

# HARP™ PMMA and HARP-C™ Copolymer

## High Aspect Ratio PMMA and Copolymer for e-Beam Lithography

### HARP™ & HARP-C™ RESIST SERIES

#### 1000 HARP eB

- Highest Mw (molecular weight) PMMA polymer
- Manufactured in Anisole
- Best resolution & contrast PMMA
- Competes with 950 PMMA

#### 500 HARP eB

- PMMA Polymer with mid-range Mw
- Faster throughput versus 1000 HARP eB
- Manufactured in Anisole
- Competes with 495 PMMA

#### HARP-C

- MMA/MAA (*methyl methacrylate/methacrylic acid*) copolymer
- Manufactured in Ethyl Lactate
- Used in multi-layer process with PMMA
- Competes with MMA(8.5)MAA

### DESCRIPTION

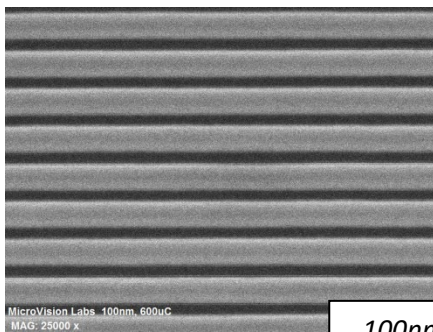
HARP PMMA (polymethyl methacrylate) resist is designed for high resolution direct write e-Beam lithography. When combined with HARP-C copolymer the HARP multi-layer system is ideal for T-gate manufacture. HARP PMMA has excellent adhesion to a wide variety of substrates, and is used as a protective coating layer for wafer thinning and sacrificial layers.

### APPLICATIONS

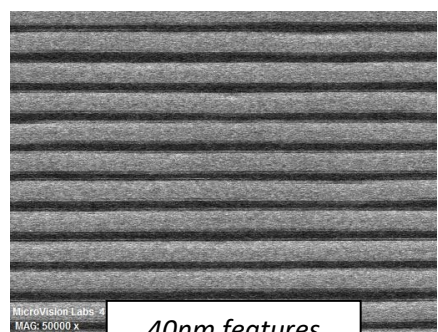
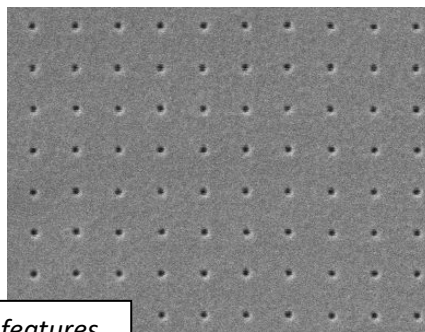
- e-beam direct write lithography
- Multi-layer T-gate manufacture
- X-Ray LIGA
- Protective Coating for wafer thinning

### SAFE SOLVENT

HARP PMMA products are manufactured in safe solvents (anisole and ethyl lactate).



100nm features



40nm features

## HARP PMMA and Copolymer Series Resists

### SUBSTRATE

HARP PMMA adheres to a variety of substrates including; silicon, gold, aluminum, chromium and copper. Proper substrate cleaning (with O<sub>2</sub> plasma) and dehydration bakes can improve adhesion.

### SPIN COAT

Film thickness is targeted using the spin speed curves on the following page. Coat program includes a 5-10 second spread cycle. Spin time at final speed is 45 seconds. Spin curves are determined using 6 inch Si and static dispense of approximately 3ml of photoresist.

### SOFT BAKE

Recommended soft-bake on contact hotplate:

HARP PMMA  
180 °C for 2 min.

HARP-C Copolymer  
150 °C for 90 sec.

### EXPOSURE (SEE DOSING MATRIX)

e-Beam: 100 – 1000  $\mu\text{C}/\text{cm}^2$

Energy: 20 – 100 kV source

*Example exposure: 1000 HARP at 0.2 – 0.5  $\mu\text{m}$  film thickness*

*600  $\mu\text{C}/\text{cm}^2$  using 50kV energy source to obtain 40 nm feature size*

### DEVELOP

HARP PMMA and Copolymer Series Resists are developed with MIBK / IPA Developer using immersion, puddle, and spray techniques.

*Example process (immersion)*

1. 60 second immersion in MIBK/IPA
2. 30 second rinse with IPA
3. Spin dry or N<sub>2</sub> blow dry

| HARP PMMA Developers |                                     |
|----------------------|-------------------------------------|
| MIBK/IPA 1:1         | High resolution and fast develop    |
| MIBK/IPA 1:3         | Highest resolution and slow develop |

### RINSE & DRY

*Rinse:* IPA (Isopropyl alcohol) or DI water to end the development process.

*Dry:* Blow dry with N<sub>2</sub> or bake at 100oC for 60 seconds to remove residual developer & rinse materials.

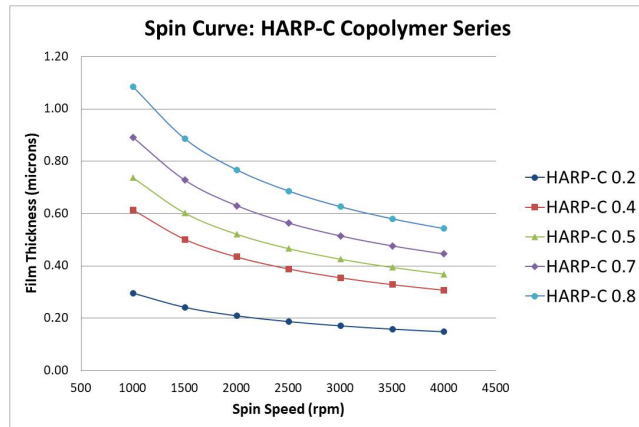
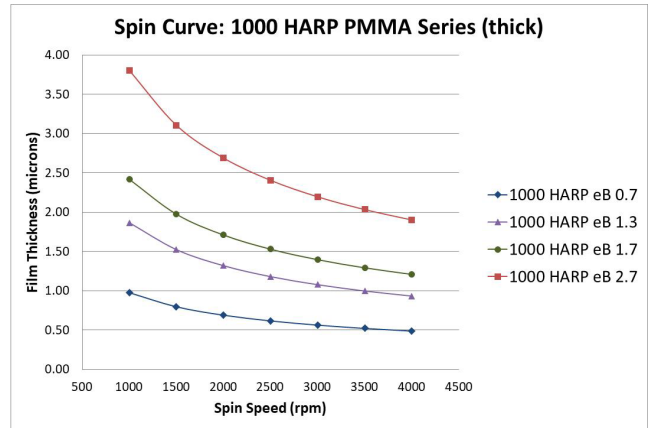
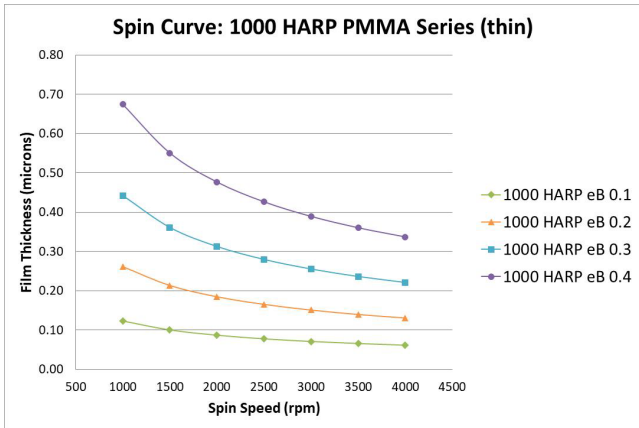
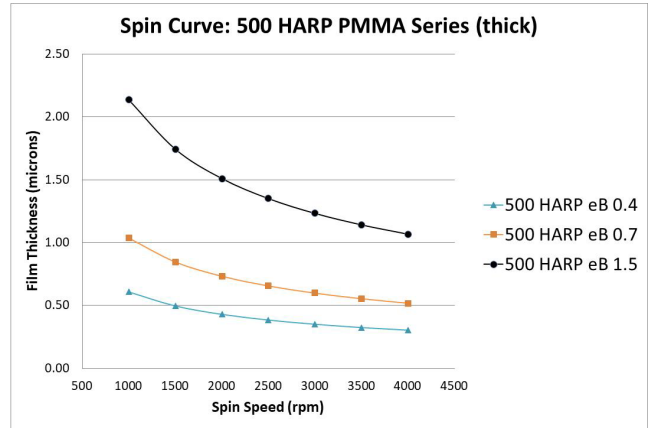
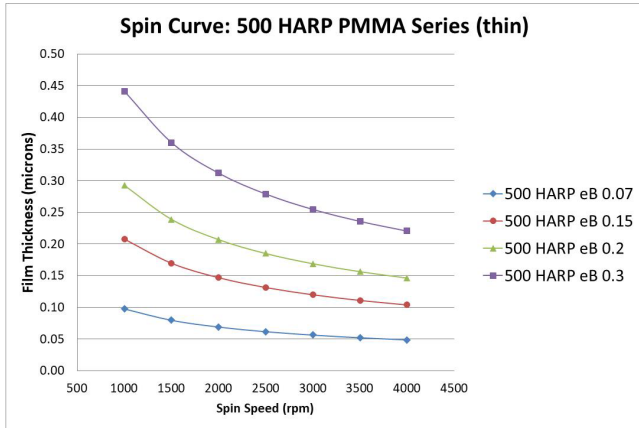
### REMOVAL

Removal is performed using industry standard removers:

- Acetone & other cleanroom solvents
- NMP-based (n-methyl-2-pyrrolidone)
- O<sub>2</sub> plasma
- Glacial acetic acid

## HARP PMMA and Copolymer Series Resists

### SPIN SPEED CURVES FOR HARP PMMA AND COPOLYMER RESISTS



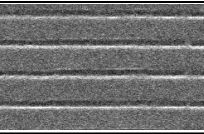
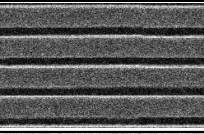
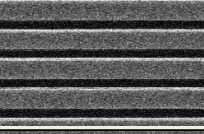
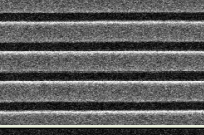
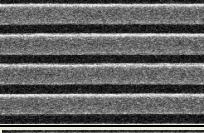
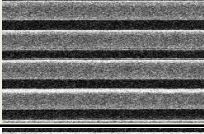
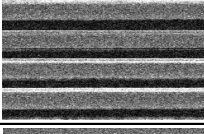
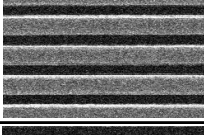
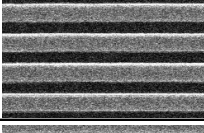
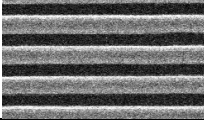
HARP PMMA and Copolymer Series Resists

**FILM THICKNESS @ 2000 RPM AND VISCOSITY  
FOR HARP PMMA AND COPOLYMER RESISTS**

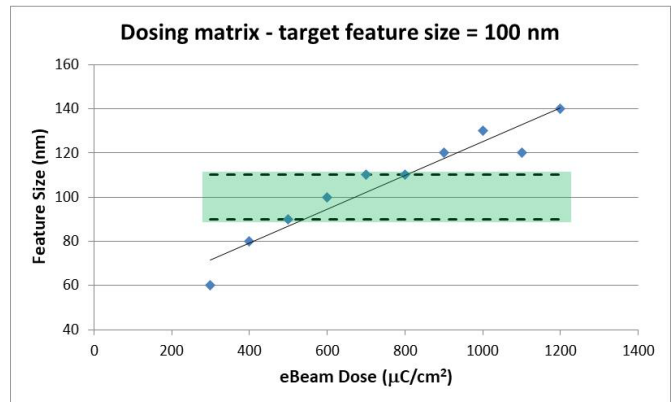
| <b>Product</b>   | <b>Approximate FT (microns)<br/>at 2000 rpm</b> | <b>Approximate<br/>Viscosity (cst)</b> |
|------------------|---|--|
| 1000 HARP eB 0.1 | 0.1   | 8                                      |
| 1000 HARP eB 0.2 | 0.2   | 15                                     |
| 1000 HARP eB 0.3 | 0.3   | 27                                     |
| 1000 HARP eB 0.4 | 0.4   | 47                                     |
| 1000 HARP eB 0.7 | 0.7   | 75                                     |
| 1000 HARP eB 1.3 | 1.3   | 191                                    |
| 1000 HARP eB 1.7 | 1.7   | 282                                    |
| 1000 HARP eB 2.7 | 2.7   | 620                                    |
| 500 HARP eB 0.07 | 0.07  | 5                                      |
| 500 HARP eB 0.15 | 0.15  | 9                                      |
| 500 HARP eB 0.2  | 0.2   | 14                                     |
| 500 HARP eB 0.3  | 0.3   | 21                                     |
| 500 HARP eB 0.4  | 0.4   | 32                                     |
| 500 HARP eB 0.7  | 0.7   | 63                                     |
| 500 HARP eB 1.5  | 1.5   | 169                                    |
| HARP-C 0.2       | 0.2   | 9                                      |
| HARP-C 0.4       | 0.4   | 18                                     |
| HARP-C 0.5       | 0.5   | 22                                     |
| HARP-C 0.7       | 0.7   | 30                                     |
| HARP-C 0.8       | 0.8   | 39                                     |

## HARP PMMA and Copolymer Series Resists

### DOSING MATRIX

| Target 100 nm                      |                   |   |
|------------------------------------|-------------------|---|
| Dose ( $\mu\text{C}/\text{cm}^2$ ) | Feature Size (nm) | SEM (1000x)   |
| 300                                | 60                |    |
| 400                                | 80                |    |
| 500                                | 90                |    |
| 600                                | 100               |   |
| 700                                | 110               |  |
| 800                                | 110               |  |
| 900                                | 120               |  |
| 1000                               | 130               |  |
| 1100                               | 120               |  |
| 1200                               | 140               |  |

| Process                     |  |
|-----------------------------|--|
| Product:                    | 1000 HARP eB 0.3   |
| Tool:                       | Raith EBPG5000   |
| Film Thickness:             | 0.3 microns  |
| Accelerating Voltage:       | 50 kV  |
| Develop:                    | 60 sec immersion in MIBK/IPA 1:3   |
| Rinse:                      | IPA  |
| <b>Optimal Dose:</b>        | <b>600 <math>\mu\text{C}/\text{cm}^2</math></b>  |
| <b>Dose Range (+/-10%):</b> | <b>500 <math>\mu\text{C}/\text{cm}^2</math> - 800 <math>\mu\text{C}/\text{cm}^2</math></b> |



## HARP PMMA and Copolymer Series Resists

### PROCESSING ENVIRONMENT

For best results, use HARP PMMA and Copolymer Series Resists in a controlled room temperature environment of 68 – 77°F (20-25°C) is recommended.

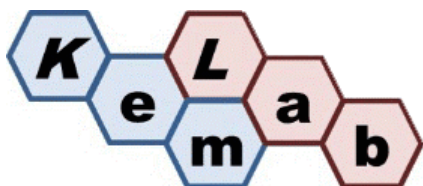
### STORAGE

Avoid light and store in an upright airtight container at room temperature. Do not refrigerate. Keep resist away from oxidizers, acids, bases and sources of ignition. Shelf life is 18 months from date of manufacture.

### HANDLING & DISPOSAL CONSIDERATIONS

Consult the SDS for handling and appropriate PPE. HARP PMMA contains a combustible liquid; keep away from ignition sources, heat, sparks and flames. HARP PMMA materials are compatible with typical waste streams used with photoresist processing. It is the user's responsibility to dispose in accordance with all local, state, and federal regulations.

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