PMMA Resist - Product Information

Introduction
PMMA (polymethyl methacrylate) is a widely used, versatile, positive tone electron beam resist. It is used in many micro and nano-electronic applications. Typically exposed using direct write e-beam lithography, PMMA can also be exposed with x-ray and deep UV microlithography processes.

In addition to its lithography properties, PMMA can be used in other micro and nanoelectronics applications as a sacrificial layer, protective coating for wafer thinning or as a bonding adhesive.

EM Resist can supply PMMA with a range of film thicknesses and molecular weights. Standard molecular weights are 950,000, 495,000 & 350,000, however EM Resist can also supply molecular weights of 35,000 & 120,000. All PMMA resins are supplied in the safe solvent anisole.

We also offer the copolymer P(MMA₀.₇-MAA₀.₃) in ethyl lactate. This copolymer is typically used in lift-off applications where a deep undercut is required.

All of EM Resist’s PMMA and P(MMA/MAA) products are available in volumes from 250mL up.

For more information or to enquire about products, please call or email us.

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EM Resist, Alderley Park, Alderley Edge, Cheshire, SK10 4TG
Processing Conditions

Substrate Preparation
PMMA can be spun on a range of substrates without adhesion layers. Ensure that the substrate is clean and dry. Substrate cleaning can be performed using solvents, $O_2$ plasma and $O_3$.

Coat
EM Resist PMMA products are coated on the substrate using a spin coating process. The film thickness spin curves for our most common products are displayed below. These provide the information required to select the PMMA dilution for the desired film thickness.

Recommended coating conditions:

Dispense: Static 5-8 mL for a 150 mm wafer
Spread: Dynamic - 500 rpm for 5s
Static - 0 rpm for 10s
Spin: Ramp to final speed selected from spin curves at a high acceleration rate. Hold for 45s

Pre Bake
PMMA
Hotplate: 180°C for 60 – 90 s
Convection Oven: 170°C for 30 min

Copolymer
Hotplate: 150°C for 60 – 90 s
Convection oven: 140°C for 30 min

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Exposure

Electron beam lithography: Dose 50 – 500µC/cm² depending on electron source, equipment, exposure energy and developer used.

Energy – 20 – 50kV: higher kV for higher resolution.

DUV (deep UV): Low sensitivity, requiring doses >500mJ/cm² @ 248 nm.

X-ray: Low sensitivity, 1-2 J/cm² @ 8.3A. Sensitivity increases at longer x-ray wavelengths.

Develop

PMMA and copolymer resists can be developed using immersion (21°C), spray puddle and spray process techniques. The process conditions that are selected, such as resist selection, baking conditions, exposure conditions and development conditions, should be selected to optimise the desired results.

<table>
<thead>
<tr>
<th>Product</th>
<th>Composition</th>
<th>Resolution</th>
<th>Sensitivity/Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMMA-Dev1</td>
<td>1:1 MIBK/IPA</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>PMMA-Dev2</td>
<td>1:2 MIBK/IPA</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>PMMA-Dev3</td>
<td>1:3 MIBK/IPA</td>
<td>Very High</td>
<td>Low</td>
</tr>
<tr>
<td>PMMA-Dev4</td>
<td>MIBK Pure</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>PMMA-Dev5</td>
<td>3:7 Water/IPA</td>
<td>Very High</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Rinse and Dry

Upon completion of the development process and to prevent scumming, the resist should be immersed or sprayed with alcohol or DI water immediately.

Substrates can be spin dried at 3000rpm for 20s or blow dried with a dry, inert gas (typically N₂).
**Postbake or Hardbake (optional)**

A postbake or hardbake can be used to remove residual developer, moisture or rinse solvent from the remaining resist layer. Note that PMMA will re-flow above 125°C.

- **Hotplate:** 100°C for 60 – 90 s
- **Convection oven:** 95°C for 30 min

**Removal techniques**

- **Wet:** photoresist remover, Acryl strip or standard laboratory solvents (acetone)
- **Bath:** time as required at ambient temperature
- **Spray:** time as required, 500 – 1000 rpm
- **Dry:** plasma O₂

Resist films that have seen higher temperatures may require a more aggressive removal process including harsher solvents, acid/base baths and elevated temperatures.

For any technical assistance please contact Technical Services.

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### Example Processing Conditions

#### Typical immersion development process:

1. Immerse sample completely into developer solution for 30 s (Temperature 21°C)
2. Immerse sample completely into rinse solution for 30 s (alcohol or DI water)
3. Blow dry with a dry, inert gas (typically N₂)

#### Typical spray/puddle development process*:

1. Dispense developer onto substrate for 3-4 s ensuring complete wafer coverage
2. Oscillate sample during development process for 25-40 s
3. Dispense rinse solution at 500 rpm for 3-4 s
4. Dry at 5000rpm for 30 s

*The exact process steps may vary depending on equipment used.
The spin curves shown below are for PMMA and copolymer resists. They show the film thickness that is obtained based on the spin speed that is selected. This data provides approximate information to allow for the selection of the correct product/dilution for your application and desired film thickness. Actual results will vary based on equipment, environment, process conditions and application. Additional dilutions are available upon request.

PMMA 950K in Anisole
PMMA 495K in Anisole

PMMA 350K in Anisole

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P(MMA$_{0.7}$-MAA$_{0.3}$) in ethyl lactate

Optical Data

PMMA Resist absorption curve