UniLOR® N

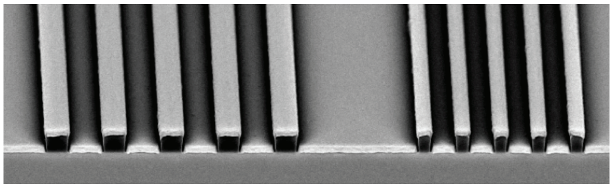
Negative Photoresist for Single Layer Lift-Off Processes

Description

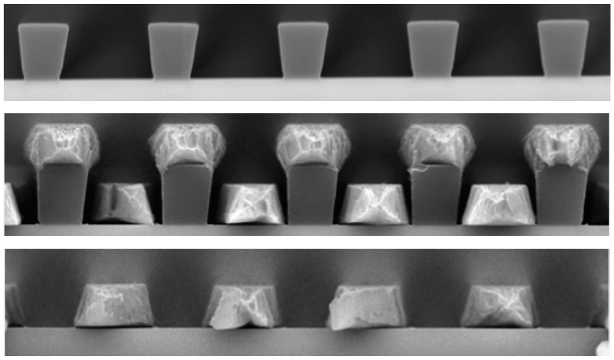
UniLOR® N is a negative-tone, chemically amplified proprietary co-polymer resist for use in UV lithography processing of semiconductors, MEMS and other nanofabricated structures. It is available in three standard viscosities and provides wall profile adjustability and high thermal stability across film thicknesses ranging from 1 to 5 µm in a single coat. Ideally suited for lift-off applications, it is easily removable and compatible with a range of TMAH developers.

Features

- Adjustable sidewall profile angle
- Single coat thickness capability 1 to 5 µm
- Negative-tone, photo-imageable resolution to 2 µm
- Broadband/i-Line sensitivity with 1:1 aspect ratio capability
- Thermal resistance for geometric stability in deposition
- Excellent adhesion to many substrates (Si, GaAs, SiC)
- Compatible with TMAH developers
- Easy removal

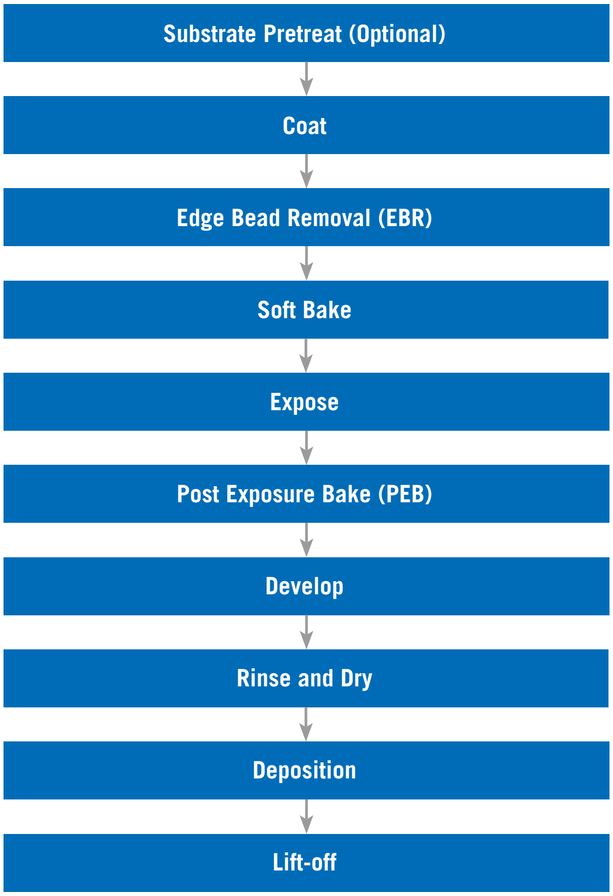


2 µm & 3 µm L/S after 5000 Å Aluminum Deposit



3 µm L/S and 3 µm film thickness: before,
after 2 µm Al evaporative deposit, and post clean lift-off

Process Flow



PROCESSING GUIDELINES

The following conditions represent Kayaku Advanced Materials' recommendation for a baseline process. It is expected that a certain amount of engineering and optimization will be required for customer-specific systems, facilities and application. For guidance on optimizing the process for a specific application, please contact your local Kayaku Advanced Materials Technical Sales Representative or Technical Support. The overall UniLOR® N process flow is depicted above.

Substrate Preparation

To obtain maximum process reliability, substrates should be clean and dry prior to applying UniLOR® N 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. Substrates may also be cleaned using reactive ion etching (RIE) or any barrel asher supplied with O_2 gas.

For applications on bare Si, a HMDS (Hexamethyldisilazane) vapor priming is recommended following a wafer dehydration step in the vacuum oven. HMDS may be applied by spin coating as well, but not as effectively as vapor priming.

Coat

UniLOR® N resist is available in three standard viscosities that range in film thickness (Table 1). The film thickness vs. spin speed curves are displayed in 1A, 1B and 1C for various air flows. The curves were generated using static dispense on 6" (150 mm) silicon wafers and a soft bake of 115°C on a level hot plate. Please note that the exact thickness obtained may be slightly offset from curves in Figure 1 due to equipment type, setting differences and room conditions, as demonstrated by varying exhaust level. For clean lift-off processing, LOR/PMGI films should be thicker than the deposited metal film, typically by 33%.

Recommended Coating Conditions

(1) Dispense: Approximately 1 ml of UniLOR® N per inch (25 mm) of substrate diameter.
(2) Spread Cycle: Spin to 500 rpm for 5–10 seconds with acceleration ramp of 500 rpm/second.
(3) Spin Cycle: Ramp to final speed with acceleration of 500 rpm/second and hold for 30 seconds.

Soft Bake and Edge Bead Removal (EBR)

The primary function of the soft bake process is to dry the UniLOR® N film. A 115°C soft bake for 2 minutes on a level hotplate with good thermal control and uniformity is recommended. UniLOR® N film typically remains slightly tacky after soft bake.

During the spin coating process, a build-up of photoresist can occur on the outer edge of the substrate, especially for thicker resist coatings. Although an edge bead has not been observed in UniLOR® N film, it can be removed by directing a small stream of Kayaku Advanced Materials' EBR PG at the edge of the wafer. An edge bead removal step can be done immediately following soft bake using Kayaku Advanced Materials' EBR PG. A 65°C bake for a minimum of 1 minute is necessary to drive off any remaining solvent following EBR. For edge bead removal using EBR PG, please refer to the EBR PG technical data sheet.

Technical Data

Product Dilution	Viscosity, cSt	Film Thickness @2000, rpm	Film Thickness Range, µm
N 1.5 µm	15	1.5	1.7–0.9
N 2.5 µm	35	2.5	3.2–1.6
N 3.5 µm	70	3.5	4.9–2.4

Table 1. Thickness and Viscosity

Optical Parameters

The dispersion curve and Cauchy coefficients are shown in Figure 2. This information is useful for film thickness measurements based on ellipsometry and other optical measurements.

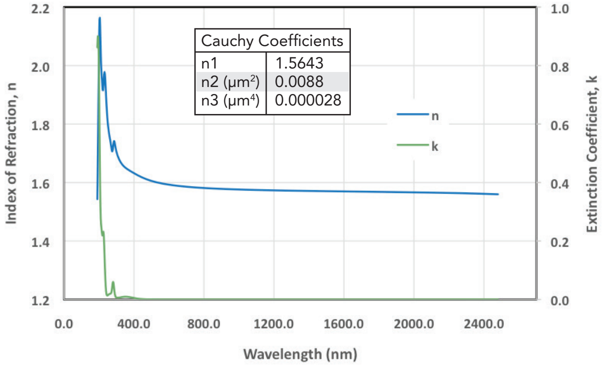


Figure 2. Cauchy Coefficients

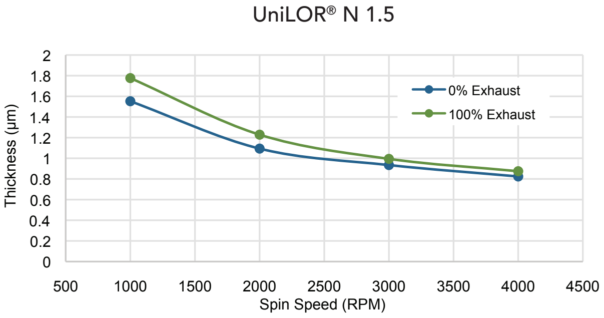


Figure 1A. UniLOR® N 1.5 Spin Speed Curve

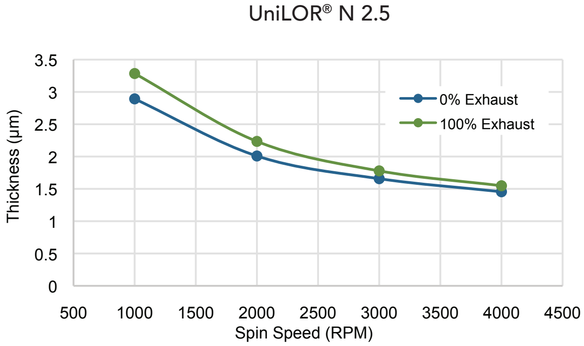


Figure 1B. UniLOR® N 2.5 Spin Speed Curve

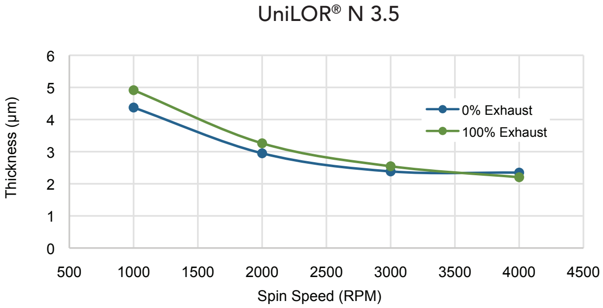


Figure 1C. UniLOR® N 3.5 Spin Speed Curve

Exposure

UniLOR® N is optimized for near UV (350-450 nm) exposure. The exposure dose is a critical lever for controlling the profile angle. Higher or lower exposure doses will promote more or less crosslinking, respectively, in the following PEB step. By extension, this will also set the foundation for the angular profile of the resist. Exposure conditions are listed for multiple exposure wavelength ranges and sources in Table 2. Together, Figures 4 and 5 provide a processing window that will help with determining an ideal process under 365 nm long pass filter and i-Line (on Veeco Ultratech Stepper, Figure 6.) exposure.

Feature undersizing associated with exposure and PEB are typically observed. The higher the dose, the closer sizing approaches 1:1 as shown in Figure 3 3 µm L/S. Features typically undersize from 0.5 µm to 1.25 µm as exposure dose is lowered. Undersizing may be corrected by increasing exposure dose, PEB temperature or by using a compensating mask with adjusted feature sizing. Ultimately, a matrix design varying exposure dose and PEB temperature is recommended to fine-tune the profile angle.

Note: While using hard contact alignment, the mask has been observed to occasionally stick to the film with no detrimental effects observed in the desired profile.

Radiation Source	Filter/Line	Recommended Starting Dose (Si) mJ/cm²
Stepper	i-Line	260
Aligner	365 nm Long Pass Filter	260
Aligner	No Filter	100

Table 2. Exposure Conditions for Stepper and Aligner with Various Spectrum Filters

All values are approximate for the best balance of control between feature sizing and profile angle

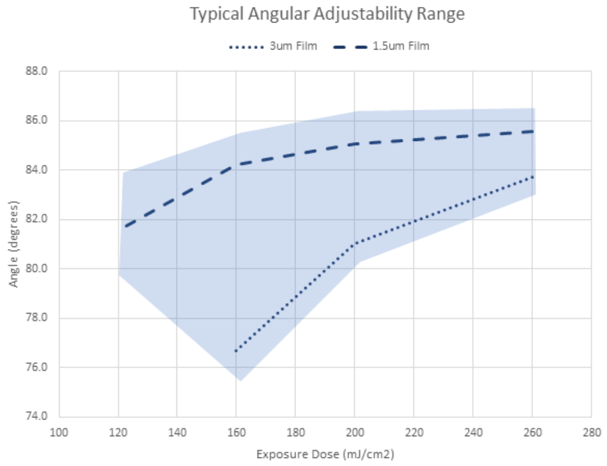
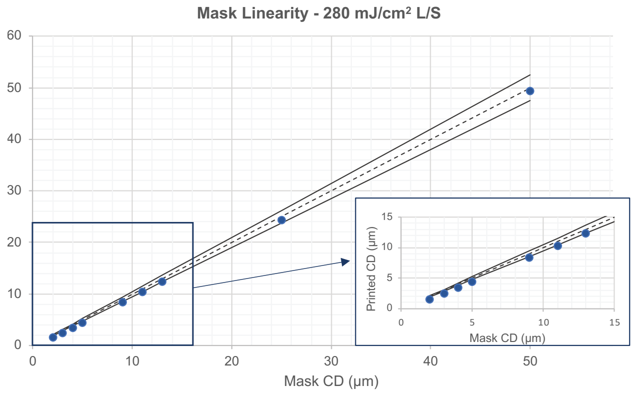


Figure 4. Process Window of Variable Exposure Doses in 1.5 µm and 3 µm Film Thicknesses on Si



Coated Thickness: 2.5 µm on Si wafer
Soft Bake: 115°C/2 min contact hot plate
Exposure: ABM Broadband mask aligner with 360 nm long pass filter Intensity measured at 365 nm
Post Exposure Bake: 120°C/2 min contact hot plate
Develop: CD-26 Developer 1 x 45 sec puddles

Figure 5. Exposure (2.5 µm film thickness on Si)

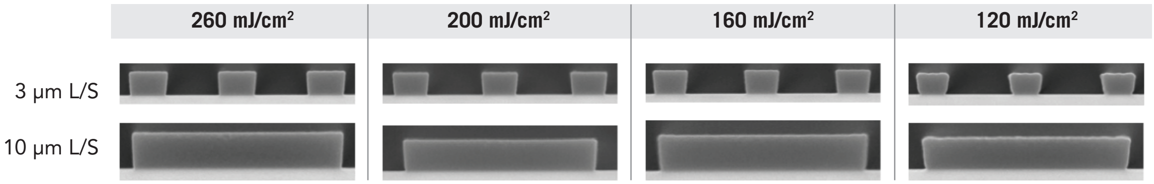


Figure 3: Varying Exposure Dose of 3 and 10 µm L/S in 1.5 µm Thick Film

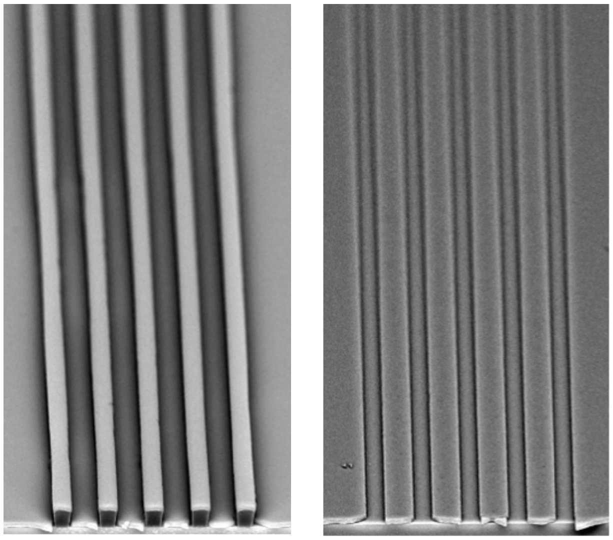
Post Exposure Bake (PEB)

A PEB is essential for effectively crosslinking the polymer after exposure because it is chemically amplified. To achieve good feature acuity, a PEB temperature of 120°C for 2 minutes on a level hotplate with good thermal control and uniformity is recommended. Temperatures may be adjusted between 115°C–125°C to modulate the extent of crosslinking. As a result, the feature wall slope is controllable. PEB temperature is a secondary lever for angle adjustability; exposure dose is the primary lever. Ultimately, a matrix design varying exposure dose and PEB temperature is recommended for fine-tuning profile angle.

Note: *An image of the mask should appear in the UniLOR® N coating within the first 15 seconds on a hotplate. No visible latent image during or after PEB means that there was insufficient exposure, temperature, or both.*

Development

UniLOR® N resist is compatible with TMAH based developers, including surfactant and surfactant-free variations. Development methods such as immersion, spray, puddle or spray/puddle may be used. Process optimization is necessary for different developer chemistries to achieve desired performance. Once optimized, it is a quick and simple process. A recommended spray/puddle step uses 2.38% TMAH (0.26N) at 23°C for one 45 second developer puddle.



3 µm L/S before/after lift-off of 4000 Å evaporated Aluminum deposition on 2.5 µm thick film

Rinse and Dry

Following TMAH development, the substrate should be spray rinsed with de-ionized water for at least 20

3 µm Line/Space UniLOR® N @ 250 mJ/cm², i-Line

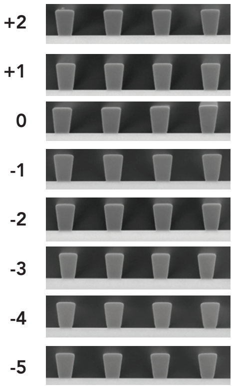


Figure 6. Depth of Focus Study

Performed in a collaboration with Veeco/ Ultratech using an AP200 Stepper

Thermal Stability in 3 µm UniLOR® N Film

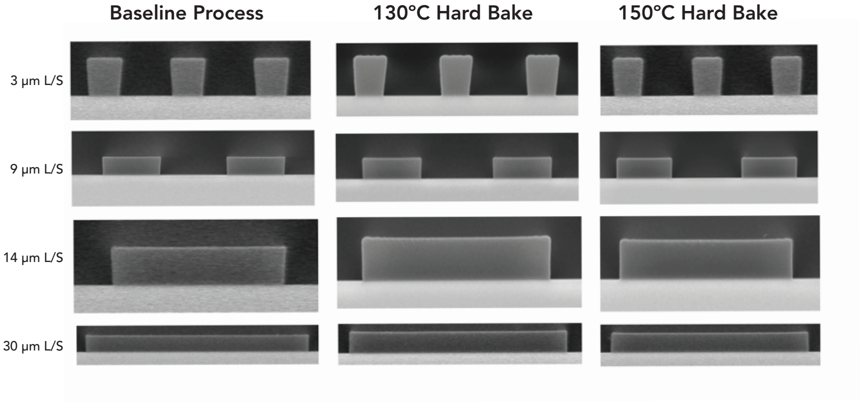


Figure 7. Dimensional Stability of Line/Spaces vs. Exposure Temperature

seconds and then air dried with filtered, pressurized air or nitrogen.

Deposition

UniLOR® N resist is optimized for evaporation deposition processes using planetary tooling with lift-off geometry. Deposition thicknesses to at least 66% of applied UniLOR® N thickness yield a clean lift-off.

Lift-off

For best results use Kayaku Advanced Materials' Remover PG, or other NMP or DMSO based removers to remove the UniLOR® N film. Removal rate is dependent upon the remover bath temperature, lithographic processing conditions and resist patterns. As a baseline process, use a 10–15 minute submersion in Remover PG at 60°C for a clean lift-off. Ultrasonic action will improve the resist removal efficiency. Consult the Remover PG technical data sheet for more information on this product.

Thermal Properties

UniLOR® N resist yields stable line/space profiles after prolonged exposure to high temperatures and is dependent on feature size. Stability of the resist's geometry is observed to at least a temperature of 150˚C for smaller features. This observed phenomenon can be attributed to the surface area to volume ratio specific to any given feature size (Figure 7).

Storage

Store UniLOR® N resists upright in tightly closed containers in a cool, dry environment away from direct sunlight at a temperature of 50–77°F (10–25°C). Store away from light, acids, heat and sources ofignition. Shelf life is thirteen months from date of manufacture.

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.

Disposal

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

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