

Cathodoluminescent Evaluation: Validating a Broadband Cathodoluminescent Technology for 193 Nanometer Photoresist Processing

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Primary CNF Tools Used: ABM Mask Aligner

Abstract:

Work at the Cornell NanoScale Science and Technology Facility evaluated whether a broadband cathodoluminescent source emitting near 190 nanometers could produce an actinic response in photoresist intended for 193 nanometer processing. A four-inch wafer carrying a 36–39 nanometer resist film was exposed through a rotating mechanical sector mask containing repeated resolution targets. The clearest patterned response occurred after a 45 second exposure at 10 percent pulsed duty, equivalent to approximately 4.5 seconds of cumulative full-on operation. After post-exposure bake and development, patterned regions remained. The present interpretation is negative-tone behavior. This result establishes preliminary actinic feasibility, while dose optimization, repeatability, quantitative resolution, and full-field uniformity remain to be demonstrated.

Summary of Research:

The project is developing a cleanroom-operable, large-area cathodoluminescent flood source for photoresist processing near 193 nanometers. The initial facility experiment addressed the most basic feasibility question: whether the lamp emission could create a developed resist response. The lamp was positioned over the wafer stage in the ABM Mask Aligner exposure area, as shown in Figure 1. The exposure fixture used a lower plate with six evenly spaced sector openings and a rotatable upper plate with one matching opening. Repeated line-and-space targets were distributed around the mask, including fields identified as 550 nanometers and 500 nanometers.

Two wafer runs were completed at 10 percent pulsed duty. The first used exposure times from less than one second through eight seconds. The second used times from 10 seconds through two minutes. The



Figure 1: Cathodoluminescent lamp and temporary support fixture positioned over the ABM Mask Aligner wafer stage for the initial exposure experiment.

clearest interpretable feature response was observed in the 45 second sector. This condition corresponds to approximately 4.5 seconds of cumulative full-on exposure. The wafer received a post-exposure bake at 110 degrees Celsius for 60 seconds and was developed in fresh 2.38 percent tetramethylammonium hydroxide for 45 seconds, followed by a deionized-water rinse and nitrogen dry.

Post-development optical inspection showed visible line-and-space response and adjacent mask-label features in the 45 second region. Figure 2 shows the close view, and Figure 3 shows the wider view with the 550 and 500 nanometer labels. The one-minute and two-minute sectors showed mainly sector outlines without visible fine features. The current working interpretation is overexposure within an observed negative-tone response: exposed material became less soluble or chemically hardened and remained after development. The images are qualitative microscope-monitor photographs and do not support a final claim for resolution, optimized dose, process repeatability, or uniform exposure.

The first test was enabled by coated wafers provided through Professor Greg Denbeaux at the University at Albany. Garry Bordonaro at the Cornell NanoScale Science and Technology Facility, with assistance from Erin Lavigne at NY CREATES, helped establish a practical path toward future resist preparation and testing at Cornell. This coordination removed an immediate material-access barrier and supports the next controlled process sequence.

The next phase will be scaled to the available source rather than framed as a full-wafer demonstration. The present 50 millimeter lamp is expected to support a reproducibly illuminated raster-scan region of approximately 40 millimeters in diameter. Initial work will therefore evaluate uniformity only within the illuminated area of a selected mask sector, with the goal of covering that sector completely. Depending on available funding, hardware, and authorization, uniformity may first be established by direct measurement scanning rather than by another photoresist exposure. Development of additional 190 nanometer lamp assemblies and a broader photoresist-uniformity study remain possible later steps, but are not assumed in the current plan.

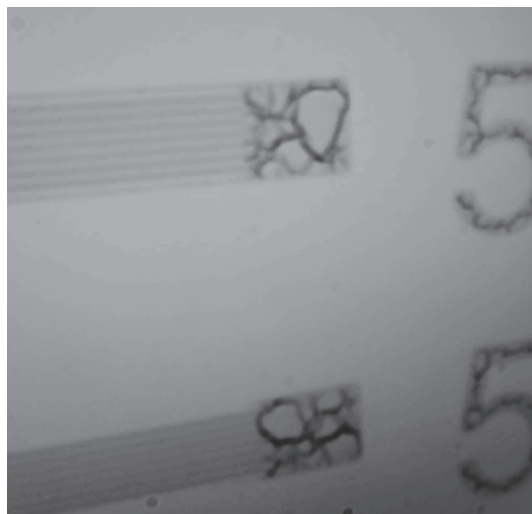


Figure 2: Close microscope-monitor photograph from the 45 second exposure region showing visible patterned response near the line-and-space fields.

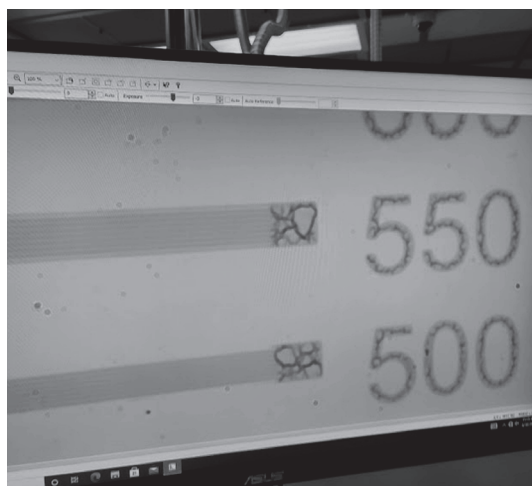


Figure 3: Wider microscope-monitor photograph from the same region showing line-and-space structures and the 550 nanometer and 500 nanometer mask labels.

Conclusions and Future Steps:

The facility work established preliminary proof that the cathodoluminescent lamp can generate a developed actinic response in 193 nanometer-type photoresist. The strongest evidence occurred at the 45 second, 10 percent duty condition. Near-term work will concentrate on characterizing the usable illuminated region of the existing 50 millimeter source and assessing uniformity over a selected sector, potentially by direct measurement scanning. Additional resist exposures, specialized lamp assemblies, and broader spatial studies will proceed only as resources and authorization permit. Claims will remain limited until calibrated measurements and repeat runs are available.

References:

- [1] ABM Mask Aligner