

Metal-Containing Resists for Extreme Ultraviolet Lithography

CNF Project Number: 3108-23

Principal Investigator(s): Robert L. Brainard

User(s): Munsaf Ali, Moira Niluxsshun, Harry Weinstein, Stephen Smith

Affiliation(s): Department of Nanoscale Science and Engineering, University at Albany, SUNY

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Contact: rbrainard@albany.edu, mali5@albany.edu, mniluxsshun@albany.edu, hgweinstein@albany.edu, ssmith30@albany.edu

Primary CNF Tools Used: JEOL E-beam 6300, Woollam RC2 Spectroscopic Ellipsometer, Zeiss Supra SEM, Zeiss Ultra SEM

Abstract:

Since 2011, our research group has developed Molecular Organometallic Resists for Extreme Ultraviolet Lithography (MORE), a family of amorphous thin-film photoresists based on organometallic compounds containing tin, cobalt, platinum, palladium, bismuth, and antimony.¹⁻⁹ This project focuses on the design, synthesis, and characterization of metal-containing photoresist platforms for advanced Extreme Ultraviolet (EUV) and electron-beam (E-beam) lithography. The objective is to develop high-performance materials suitable for both positive-tone and negative-tone patterning while achieving high sensitivity, high resolution, and low line-edge roughness. During this reporting period, Cornell NanoScale Science and Technology Facility (CNF) resources were used to perform high-resolution electron-beam lithography patterning and scanning electron microscopy characterization of the developed resist platforms. These capabilities enabled systematic evaluation of lithographic performance and pattern fidelity, providing critical insight into structure–property relationships and guiding the optimization of next-generation molecular organometallic photoresists for advanced nanofabrication applications.

Summary of Research:

Platform Selection

We prioritized the development of organometallic resist platforms that demonstrated promising initial positive-tone lithographic performance. Based on these results, we systematically modified molecular structures and optimized processing conditions to improve resist performance, including sensitivity, resolution and pattern fidelity. Structural modifications were guided by understanding the relationship between metal-containing molecular design, film properties, and lithographic

response. These efforts enabled the evaluation of new resist formulations and identification of promising candidates for advanced Extreme Ultraviolet (EUV) and electron-beam (E-beam) lithography applications.

CNF Usage and Progress

Between February 2026 and April 2026, we conducted multiple visits to CNF, steadily increasing the productivity of each session:

Imaging Trips Schedule

- CNF 8: Feb.02, 2026
- CNF 9: April 10, 2026

CNF-#	Dates	# of Resists	Total Wafers	Total Samples	CC	IMG	OM	Best Resolution (nm)
CNF-8	2/2/2026	25	80	320	100	220	58	50
CNF-9	4/10/2026	16	37	148	68	80	61	50

Figure 1: Shows list of experimental details from each visit.

Over the course of the project, we improved our experimental workflow by increasing team participation, implementing pre-experiment planning meetings, and focusing on optimizing high-performing organometallic resist platforms rather than screening new candidates. Increased experience with electron-beam lithography and scanning electron microscopy (SEM) also improved process consistency. Reducing the electron-beam current from 10 nA to 1 nA significantly enhanced pattern fidelity and improved feature visibility in both SEM and optical microscopy.

Technical Achievements

- Developed an atomic force microscopy (AFM)-based method to generate electron-beam (E-beam) contrast curves for quantitative evaluation of resist performance (Figure 2).
- Achieved high-resolution imaging for both positive- and negative-tone resists
- Increased resolution from 50 nm to 20 nm using the JEOL 6300
- Demonstrated excellent line edge roughness (LER) in optimized formulations
- Used RC2 ellipsometry to monitor film thickness pre- and post-development

Successful Use of AFM to Measure E-Beam Contrast

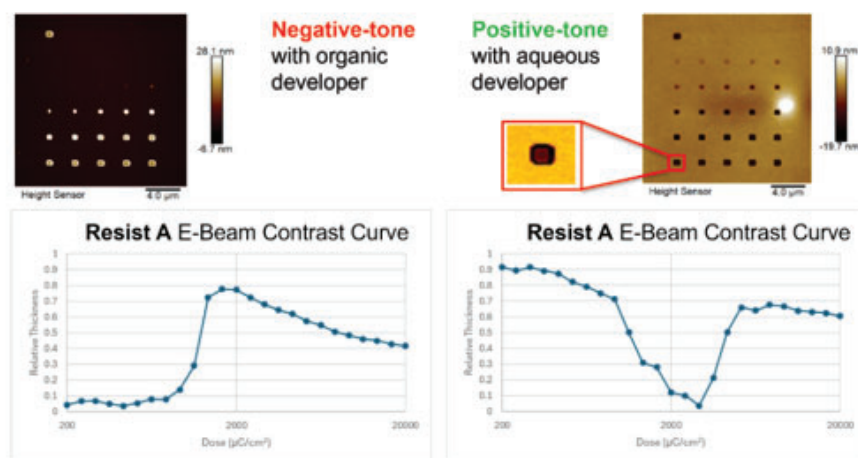


Figure 2: Positive-tone and Negative-tone contrast curve of Resist A.

Conclusions and Future Steps:

Our CNF trips became increasingly effective as the team-built process familiarity and focused on materials with the most promise. Key future work includes:

- Continued exploration of new organo-molecular resists.
- Further dose optimization and LER analysis.
- Testing of various development protocols on positive and negative tone resist platforms.
- Continued e-beam lithography and SEM imaging of optimized resists.

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