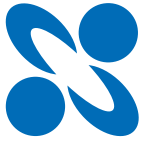


LOR and PMGI Resists for Bi-layer Lift-off Processing

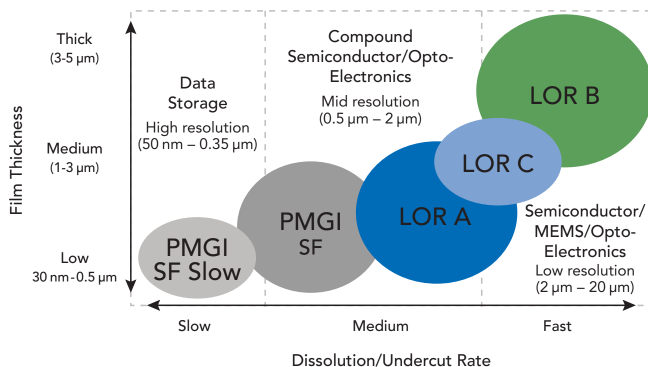
Description

LOR and PMGI lift-off resists are based on polydimethylglutarimide (PMGI) polymers and are well suited for a variety of critical and non-critical level lift-off processes, and as sacrificial release layers. Used as under layers in combination with conventional positive and negative resists, these resists are available in a wide range of film thicknesses and undercut rates, addressing a broad range of application requirements.

Features

- Enables sub 0.25 µm deposition patterning
- Does not intermix with imaging resists (no scum)
- Excellent adhesion to Si, NiFe, GaAs, InP and many other III–V and II–VI materials
- Simple bi-layer processing without extra develop, amine treatment or toxic chemical soak steps
- Formulations optimized for deposition thicknesses from less than 50 nm to greater than 3 µm thick
- Compatible with g-line, i-line, DUV, 193 nm and E-beam resists
- Compatible with TMAH and metal-ion bearing developers
- High thermal stability: Tg > 190°C

Product Range



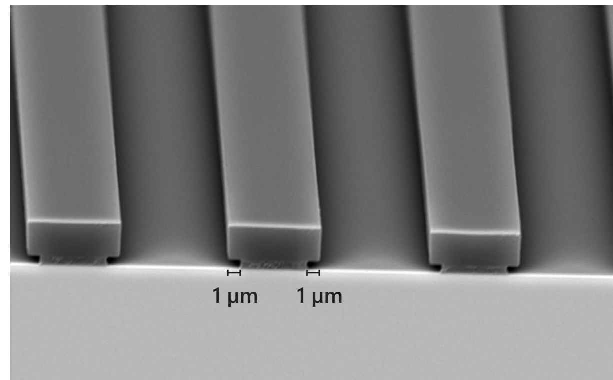


Figure 1: LOR 10A with High Temperature Negative Resist 20 µm lines

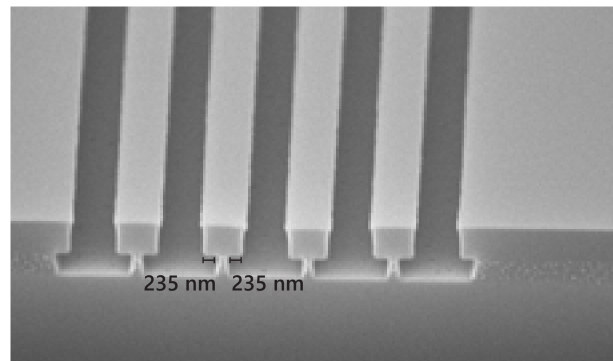


Figure 2: SF 6 with UV 6 Resist 0.35 µm lines

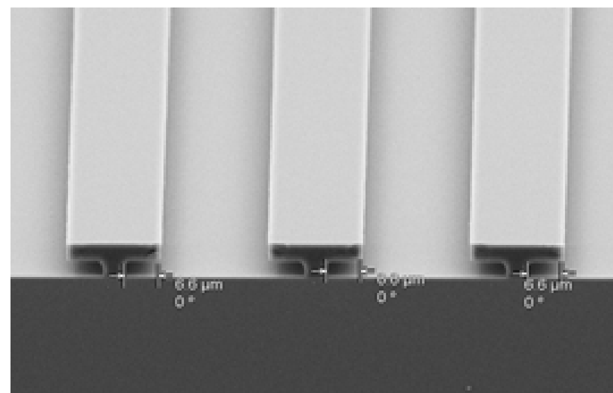


Figure 3: LOR 30C with SPR 220 Resist 20 µm lines

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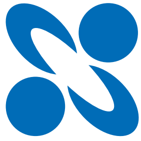
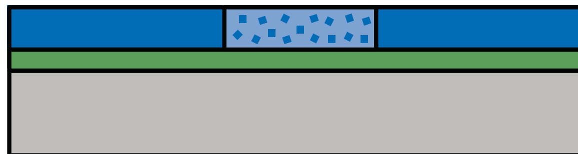


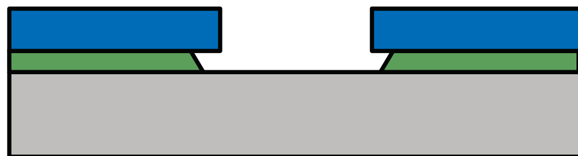
Figure 4: LOR/PMGI Process Flow

1. Coat and soft-bake LOR or PMGI.

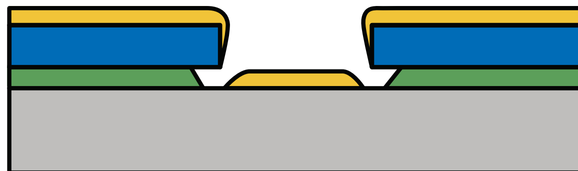
2. Coat and soft-bake imaging resist.



3. Expose imaging resist.



4. Develop resist and LOR or PMGI. LOR or PMGI develops isotropically, creating a bi-layer re-entrant sidewall profile.



5. Deposit film. The re-entrant profile ensures discontinuous film deposition.

6. Lift off bi-layer resist stack, leaving only desired film.

Substrate Preparation

LOR/PMGI resists exhibit excellent adhesion to most semiconductor, GaAs, and thin-film head substrates. Primers, such as HMDS, are typically not required to promote adhesion with LOR/PMGI products when used as recommended. LOR/PMGI is virtually insoluble in typical photoresist solvents, therefore, there is no intermixing between layers when baked properly.

To obtain maximum process reliability, substrates should be clean and dry prior to applying the LOR/PMGI resist. Start with solvent cleaning, or rinse with dilute acid, followed by a 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.

For clean lift-off processing, LOR/PMGI films should be thicker than the deposited metal film, typically by 33%.

The film thickness versus spin speed curves are included in the technical data section. The spin speed needs to be optimized for the substrate size and shape. Substrates with deep topography or irregular shape will need to be spun slower for improved coverage. LOR C products are recommended for coating into trenches or over topography without trapping bubbles.

Coating equipment should be compatible with cyclopentanone. To minimize drain-line clogging associated with mixing a conventional resist process and LOR/PMGI resists, a dedicated coat-bowl and drainage system is recommended, but not mandatory. When Kayaku Advanced Materials' EBR PG is used for clean-up and edge bead removal, LOR/PMGI and conventional resist processing may be employed in the same system.

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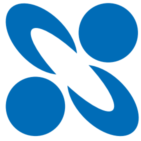


Edge Bead Removal

Kayaku Advanced Materials' 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 and negative resists, and commercially available coating tracks. EBR PG is also an effective solvent for spin-bowl clean up and rework of unbaked wafers. Acetone and conventional resist edge bead removers are not recommended with LOR/PMGI. *See the EBR PG data sheet for more details.* A reduction in whiskers is achieved with the use of LOR C resists especially in thicker applications.

Soft-Bake/Prebake Process

The primary functions of the prebake process are to dry the PMGI/LOR film, and to fix the development and undercut rate. Once the exposure and development processes have been defined, careful design of the prebake process enables precise control of the under-cut and maximum process windows. The prebake temperature shows the greatest influence on undercut rate, although prebake time, choice of developer, develop mode, and particularly develop time are also influential. *Refer to Figures 5a and 5b.*

Hot plates are the preferred tool for the prebake step. The recommended bake temperature range is 160°C – 210°C, although some PMGI products may be baked to 280°C. Ultimately, a matrix design varying prebake temperature and develop 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, 193 nm, and e-beam photoresists. The resist can be applied and prebaked directly over PMGI without the need for barrier layers or plasma descum steps. LOR and PMGI resists do not require an exposure step when using the simple bi-layer lift-off process.

Figure 5a

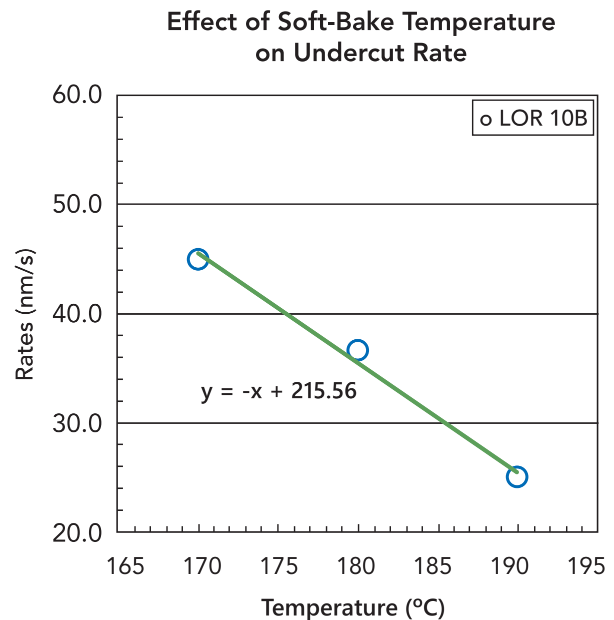
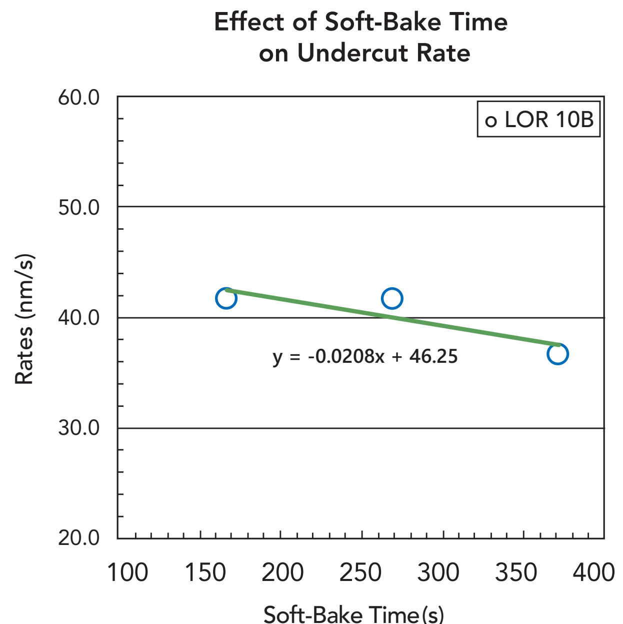


Figure 5b



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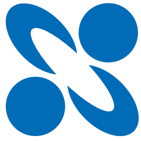


Post Exposure Bake (PEB) Process

LOR/PMGI resists do not require a Post Exposure Bake. Refer to the 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 (MIF) and Metal-Ion-Bearing (MIB) developers. The thickness of both LOR/PMGI layers and patterning resist layers ultimately contribute to the final develop time. Straighter sidewalls with thick (> 2 μm) 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 Kayaku Advanced Materials Technical Sales Representative, or refer to the PMGI Process Notes, which are available on the website www.kayakuAM.com.*

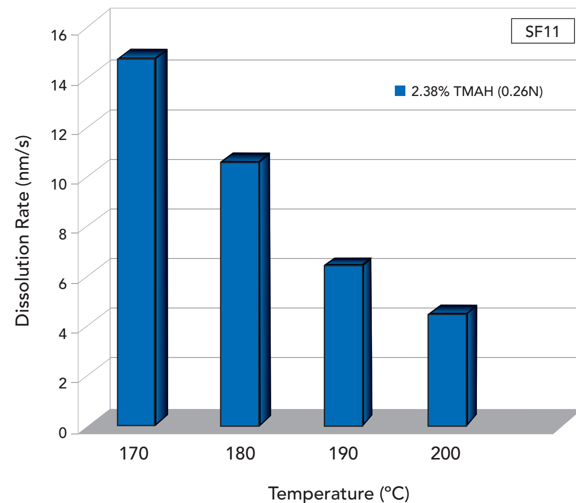
Deposition Process

LOR and PMGI are compatible with high temperature sputter, evaporative metal and dielectric deposition processes.

Lift-Off Process

Use Kayaku Advanced Materials' Remover PG, or other NMP or DMSO based removers to remove the bi-layer resist stack. Removal rate of LOR/PMGI is dependent upon the Soft-Bake temperature of the LOR/PMGI product and remover bath temperature. As a baseline process, use Remover PG in two tanks: at 60°C for 30 minutes in the first tank followed by a rinse at 60°C in the second tank. Ultrasonic action will improve the resist removal efficiency. Actual removal times will vary depending upon prebake conditions, subsequent processing and resist patterns. *Consult the Remover PG technical data sheet for more information on this product.*

Figure 6 The Effect of Soft-Bake Temperature on Dissolution Rate



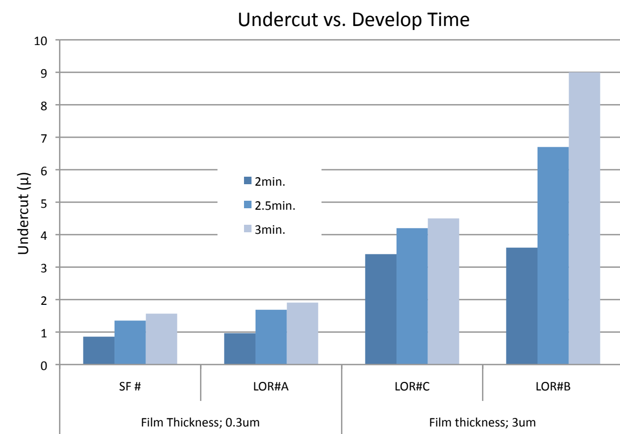
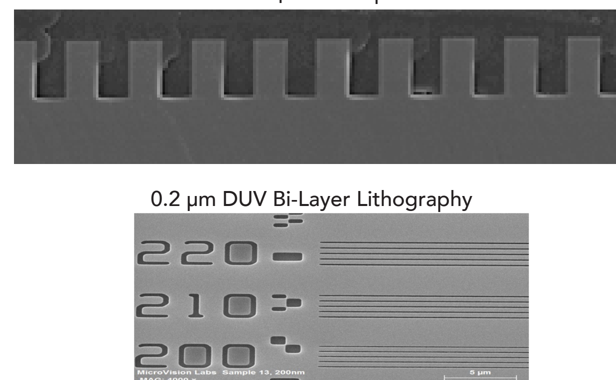


Figure 7 LOR C-10 μm Deep Trench Filling with 5 μm Line/Space



0.2 μm DUV Bi-Layer Lithography

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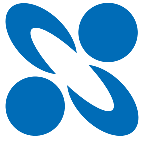
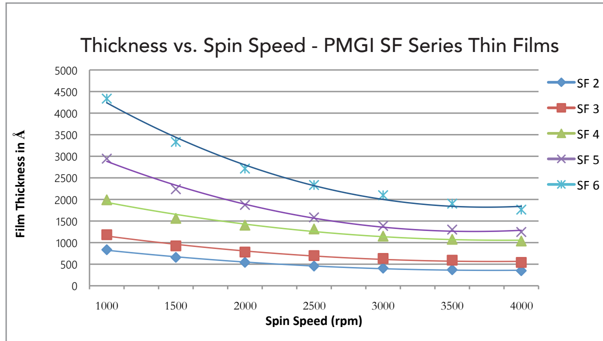
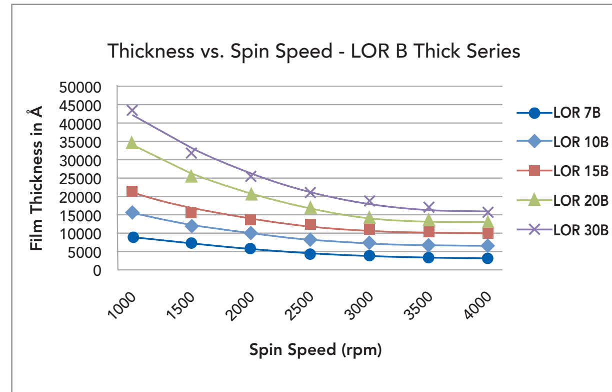
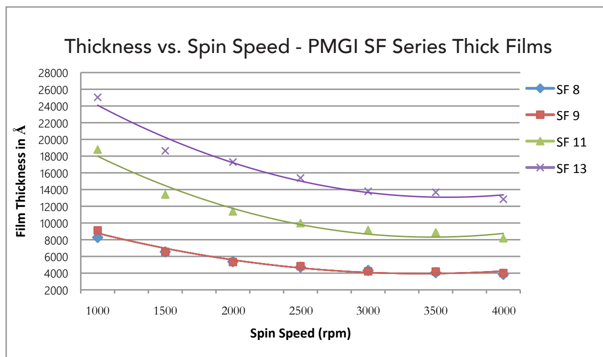
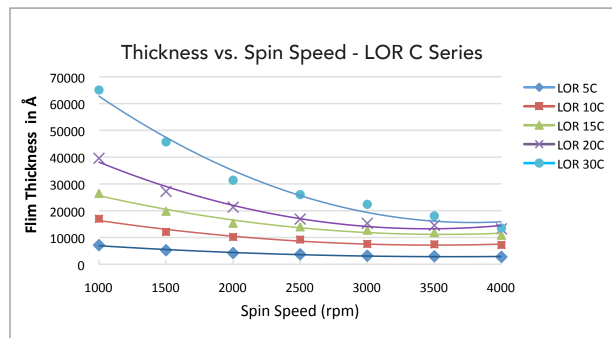


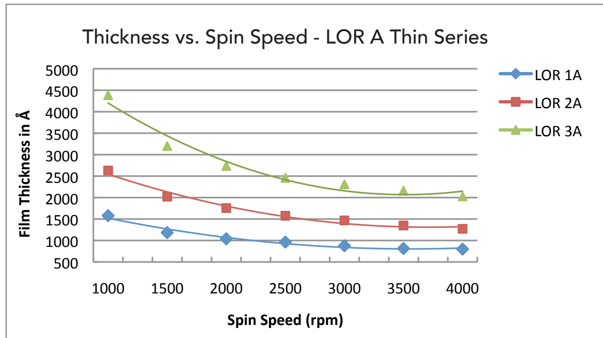
Technical Data

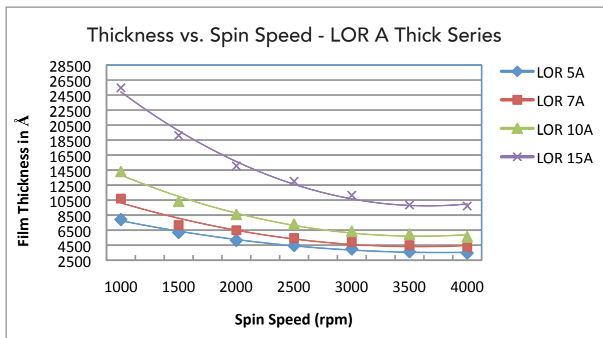












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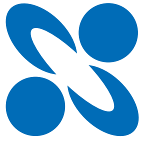


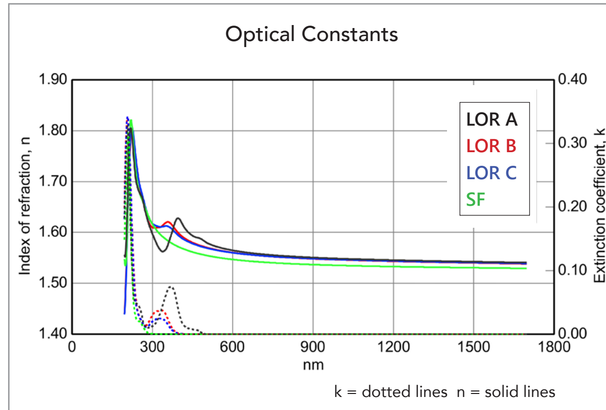
Technical Data

Optical Constants for LOR/PMGI Products

Products	436		365		248		193	
	n	k	n	k	n	k	n	k
SF	1.564	0.000	1.581	0.000	1.687	0.021	1.548	0.147
SF S	1.553	0.000	1.57	0.000	1.669	0.02	1.56	0.104
LOR A	1.599	0.010	1.588	0.073	1.683	0.045	1.550	0.179
LOR B	1.584	0.000	1.619	0.016	1.708	0.032	1.439	0.195
LOR C	1.581	0.000	1.610	0.010	1.707	0.031	1.439	0.177

Cauchy Parameters for LOR/PMGI in the Transparent Region

Product	An	Bn	Cn	Wavelength Range (nm)
SF	1.529	0.00569	0.00017111	300-1700
SF S	1.522	0.00505	0.00002113	300-1700
LOR A	1.539	0.00893	0.00030957	470-1700
LOR B	1.538	0.00814	3.5340E-05	450-1700
LOR C	1.539	0.00772	2.4806E-05	450-1700



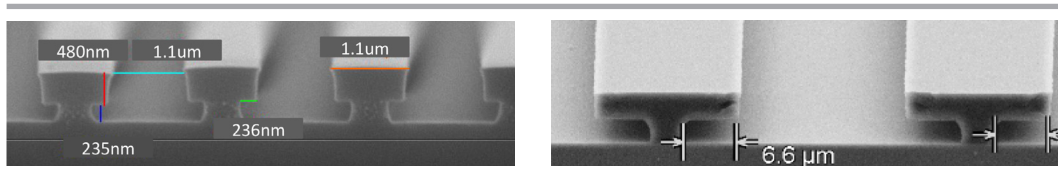
Recommended Coating Parameters

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

Viscosity & Density Data

Product Film Thickness @ 3,000 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 µm	115	0.99
2 µm	450	1.00
3 µm	750	1.00

Varying LOR/PMGI Undercut



SF 6 230 nm Undercut

LOR B/C >5 µm Undercut

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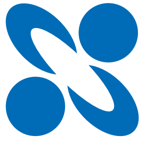

LOR/PMGI Product Selection Guide

Attributes		LOR C	LOR A	LOR B	SF	SFS
		Products ● Recommended ○ Some compatibility				
Undercut Geometry	<0.35 µm				○	●
	0.35-0.5 µm		●	○	●	●
	0.5-1.0 µm	●	●	●[1]	●	○
	>1 µm	●	○	●	○[2]	○[2]
Thickness Range	<100 nm				●	●
	0.1-1 µm	●	●	●	●	●
	1-5 µm	●	○	●	●	○
Temperature Range	160°C-190°C	●	●	●	●	●
	>190°C	●	●	●	●	●
Developer Compatibility	0.26N TMAH	●	●	○	●	●
	0.24N TMAH	●	●	●	○	○
	MIB			●		
Resist Solvent Compatibility	Ethyl Lactate	●	●	●	●[2]	●[2]
	PGMEA	●	●	●	●	●
	2-Heptone	●	●	●	●	●
	Cyclohexanone	●[3]	●[3]	●[3]	●[3]	●[3]
	Anisole	●	●	●	●	●
Substrate Compatibility	Si	●	●	●	●	●
	Glass	●	●	●	●	●
	NiFe	●	●	●	●	●
	III-V Metals	●	●	●	●	●
	Au	●	●	●	●	●
Coating	Via Fill	●			○	○
	Topography	●			○[4]	○[4]

Advice

1. Controlled undercut achievable with weaker MiFi developers or typical MIB developers.
2. Adhesion loss can occur with reworked substrates when soft-baking the PMGI with temperatures lower than 180°C.
3. Intermixing can occur with ethyl lactate based resists at temperatures below 180°C.
4. High temperatures >250°C are needed for reflow.

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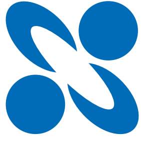

Handling

Consult Safety Data Sheet (SDS) for details on the handling procedures and product hazards prior to use. If you have any questions regarding handling precautions or product hazards, please email *productsafety@kayakuAM.com*.

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.

Storage

Store upright in original sealed containers in a dry area between 10-24 °C (50-76°F). Keep away from sources of ignition, light, heat, oxidants, acids and reducers. Do not use product after the expiration date (13 months from date of manufacture).

Disposal

The material and its container must be disposed in accordance with all local, state, federal and/or international regulations.

Processing Environment

For optimum results, use LOR/PMGI resists in a controlled environment:

Temperature	20-25°C ± 1°C (68-77° ± 2°F)
Relative humidity	35-45% ± 2%

For further information on the use and performance of LOR and PMGI Resists, please contact your local Kayaku Advanced Materials representative.

Disclaimer

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