- Mask for ion implantation
- Stamp fabrication for NIL

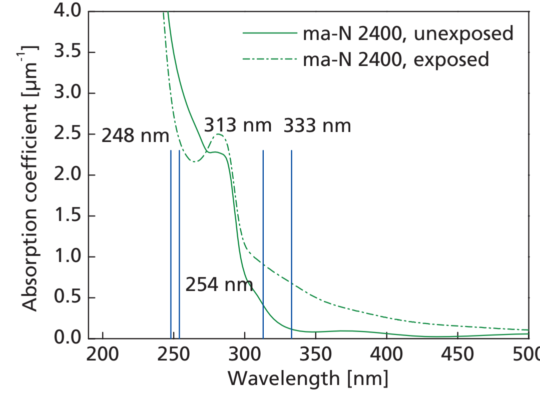
### ma-N 2400 is well suited for e-beam exposure

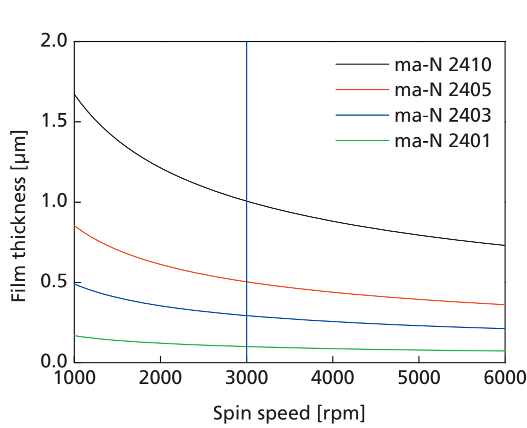



### Technical data

| Resist | | | ma-N 2401 | ma-N 2403 | ma-N 2405 | ma-N 2410 |
|---|---|---|---|---|---|---|
| Film thickness | | nm | 100 | 300 | 500 | 1000 |
| Spin coating | | rpm/ s | 3000/ 30 | | | |
| Exposure dose - E-beam 20 keV[1] | | $\mu C\ cm^{-2}$ | 120 - 200 | 170 - 235 | 170 - 250 | - |
| Exposure dose - E-beam 50 keV[1] | | $\mu C\ cm^{-2}$ | 220 - 350 | 250 - 350 | 300 - 350 | - |
| Exposure dose - Deep UV[2] | | $mJ\ cm^{-2}$ | - | 260 | 330 | 420 |
| Pattern resolution | E-beam | nm | < 50 | 50 | 100 | 150 |
| | Deep UV | nm | - | 200 | 300 | 500 |

[1] exposure dose depends on the pattern size/ resolution
[2] broadband exposure, intensity measured at 260nm



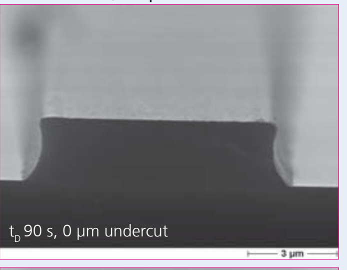



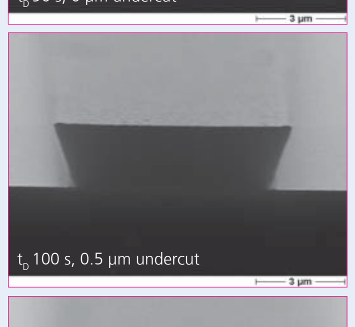
*micro resist technology* GmbH
Köpenicker Straße 325
12555 Berlin-Köpenick
Germany
Telephone +49 30 65762192
Fax +49 30 65762193
E-Mail mrt@microresist.de
www.microresist.com

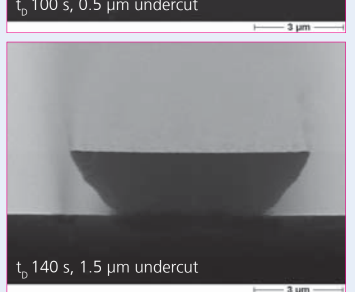
# ma-N 400 and ma-N 1400 — Negative Tone Photoresists

## Conventional Pattern Transfer and Single-Layer Lift-Off

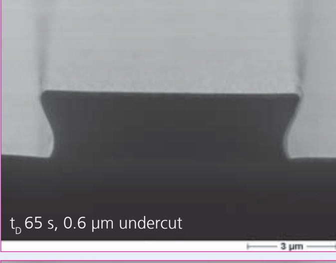
ma-N 400, 2 µm thick

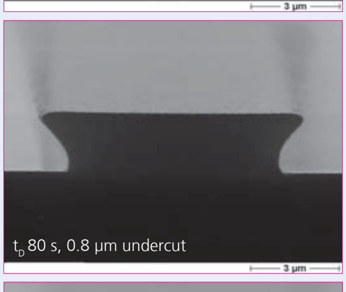


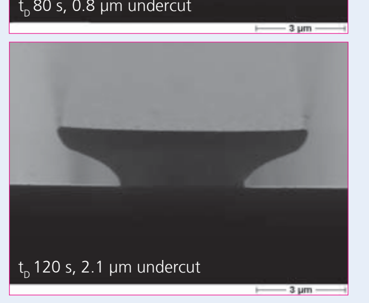




ma-N 1400, 2 µm thick



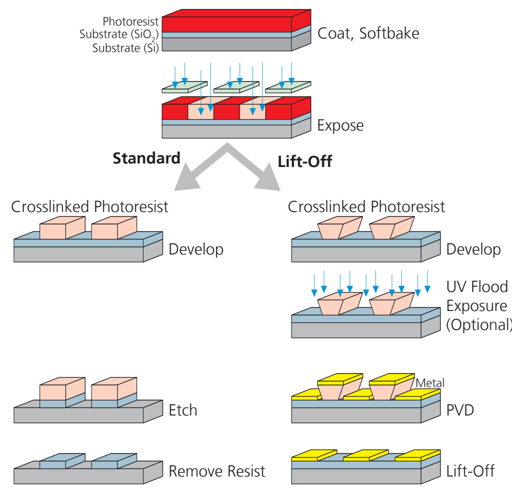




### Unique features

- High wet and dry etch resistance
- Good thermal stability of the resist pattern
- Tunable pattern profil: vertical to undercut
- Aqueous alkaline development
- Easy to remove
- Based on safe solvents
- Resists available in a variety of viscosities

### Standard and Lift-off process

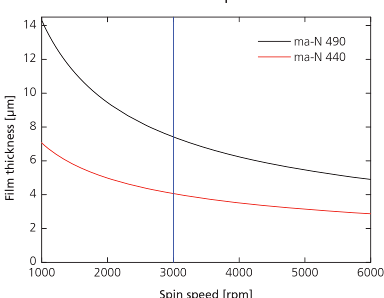


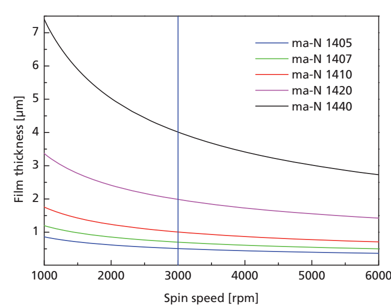

### Technical data

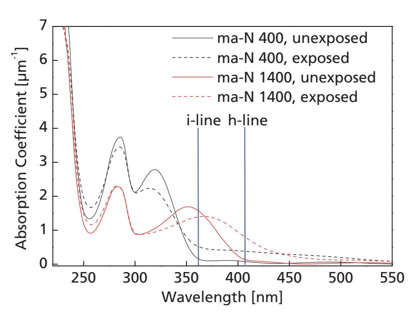
| Resist | ma-N 400 | µm | ma-N 1400 | µm |
|---|---|---|---|---|
| Film thickness | ma-N 440<br>ma-N 490 | 4.1<br>7.5 | ma-N 1405<br>ma-N 1407<br>ma-N 1410<br>ma-N 1420<br>ma-N 1440 | 0.5<br>0.7<br>1.0<br>2.0<br>4.0 |
| Spin coating / time | 3000 rpm, 30 s | | | |
| Spectral sensitivity | 300 - 380 nm | | 300 - 410 nm | |
| Thermal stability | up to 110 °C, for metal evaporation | | up to 160 °C, for metal evaporation and sputtering | |

### Applications

- Microelectronics and micro systems technology
- Mask for lift-off processes
- Etch mask for semiconductors and metals
- Well suitable for implantation



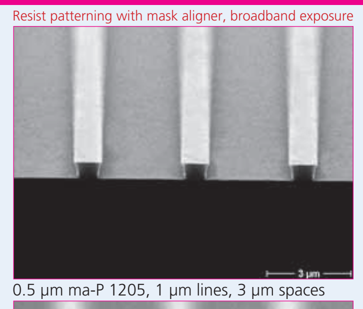



micro resist technology GmbH
Koepenicker Straße 325
12555 Berlin-Koepenick
Germany
Telephone +49 30 65762192
Fax +49 30 65762193
E-Mail mrt@microresist.de
www.microresist.de

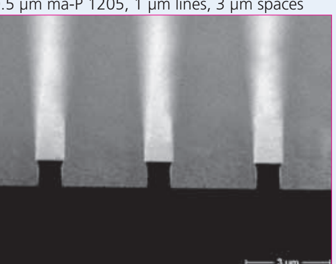
# ma-P 1200 — Positive Tone Photoresist Series

## Resists for UV Lithography

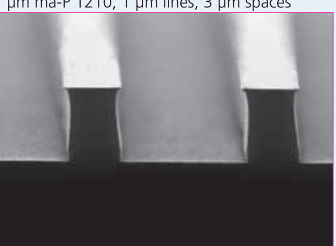
Resist patterning with mask aligner, broadband exposure



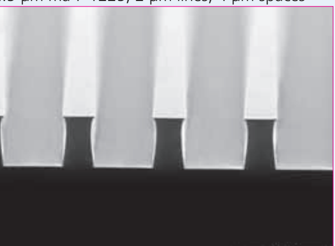
0.5 µm ma-P 1205, 1 µm lines, 3 µm spaces



1 µm ma-P 1210, 1 µm lines, 3 µm spaces

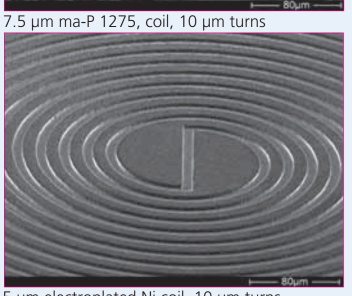


2.5 µm ma-P 1225, 2 µm lines, 4 µm spaces



4 µm ma-P 1240, 3 µm lines, 5 µm spaces

7.5 µm ma-P 1275, coil, 10 µm turns



5 µm electroplated Ni coil, 10 µm turns

## Unique features

- Outstanding pattern stability in wet etch processes and acid and alkaline plating baths
- Highly stable in dry etch processes e.g. $CHF_3$, $CF_4$, $SF_6$
- Aqueous alkaline development
- Easy to remove
- Resists available in a variety of viscosities

## Applications

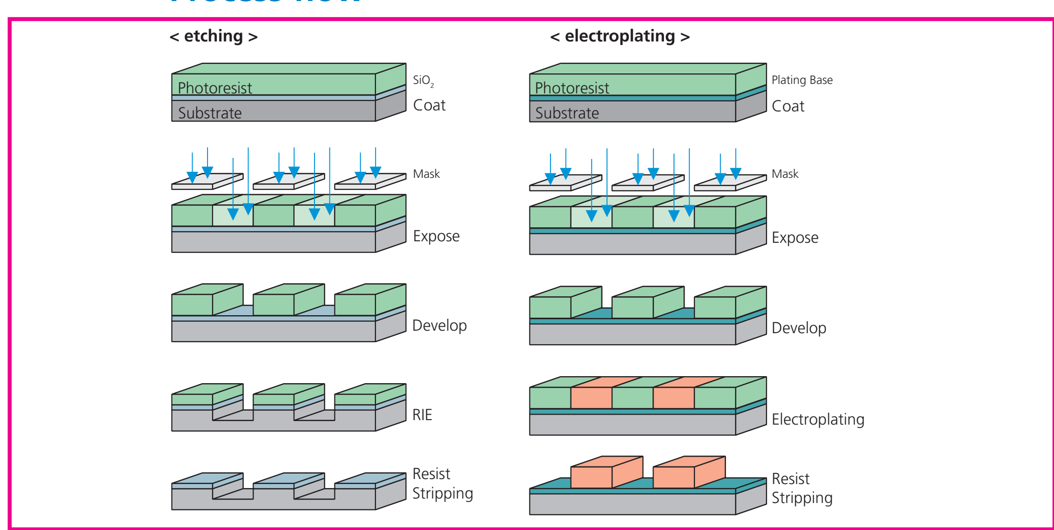
Mask for etching e.g.

- Si, $SiO_2$
- Metals
- Semiconductors

Mask for ion implantation

Moulds for electroplating

## Process flow




## Technical data

| Resist | | ma-P 1205 | ma-P 1210 | ma-P 1215 | ma-P 1225 | ma-P 1240 | ma-P 1275 |
|---|---|---|---|---|---|---|---|
| Film thickness | µm | 0.5 | 1.0 | 1.5 | 2.5 | 4.0 | 7.5 |
| Spin coating | $U\ min^{-1}$<br>s | 3000<br>30 | | | | | |
| Spectral sensitivity | | broadband, g-, h-, i-line | | | | | |
| Dose @ 365 nm (broadband exposure) | $mJ\ cm^{-2}$ | 35 | 35 | 45 | 55 | 110 | 210 |

ma-P 1200, unexposed
ma-P 1200, exposed
i - line h - line g - line
Absorption coefficient [$\mu m^{-1}$]
Wavelength [nm]

ma-P 1275
ma-P 1240
ma-P 1225
ma-P 1215
ma-P 1210
ma-P 1205
Film thickness [µm]
Spin speed [rpm]

ls.07.06.22.01

# CYCLOTENE™ 4000 Series Advanced Electronics Resins (Photo BCB)

Processing Procedures for CYCLOTENE 4000 Series Photo BCB Resins
DS2100 Puddle Develop Process

## Regional Product Availability

- North America
- Europe, Middle East and Africa
- Latin America
- Asia-Pacific

## Introduction

The CYCLOTENE™ 4000 Series Advanced Electronics Resins are I-line-, G-line-, and broad band-sensitive photopolymers that have been developed for use as dielectrics in thin film microElectronicss applications. These polymers are derived from B-staged bisbenzocyclobutene (BCB) chemistry and have final film properties that are similar to the dry etchable 3000 series. Products are listed in Table 1. Note that, for the thicker and thinner XUS products, the DS2100 develop process described in this guide is possible but immersion develop with D3000 is preferred. Please see our related immersion develop processing guide for more details on this process. Properties of CYCLOTENE Resins are shown in Tables 2-4 and Figure 1. Additional information on CYCLOTENE Resins can be found on the web site, www.cyclotene.com.

**Table 1.** Photo-BCB Formulations

| CYCLOTENE™ Resin | Viscosity (cSt) | Cured Thick-ness[1] (µm) |
|---|---|---|
| XUS35078 type 2 | 96 | 1.8 – 3.6 |
| 4022-25 | 34 | 0.8 – 1.8 |
| 4022-35 | 192 | 2.5 – 5.0 |
| 4024-40 | 350 | 3.5 – 7.5 |
| 4026-46 | 1100 | 7.0 – 14.0 |
| XUS35078 type 3 | 1950 | 15 – 30 |

**Table 2.** Electrical and Thermal Properties of Photo-BCB (CYCLOTENE 4000 Resin Series)

| Property | Value |
|---|---|
| Dielectric constant (1kHz – 20GHz) | 2.65 |
| Dissipation factor | 0.0008 |
| Breakdown voltage | 5.3 MV/cm |
| Leakage current | $4.7 \times 10^{-10}$ A/cm$^2$ at 1.0 MV/cm |
| Volume resistivity | $1 \times 10^{19}$ Ω-cm |
| Thermal conductivity | 0.29 W/m°K at 24°C |
| Thermal stability | 1.7% weight loss per hour at 350°C |

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**Table 3.** Mechanical Properties of Photo-BCB (CYCLOTENE™ 4000 Resin Series)

| Property | Value |
|---|---|
| CTE | 42 ppm/°C at 25°C |
| Tg | >350°C |
| Tensile modulus | 2.9 ± 0.2 GPa |
| Tensile strength | 87 ± 9 MPa |
| Elongation at break | 8 ± 2.5% |
| Poisson ratio | 0.34 |
| Stress on Si at 25°C | 28 ± 2 MPa |

## Material Arrival and Storage

Photosensitive CYCLOTENE Advanced Electronics Resins are shipped frozen in dry ice. If your shipment arrives with no dry ice and is warm, please contact your local Dow representative.

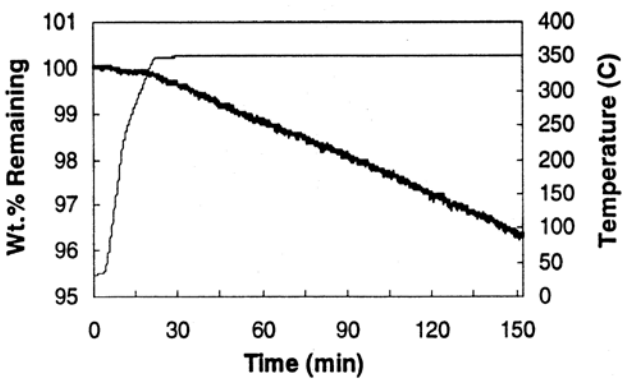
**Table 4.** Equilibrium wt % Water in Photo-BCB at Various RH at 23°C

| CYCLOTENE™ Resin | Film thickness (µm) | Relative Humidity (%) | | |
|---|---|---|---|---|
| | | 30 | 54 | 84 |
| 4024-40 | 5 | 0.061 | 0.075 | 0.14 |
| 4026-46 | 10 | 0.058 | 0.077 | 0.14 |
| 4026-46 | 20 | 0.050 | 0.082 | 0.14 |

**Table 5.** Recommended Storage Temperatures and Times

| Storage Need | Temperature | Shelf Life |
|---|---|---|
| Long term | Freezer (-15°C) | 12-18 months from date of manufacture |
| Medium term | Refrigerator (4°C) | 1-2 months |
| Short term | Clean room (20°C) | 5-10 days |

**Figure 1.** Weight loss from a 10µm film of CYCLOTENE 4026-46 Resin by isothermal TGA under nitrogen at 350°C



Precipitation of a photo additive can sometimes occur with CYCLOTENE™ 4022-35 Resin, and occasionally with CYCLOTENE 4024-40. The additive readily re-dissolves upon warming to room temperature. Should this occur, some gentle mixing of the contents is desirable to ensure a homogeneous solution. See our application note on bottle rolling procedures for more information. An alternative is to remove the product from the dry ice and store it at -30°C to -40°C, as we have found that it is the transition from -78°C to -15°C that tends to initiate crystallization. Allowing the material to warm to room temperature before placing in the freezer also helps avoid precipitation.

### Storage

As photosensitive CYCLOTENE Resin ages, the spun-on thickness, and the develop end point, will gradually increase. The lifetime is based on the criterion of less than 5% change in thickness. Resins should be allowed to equilibrate to room temperature before use. Recommended storage conditions and times are shown in Table 5.

## Processing

Several process options are available, and are shown in Figure 2. Process A uses a hot plate soft bake and includes a develop end point monitor with each lot. Process B uses a hot plate soft bake and a pre-develop bake to stabilize the develop end point. (See below for further description of these process options.) An oven soft bake is also possible. The process that you choose is dependent on tool capabilities and manufacturability requirements.

## Surface Preparation

Substrates to be coated with CYCLOTENE™ Resin should be free of all organic impurities and other contaminations prior to coating. A clean surface is important to ensure good adhesion. An example of a cleaning procedure is an oxygen plasma clean, followed by dump rinse and spin-rinse dry.

## Adhesion Promoter

Adhesion promoter is recommended whenever the resin is to be adhered to any exposed metal or inorganic (silicon oxide, silicon nitride, alumina) surfaces. For example, we recommend. adhesion promoter application between multiple coatings of BCB if there is metal sandwiched between the two BCB layers. The recommended adhesion promoter is AP3000, which is an organosilane coupling agent in an organic solvent. It comes pre-mixed and does not require further mixing or dilution.

We recommend the use of AP3000 for most surfaces, including silicon oxide, silicon nitride, silicon oxynitride, aluminum, copper, titanium and chromium.

Adhesion promoter is applied by dispensing statically or dynamically to cover the surface of the wafer. The wafer is then spun dry at 3000 rpm for 10-20 seconds.

Though often not required, the adhesion to surfaces such as silicon nitride, silicon oxide, copper, and aluminum, can be enhanced by baking the adhesion promoter for 30 seconds at 100 - 150°C, depending on surface, prior to BCB application. Please see our application note "Processing Procedures for BCB Adhesion" for more details on adhesion of BCB to various surfaces.

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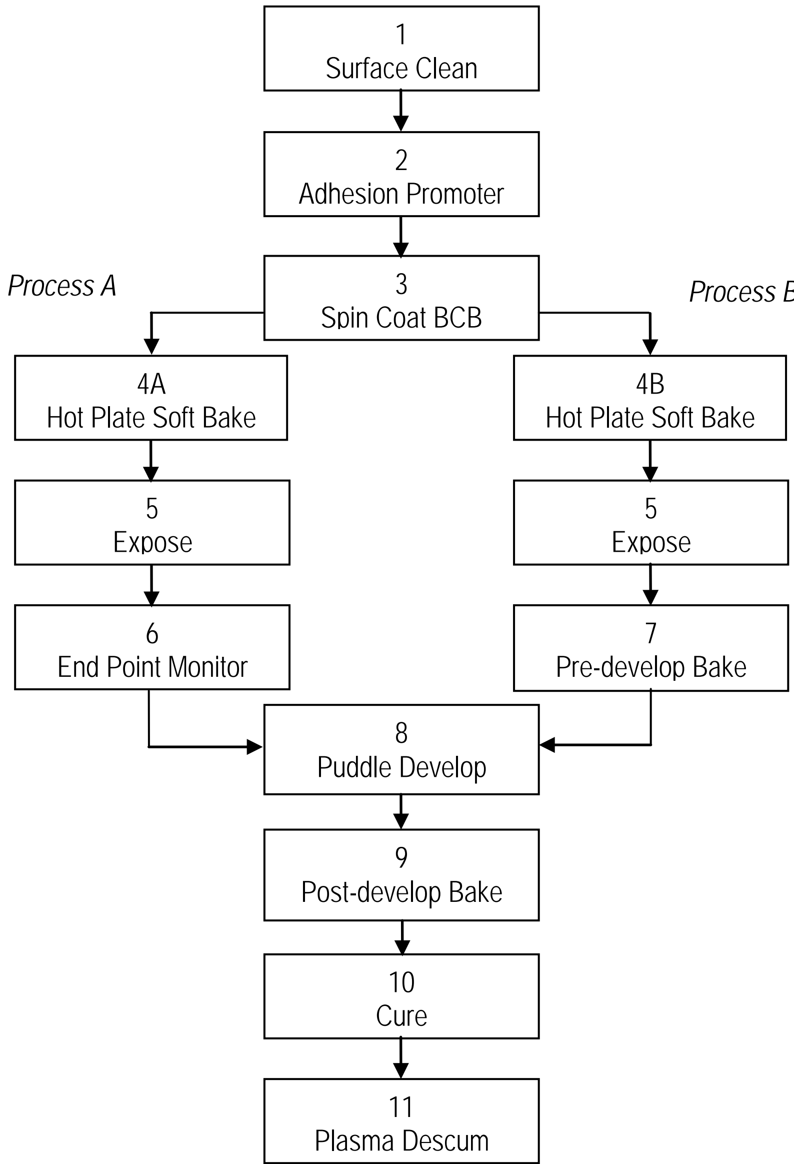
**Figure 2.** Process Flows for CYCLOTENE™ 4000 Series Advanced Electronics Resins




**NOTE**: Vapor prime adhesion promoters developed for photoresists (e.g., HMDS) do not work with the CYCLOTENE family of resins.

## BCB Coating

### Equipment

It is recommended that coaters be equipped with two dispense heads (CYCLOTENE™ Resin and adhesion promoter), backside rinse and EBR capability, hot plates and bowl exhaust.

### Coating Process

Photo BCB films are spun onto the substrate directly after the adhesion promoter application and spin dry. The precise conditions used to deposit the resins (e.g. spin speed) will vary according to the final film thickness desired and which formulation of resin is being used. Table 6 shows thickness vs spin speed for CYCLOTENE 4022-35, 4024-40, and 4026-46 Resins after soft bake (see section 4) and final thickness after exposure, development, and cure. Most of the loss in film thickness in the final, cured film occurs during the develop step. The loss in film thickness during the cure step (other than removal of residual developer solvent) is less than 5%. The thicknesses in Table 6 were determined using an open spin bowl. If a covered or closed cup coater is used, the thicknesses will differ and will depend on spin time as well as spin speed. Figure 3 shows a comparison of film thickness using open and closed bowl configurations.

Thicknesses of the XUS photosensitive products are shown in Table 7.

Final hard cured film thickness is also a function of subsequent processing steps, including soft bake conditions, exposure dose and develop-ment as explained in those sections below.

### Dispense Resin

Dispense a puddle of resin of 1-5 ml (depending on topography, substrate size and resin viscosity) onto the center of the wafer. Either static or dynamic dispense (10-100 rpm) can be used. Alternatively, a reverse radial dispense can be used, which has been found to improve the material usage efficiency.

### Spread

Increase the substrate speed to 500 rpm for about 5–10 seconds to spread the resin out from the center of the substrate.

### Spin

Increase the substrate speed to a rate that will achieve the desired pre-exposure thickness (see Tables 6, 7). Backside rinse during spin of CYCLOTENE 4026-46 Resin during the spin process will help suppress polymer filament ("cotton candy") formation.

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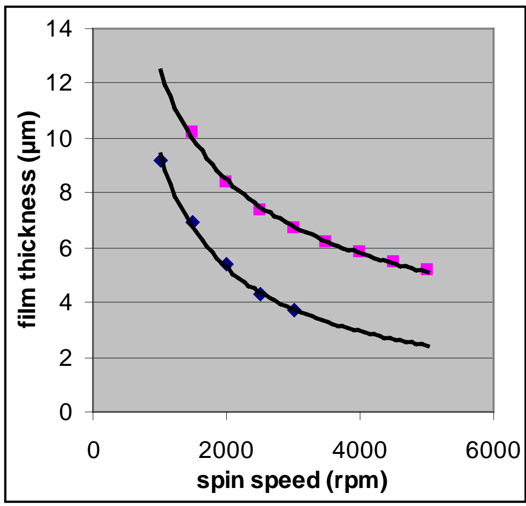
**Table 6.** Typical CYCLOTENE™ 4000 Series Advanced Electronics Resin thicknesses after soft bake, and final thicknesses after full photo processing and hard cure (not to be construed as product specification).

| | 4022-25 thickness (µm) | 4022-35 thickness (µm) | | 4024-40 thickness (µm) | | 4026-46 thickness (µm) | |
|---|---|---|---|---|---|---|---|
| Spin speed (rpm) | After soft bake | After soft bake | Final thickness | After soft bake | Final thickness | After soft bake | Final thickness |
| 1500 | 2.4 | 6.9 | 5.2 | 10.2 | 7.2 | 18.5 | 14.2 |
| 2000 | 2.0 | 5.8 | 4.3 | 8.4 | 5.9 | 15.2 | 11.6 |
| 2500 | 1.83 | 5.2 | 3.8 | 7.4 | 5.2 | 13.3 | 10.2 |
| 3000 | 1.60 | 4.7 | 3.4 | 6.7 | 4.8 | 12.2 | 9.4 |
| 3500 | 1.41 | 3.1 | 6.2 | 4.4 | 4.4 | 11.3 | 8.7 |
| 4000 | | 2.9 | 5.8 | 4.1 | 4.1 | 10.6 | 8.1 |
| 5000 | | 2.6 | 5.2 | 3.7 | 3.7 | 9.4 | 7.3 |

**Table 7.** Thicknesses of XUS35078 photo-sensitive products after soft bake

| Spin speed (rpm) | XU35078 type 2 thickness (µm) | XU35078 type 3 thickness (µm) |
|---|---|---|
| 1000 | 6.22 | 37.3 |
| 1500 | 4.60 | 27.2 |
| 2000 | 3.90 | 21.3 |
| 2500 | 3.53 | 18.2 |
| 3000 | 3.11 | 15.8 |
| 3500 | 2.92 | 14.5 |
| 4000 | 2.72 | 13.4 |

**Figure 3.** Spin curves of CYCLOTENE 4024-40 Resin in open and closed bowl configurations. Spin time was 30 seconds.

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### Edge bead removal and backside rinse

Decrease the substrate speed to 600-1000 rpm and dispense the backside solvent (T1100 Rinse Solvent) for 5-10 seconds to remove any contamination from the back side of the substrate and remove the "bead" that has formed on the front side edge. Increase the speed and spin for 10 seconds to dry (do not exceed the original spin speed). Top side edge bead removal can also be used, either from a dispense head on a track or manually with a syringe.

## Soft Bake

After spin coating, the films should be heated for a short period of time to drive out residual solvent. The specific time and temperature are dependent on the composition of the substrate as well as the thickness of the film. This can be done on a hot plate, in conjunction with a develop end point monitor (Step 4A) or in conjunction with a pre-develop bake (Step 4B). Either Step 4A or Step 4B is used and correspond to Process A and B in Figure 2, respectively. The soft bake is normally carried out immediately after spin coating.

If rework is needed after coat and soft bake, the film can be stripped with T1100 rinse solvent. Either a puddle process on a track or immersion in a tank can be used. DS2100 developer can also be used to remove an unexposed film.

### Hot plate soft bake; develop end point monitor (Process A)

The recommended hot plate bake temperature depends on the thickness of the film after coat and bake. Recommended bake temperatures when using the end point monitor process are shown in Table 8. The end point monitor process is explained in more detail in Step 6. These are suggested guidelines; with the develop end point monitor process the soft bake temperature is not critical. The soft bake time and temperature will, however, have an effect on the subsequent processing. A higher soft bake temperature will lead to a longer develop time, a slight decrease in final film thickness, and a slight decrease in the amount of scum left behind after develop.

### Hot plate soft bake, pre-develop bake process (Process B)

The recommended hot plate bake temperatures when using a pre-develop bake process (Step 7) are shown in Table 9. Bake temperatures higher than those indicated in Table 9, when used in conjunction with a pre-develop bake, can lead to cracking of the film.

## Exposure

Note that CYCLOTENE™ Resins are negative acting, i.e., the exposed regions are crosslinked and will remain behind after development.

After the soft bake, the substrates should be cooled to room temperature before photolithography. The photo-BCB films should be given an exposure dose appropriate for the thickness of the film. Typical exposure doses for photo-BCB films are given in Table 10. For example, a film of CYCLOTENE 4024-40 spun at 2500 rpm will have a thickness after soft bake of 7.4µm, thus, the recommended dose will be 25 $mJ/cm^2/\mu m \times 7.4 \mu m = 185 mJ/cm^2$

These doses were based on intensity measured at I-line and were determined on a proximity/contact aligner with broad-band exposure. Exposure dose and focus (gap setting for proximity printers, focal offset for steppers or projection printers) will have an effect on film quality, resolution, and side wall slope. If exposure tools with only I-line or only G-line radiation are used (e.g., steppers), a higher exposure dose will be needed.

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Narrow band I-line steppers give good results with thin films (<5µm), but the process window becomes smaller as the thickness increases. On broad band steppers, G/H-line exposure is preferred, and I-line exposure is not recommended. Note that when the coating thickness varies due to topography on the wafer, the exposure dose should be based on the thickness of the thickest regions. Note also that these recommended doses were determined on silicon substrates. Re-optimization of the dose may be necessary based on substrate roughness and reflectivity (e.g., ceramic substrates, varying topology).

Exposure can be performed essentially immediately after soft bake, as soon as the wafer has cooled to room temperature. The delay time between soft bake and exposure can be at least 24 hours with no adverse effects. Slight film thickness drift, and CD loss, may be seen at longer delay times.

When fabricating multilayer devices, BCB is deposited on top of BCB. In these cases, higher exposure doses are often needed for the second and subsequent BCB layers, because of absorp-tion of light by the underlying BCB and loss of reflected light. Insufficient exposure can lead to wrinkling of the film during the develop step.

**Table 8.** Hot plate soft bake temperatures for end point monitor process. All bakes are for 90 seconds.

| CYCLOTENE™ Resin pre-exposure thickness (µm) | Hot plate bake temp (°C) |
|---|---|
| <4.5 | 70 |
| 4.6 – 6.6 | 75 |
| 6.7 – 8.7 | 80 |
| 8.8 – 10.0 | 85 |
| 10.1 – 11.4 | 90 |
| 11.5 – 15.6 | 95 |
| >15.6 | 100 |

**Table 9.** Hot plate soft bake temperatures for pre-develop bake process. All bakes are for 90 seconds.

| CYCLOTENE Resin pre-exposure thickness (µm) | Hot plate bake temp (°C) |
|---|---|
| <4.5 | 60 |
| 4.6 – 6.6 | 65 |
| 6.7 – 8.7 | 70 |
| 8.8 – 10.0 | 75 |
| 10.1 – 11.4 | 80 |
| 11.5 – 15.6 | 85 |
| >15.6 | 90 |

**Table 10.** Exposure dose for CYCLOTENE 4000 Series Resins (broad band exposure, measured at I-line)

| CYCLOTENE Resin | Exposure Dose (mJ / $cm^2$ per µm of pre-exposure film thickness) |
|---|---|
| 4022-35 | 20 mJ/$cm^2$ per µm |
| 4024-40 | 25 mJ/$cm^2$ per µm |
| 4026-46 | 60 mJ/$cm^2$ per µm |

**Table 11.** Hot plate pre-develop bake temperatures

| CYCLOTENE™ Resin pre-exposure thickness (µm) | Pre-develop bake temp (°C) |
|---|---|
| <4.5 | 50 |
| 4.6 – 6.6 | 55 |
| 6.7 – 8.7 | 60 |
| 8.8 – 10.0 | 65 |
| 10.1 – 11.4 | 70 |
| 11.5 – 15.6 | 75 |
| >15.6 | 80 |

## End Point Monitor (Process A)

If a pre-develop bake is not used, it is recommended that the end point time be established for each processing lot. The time can be determined by including a monitor substrate with the lot of substrates being processed. The monitor substrate is preferably a blank silicon wafer. This wafer is coated and baked identically to the other substrates, but should *not* be exposed. This wafer is developed as described in Step 8 below while looking for the time to endpoint. The end point "clearing" will show up as the end of a colored interference fringing pattern moving across the surface of the wafer. Without an end point monitor wafer (unexposed substrate), this effect is difficult or impossible to see on patterned and exposed substrates. Figure 4 shows the increase of the develop end point time as a function of the time delay between soft bake and develop, when a wafer has been left at room temperature.

## Pre-Develop Bake (Process B)

Before solvent development, a hot plate bake step can be added to stabilize the development end point time. Without this bake, the develop-ment end point time will increase as the film sits at room temperature, and is thus dependent on the time delay between process steps (see Figure 4). Pre-develop bake temperatures for different film thicknesses are shown in Table 11. Note that these temperatures are 10°C lower than the soft bakes shown in Table 9. The pre-develop bake temperature should be approximately 30 seconds in duration. The pre-develop bake must be carried out immediately before developing the wafer, otherwise the end point will again drift toward longer times. However, the process is reversible and another pre-develop bake will again reset the end point. In addition to the time delay, the actual end point will be a function of film thickness, soft bake time and temperature, and developer temperature. For this reason a develop end point cannot be precisely defined here; each user will have to determine the end point at their facility on their tool set by developing at least one monitor substrate. A pre-develop bake will eliminate develop end point variation due to time delays. The user should realize that, in addition, the variables listed above need to be stable and controlled to achieve a uniform develop end point.

## Develop

Pattern development after exposure can be accomplished by puddle, immersion, or spray techniques. This processing guide is based on a puddle develop process. Please refer to "Processing Procedures for CYCLOTENE™ 4000 Series Photosensitive Resins (Immersion Develop)" for immersion development processing guidelines.

Puddle development uses DS2100 developer; immersion development uses DS3000 developer. These developers cannot be interchanged.

Develop can follow immediately after exposure; no wait time is needed. The delay time between exposure and develop can be at least 48 hours with no adverse effects. Some slight thickness drift, and CD loss, may be seen at longer delay times.

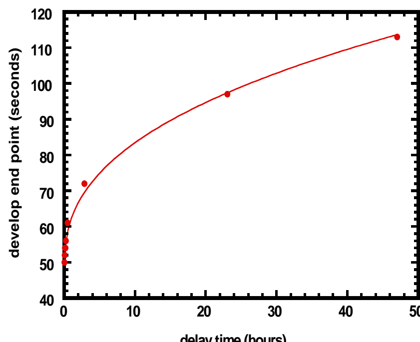
**Dispense DS2100 developer solvent**
Place the exposed substrate onto the chuck of the spin coater or track coater and dispense a puddle of developer onto the surface. Slow rotation of the substrate (50 rpm) helps to spread the solvent front. Sufficient developer is applied to allow the puddle to completely cover the wafer (10-15 ml for a 6″ wafer).

**Develop**
The wafer is allowed to sit with developer on it for a pre-determined length of time to allow dissolution of the unexposed areas. If an end point monitor (Step 6) is included with the lot, this is used to determine the develop time. The total develop time should be about 130% of the end point (i.e., overdevelop by 30%) if end point monitors are used. When using the pre-develop bake (Process B) the develop time should be 150% of the develop end point (50% over-develop) with CYCLOTENE™ 4022-35 and 4024-40 Resins, and 175% of the develop end point (75% overdevelop) with CYCLOTENE 4026-46 Resin. In all cases, the 10 second rinse (see below) is included in this total develop time. Thus, for example, if an end point monitor is used and the develop end point is 50 seconds, the total develop time will be 65 seconds (end point + 30%); the puddle time will be 10 seconds.

**Rinse**
When the puddle time is complete the wafer is rinsed by spinning at 500 rpm for 10 seconds while a stream or spray of DS2100 is dispensed onto the center of the wafer. (Note that the develop solvent and the rinse solvent are the same). This is a solvent develop process; water rinsing is not recommended. Following the rinse, the wafer is spun at 2000-2500 rpm for 30 seconds to remove the developer solvent and dry the wafer. Higher spin speeds have been found to cause anomalies in the via side wall, so the spin speed during the dry step should not exceed 2500 rpm.

**Rework**
Once the film is exposed, it is insoluble in most solvents. Exposed and developed films can be reworked by stripping in Primary Stripper A. The wafer is immersed in the stripper bath for 30 minutes at room temperature or for 5 minutes at 80°C. This is followed by a rinse in IPA and a water rinse. The stripper absorbs atmospheric moisture at room temperature, which inactivates the bath and makes it corrosive to metals. Use at 80°C is recommended because the bath remains dry at this temperature. If the stripper is to be used at room temperature, it is recommended that only a freshly poured bath be used, and that the chemical not be re-used. See "Rework Procedures for CYCLOTENE 3000 Series and 4000 Series Resins" for more details.

**Figure 4.** Increase in develop end point time as a function of delay time between soft bake and develop (CYCLOTENE 4024-40, 7.4µm soft bake thickness, no pre-develop bake).





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## Post-Develop Bake

The wafer should be baked on a hot plate immediately after developing. This serves to further dry the film and to stabilize the via side- wall. The temperature is not critical but the timing is. If this bake is omitted or delayed by more than about 60 seconds, inconsistencies in the shape of the via sidewall may be observed. The post-develop bake is typically carried out at 60 - 90°C for 60 seconds.

## Cure

After photolithographic processing is complete, the film is cured. A variety of equipment can be used for curing CYCLOTENE™ Resins, such as a box oven, belt furnace, tube furnace, and hot plate. Except for early out-gassing of residual solvent, CYCLOTENE Resins do not evolve volatiles during cure, and thus there are no constraints on the heating rate. The only requirement is that, since films of CYCLOTENE Resin are susceptible to oxidation at elevated temperatures, the film must be under an inert atmosphere at high temperature (recom-mended: <100 ppm of $O_2$ at >150°C). Please refer to "Cure and Oxidation Measurements for CYCLOTENE Advanced Electronics Resins". Thus, the maximum oven ramp rate depends on how rapidly the oven can be purged of oxygen. The extent of cure is a function of time and temperature, as shown in Figure 5.

Two different cure profiles are commonly used: "soft" or partial cure (approximately 80% conversion) and "hard" or full cure (>95% conversion). Soft cure is used for lower BCB layers when multiple BCB layers are used in a structure; it provides improved adhesion between the polymer layers. Hard cure is used when one layer is used, or for the last layer in a multi-layer build. It gives the film maximum chemical resistance and stable mechanical and electrical properties. In a box oven, a temperature of 210°C for 40 minutes is used for soft cure, and a temperature of 250°C for 60 minutes is used for hard cure. Recommended cure profiles are shown in Table 12.

The time delay between develop and cure can be up to 4 days with no adverse effects. Some slight change in via resolution may be seen with longer delays. The cure delay time does not affect film thickness or adhesion.

## Descum

Following cure the film is descummed by brief exposure to a plasma. A descum is necessary to remove a thin film of polymer residue left behind in the develop process. This residue is typically less than 1000Å thick, hence, a descum process which removes 1000 - 2000Å of polymer is generally sufficient. Best results are obtained with a parallel plate reactive ion etcher. Isotropic downstream etchers can also be used. Barrel etchers give poor etch uniformity and are not recommended. Since there is silicon in the BCB polymer, etching cannot be done in pure $O_2$; some fluorine is needed in the etch gas mixture. A typical etch gas is 80:20 $O_2/CF_4$; this provides a good balance of organic etching by $O_2$ and silicon etching by $CF_4$. $SF_6$ (90:10 $O_2/SF_6$), or other fluorine sources such as $NF_3$, can be used instead of $CF_4$ with good results. Lower concentrations of $CF_4$ will reduce the silicon etch rate and can lead to an undesirable build-up of a thin layer of amorphous $SiO_2$ on the surface of the BCB film. This can result in BCB cracking, as well as poor adhesion of materials deposited onto the BCB film.

An $O_2/CF_4$ or $O_2/SF_6$ plasma will cause corrosion of copper. If copper metal is exposed during the descum, a 30 second dip in 10% acetic acid is necessary immediately after the descum to prevent corrosion and discoloration of the copper surface.

**Figure 5.** BCB % cure vs time and temperature

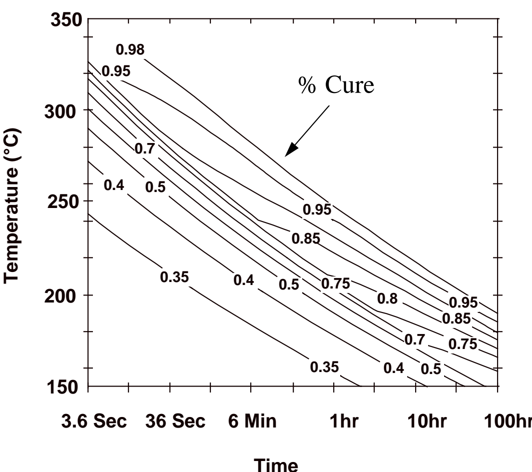


**Table 12.** Cure profiles for convection oven curing

| step | soft cure | hard cure |
|---|---|---|
| 1 | 15 min ramp to 150°C | 15 min ramp to 150°C |
| 2 | 15 min soak at 150°C | 15 min soak at 150°C |
| 3 | ramp to 210°C | ramp to 250°C |
| 4 | 40 min soak at 210°C | 60 min soak at 250°C |
| 5 | cool to <150°C | cool to <150°C |

## Handling Precautions

Before using this product, associated generic chemicals, or the analytical reagents required for its control, consult the supplier's Material Safety Data Sheet (MSDS)/Safety Data Sheet (SDS) for details on material hazards, recommended handling precautions and product storage.

**CAUTION!** Keep combustible and/or flammable products and their vapors away from heat, sparks, flames and other sources of ignition including static discharge. Processing or operating at temperatures near or above product flashpoint may pose a fire hazard. Use appropriate grounding and bonding techniques to manage static discharge hazards.

**CAUTION!** Failure to maintain proper volume level when using immersion heaters can expose tank and solution to excessive heat resulting in a possible combustion hazard, particularly when plastic tanks are used.

## Storage

Store products in tightly closed original containers at temperatures recommended on the product label.

## Disposal Considerations

Dispose in accordance with all local, state (provincial) and federal regulations. Empty containers may contain hazardous residues. This material and its container must be disposed in a safe and legal manner.

It is the user's responsibility to verify that treatment and disposal procedures comply with local, state (provincial) and federal regulations. Contact your Dow Electronics Materials Technical Representative for more information.

## Product Stewardship

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products - from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

## Customer Notice

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

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**Contact:**
North America: 1-800-832-6200
Japan: (+81) 3-5213-2910
Asia: (+852) 2680-6888
Europe: (+41) 41-259-44-44
http://www.dow.com

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# Product Information

# Lithography

# *Dow Corning*® XR-1541 E-Beam Resist

**Hydrogen silsesquioxane electron beam spin-on resist**

## FEATURES

- E-beam patternable
- Negative tone
- Etch resistance
- High purity

## BENEFITS

- Direct write
- Thin films
- High resolution
- Excellent line edge roughness
- Aqueous development

## APPLICATION METHODS

- Standard spin-on deposition coating equipment.
- Typical spin-coating speeds between 1000 to 5000 rpm’s.
- Hot plate exposure of 150 °C can be used to remove the solvent.

## TYPICAL PROPERTIES

Specification Writers: Please contact your local Dow Corning sales office or your Global Dow Corning Connection before writing specifications on this product.

| Property | Unit | Value |
|---|---|---|
| Minimal Feature Size | nm | 6 |
| Shelf Life at 5ºC | months | 6 |
| Edge Definition | nm | 3.3 |
| Refractive Index | - | 1.41 |
| Trace Metals Impurities | ppb | <10 |
| Spin-on Film Thickness - 2% | nm | 30 - 60 |
| Spin-on Film Thickness - 4% | nm | 55 - 115 |
| Spin-on Film Thickness - 6% | nm | 85 - 180 |

## DESCRIPTION

Dow Corning XR-1541 E-Beam Resists are comprised of hydrogen silsesquioxane (HSQ) resin in a carrier solvent of methylisobutyl-ketone (MIBK). It functions as a negative tone electon-beam resist with capability to define features as small as 6 nm. These resists are processed to high purity semiconductor grade (<10 ppb trace metals). They are available in compositions of resin in carrier solvent to produce thin films ranging in thickness of 30 to 180 nm in a single coat. Customized compositions are available upon request. Formulation with a volatile methyl siloxane (VMS) fluid blend carrier solvent is also available upon request. The VMS blend carrier solvent is exempt from United States federal and state regulations covering volatile organic compounds (VOC). High purity semiconductor grade MIBK and siloxane rinse solvents are available from Dow Corning as companion products. The line rinse solvents conform to the same purity specifications as the XR-1541 resist products.

## PROCESSING/CURING

Variable energy electron beam lithography allows control of the electron penetration depth in HSQ from below 35 nm to greater than 175 nm with a single exposure tool with beam energies from 200 eV to 100 keV. Optimal doses depend upon beam energy, desired resolution, and film thickness, but area doses from 400 to 700 µC/cm2 are typical and dependent on thickness. A 350 °C post exposure bake in N2 enhances the contrast properties of the film. Films can then be developed in a standard aqueous base developer (0.26 N TMAH).

## PACKAGING

Dow Corning® XR-1541 E-Beam Resists is available in 125-ml, and 250-ml containers

## STORAGE AND SHELF LIFE

Refer to the Sales Specifications and/or Product Label for these products. These products have a shelf life of 6 months from date of manufacture.

## PRODUCT LEVEL DESCRIPTION

Dow Corning E-beam Resists are formulated to directly write fine patterns with high resolution. Applications for the photoresists are for mask making and for next generation lithography processing.

## HEALTH AND ENVIRONMENTAL INFORMATION

To support customers in their product safety needs, Dow Corning has an extensive Product Stewardship organization and a team of Product Safety and Regulatory Compliance (PS&RC) specialists available in each area. For further information, please see our website, www.dowcorning.com, or consult your local Dow Corning representative.

## LIMITATIONS

These products are neither tested nor represented as suitable for medical or pharmaceutical uses.

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## For More Information

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