

Metal-Containing Resists for Extreme Ultra Violet

CNF Project Number: 3108-23

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

Abstract:

Since 2011, our group has developed Extreme Ultra Violet photoresists composed of amorphous thin-films of compounds containing tin, cobalt, platinum, palladium, bismuth and antimony in our project called Molecular Organometallic Resists for EUV (MORE).¹⁻⁹ This project focuses on the development and characterization of metal-containing photoresist platforms for Extreme Ultra Violet lithography applications. Our goal is to develop materials suitable for both positive- and negative-tone EUV resists and E-beam resists. We leveraged Cornell Nanoscale Facility's nanofabrication and characterization capabilities to carry out E-beam lithography and SEM analysis of these platforms.

Summary of Research:

Platform Selection: Focus on Reproducibility

We prioritized work on organo-metallic resists, which showed promising initial results but suffered from reproducibility issues. Addressing this is foundational to ensuring consistent performance in both academic research and industrial integration.

CNF Usage and Progress

Between August 2024 and June 2025, we conducted multiple visits to CNF, steadily increasing the productivity of each session:

Imaging Trips Schedule

- CNF 3: Aug 12, 2024
- CNF 4: Oct 2, 2024
- CNF 5: Jan 13, 2025
- CNF 6: Apr 1, 2025
- CNF 7: Jun 25, 2025

Over time, our group; Increased participation (from 2 to 4 researchers per trip), conducted process planning

meetings beforehand, reduced screening of new platforms in favor of optimizing high-performing candidates, improved familiarity with lithography and SEM tools

A significant improvement came from reducing beam current from 10 nA to 1 nA, dramatically increasing pattern fidelity and visibility via SEM and optical microscopy.

Technical Achievements

- Developed contrast curve data across several resist formulations (Figure 2).
- Achieved high-resolution imaging of 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

Figure 3 and Figure 4 present representative SEMs of successful patterns, showing clear resolution improvement.

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 reproducibility studies of 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

CNF-#	Start Date	Current (nA)	Total Wafers	Total Exposures	Number of Samples Exposed			Number of Visible Patterns	
					CC	Standard L/S	High Res L/S	OM	SEM
CNF-1	9/8/2023	1	2	2	-	2	-	1	1
CNF-2	11/13/2023	1	6	6	-	6	-	5	4
CNF-3	8/12/2024	1	31	61	26	35	-	24	11
CNF-4	10/2/2024	10	45	180	40	145	-	13	4
CNF-5	1/13/2025	1	48	192	40	144	8	108	75
CNF-6	4/1/2025	1	36	144	44	76	24	52	45

Figure 1: Shows lists experimental details from each visit.

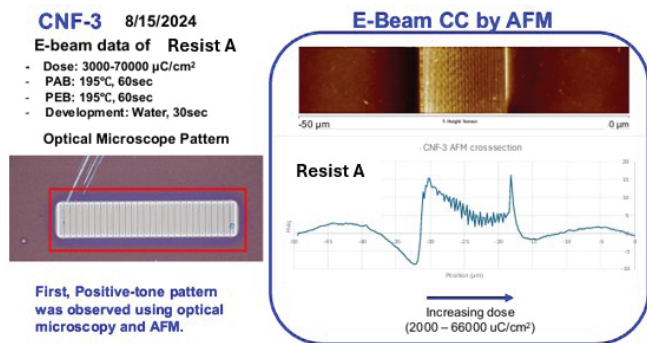


Figure 2: Positive-tone pattern Observed using optical microscope and AFM.

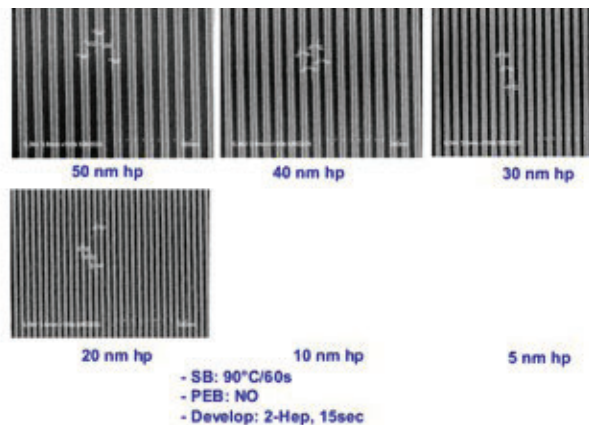


Figure 3: SEM image of negative tone resist B at 20 nm resolution (non-confidential)

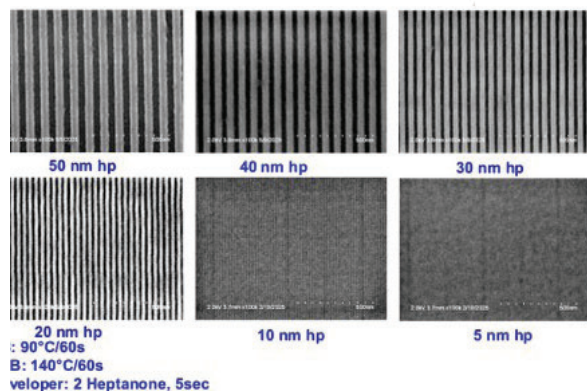


Figure 4: SEM image of negative tone resist B at 20 nm resolution (non-confidential)

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