Point-of-Use UPE Membrane Filter Optimization for EUV Chemically Amplified Photoresist

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INTRODUCTION

As semiconductor manufacturing advances toward ever-shrinking features sizes and increasingly complex, multidimensional integration schemes, extreme ultraviolet (EUV) photolithography has become a critical enabler for leading-edge technology nodes.[1] Correspondingly, the performance requirements placed on EUV lithographic processes continue to intensify. In particular, advanced EUV patterning demands stringent contamination control to enable stable, manufacturable processes. At these dimensions, even minor sources of variation can translate into printable defects,[2] making high chemical purity at the point-of-use (POU) essential for minimizing on-wafer defectivity and associated yield loss.

Among EUV related defects, bridge defects are especially yield critical[2] due to their typically high electrical kill ratio. Residual particles originating from resist formulations or track components can be transferred to the wafer during coating, leading to localized etch blocking and the formation of bridges between adjacent features in dense pitch patterns. These unintended connections between otherwise isolated structures at the tightest pitches underpin the severe yield impact of bridge defects.

POU filtration is therefore a key element of an effective defect control strategy. Highly retentive POU filters can remove particles and other defect precursors from EUV resists prior to wafer exposure. However, effective filtration requires not only high particle retention, but also exceptional filter cleanliness to ensure that the filter itself does not introduce new contaminants. Consequently, both retention performance and intrinsic cleanliness are critical attributes for EUV applications.

This study present results from ongoing POU filter development focused on particle removal in EUV chemically amplified resists (CARs).

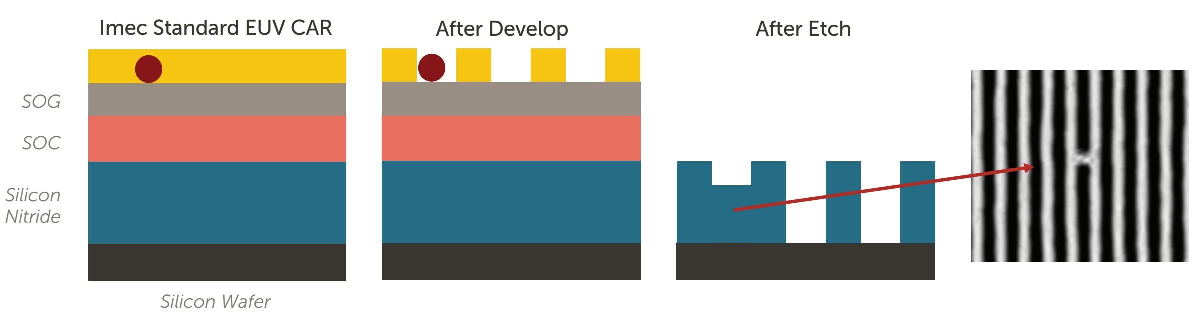

Figure 1. Bridge formation mechanism from particle in EUV CAR through etch process.

METHODS

Wafers were coated with Imec standard EUV CAR on a TEL Clean Track LITHIUS Pro™ Z series coater/developer. Filter installation, start-up, and evaluation were identical for all filters. After installation, filters were primed and measured until reaching matching baselines using PGME/PGMEA (7:3). All on-wafer processing was accomplished using the same tool recipes.

After coating, wafers were exposed on an ASML NXE3400B full field EUV scanner (0.33 NA). The test vehicle utilized was a standard 32 nm pitch line/space pattern. After exposure, development, and etch, wafers were inspected on a KLA2935 BBP inspection tool, and defects subsequently reviewed with a KLA eDR7380 SEM. Defects images were manually classified to determine resulting bridge defect density.

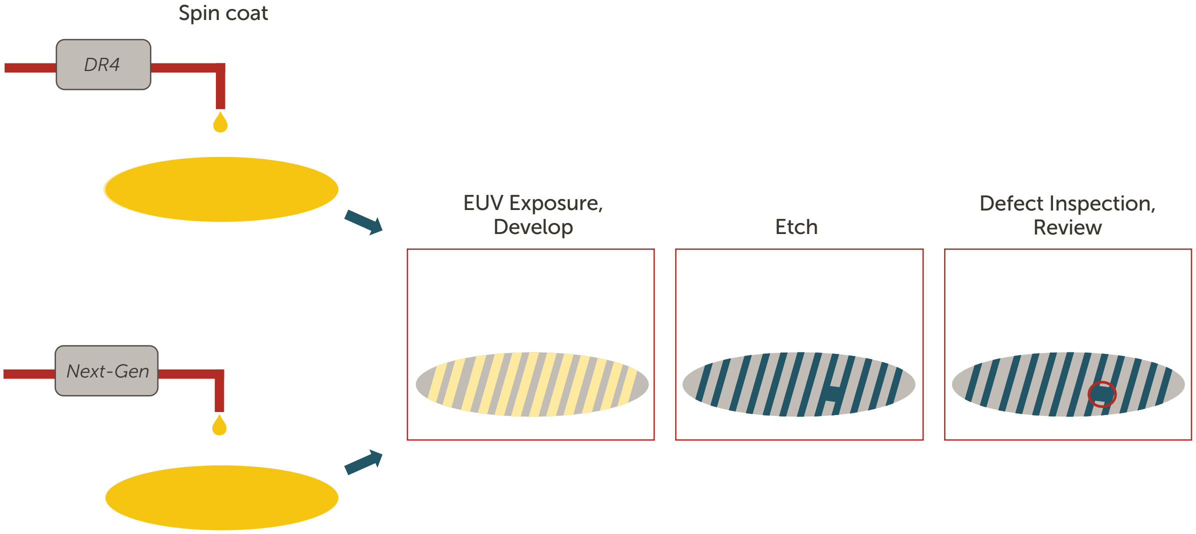

Figure 2. Filter evaluation procedure.

RESULTS

Prior studies have shown that reduced membrane pore size significantly improves particle retention in EUV CARs[3] The DR4 filter membrane was engineered to promote sieving particle removal mechanisms and demonstrated superior performance compared with designs relying on non-sieving effects. Building on these results, the next-generation DR6 filter evaluated here incorporates a 25% smaller pore size to further advance performance with tight-pore, highly sieving membrane systems.

The on-wafer results validate the hypothesis in that the tighter pore morphology of the next-generation filter resulted in significantly lower bridge defect density as well as overall defectivity under identical test conditions. This is consistent with the historical correlation between filter pore size and resulting bridge defect density in EUV CARs, as seen in figure 4. Further experiments are planned to confirm repeatability, as well as characterize retentive performance after extended loading. Future experiments will also continue to explore the relationship between chemical properties and defect retention mechanisms. These results will continue to facilitate comprehensive filtration strategies for the ever-heightening demands of EUV lithography.

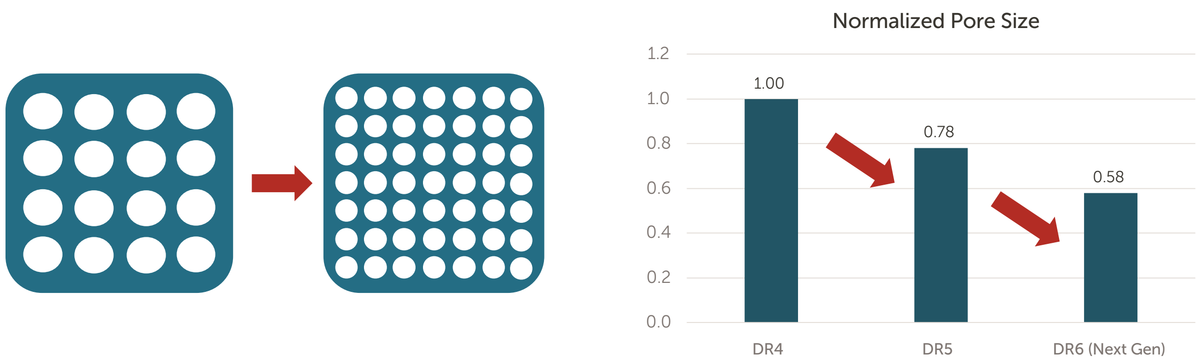

Figure 3. Pore size improvement over filter generations.

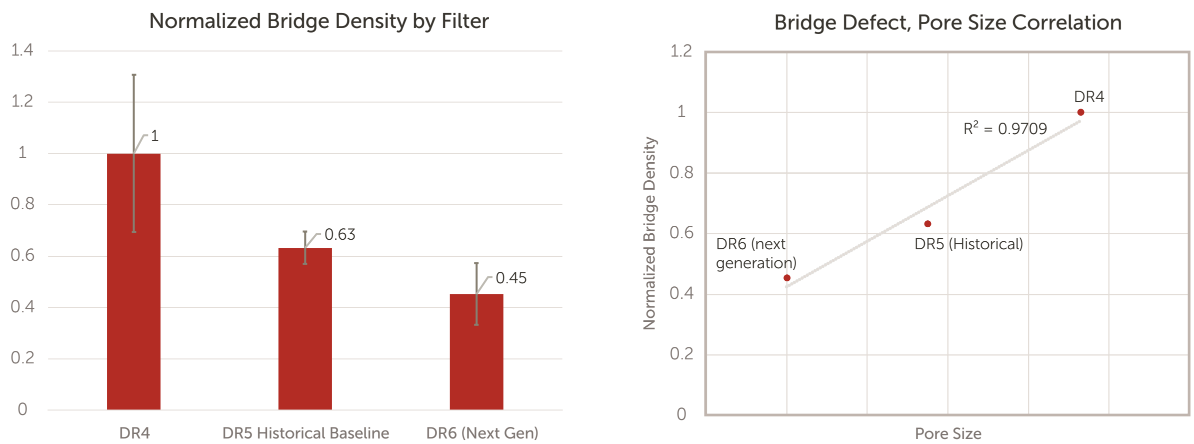

Figure 4. Pore size – bridge density correlation.

CONCLUSIONS

This study demonstrated the importance of application-specific filter optimization for highly sensitive chemistries such as EUV chemically amplified resists. At the highest resolutions enabled by EUV lithography, even the smallest defects can result in yield loss, adversely impacting process stability. As these technologies mature, robust defect control strategies therefore become increasingly critical. Prior work has shown that small pore size, sieving membranes are most effective at reducing on-wafer bridge defectivity in EUV resists. The results presented here extend this work by demonstrating continued reductions in bridging defectivity enabled by next-generation membrane technology.

Collectively, these results highlight the potential for targeted filtration solutions to improve performance and reliability in highly sensitive manufacturing processes, where a detailed understanding of defect elimination mechanisms is required to achieve desired outcomes. Future work will focus on further advancing filter performance to meet the evolving demands of emerging EUV photolithography technologies and processes.

This paper was first presented at the 2026 SPIE Advanced Lithography + Patterning conference.

References

[1] High Sensitivity Resists for EUV Lithography, T. Manouras et al.,: A Review of Material Design Strategies and Performance Results: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7466712/

[2] H. Yang et al., "Defectivity-Aware EUV Process Window Characterization for Monolithic Complementary FET HAR and 3D patterning", Proc. Of SPIE Vol. 13686 (2025)

[3] T. Kohyama et al., "Exploration of UPE membrane technology in point-of-use EUV CAR photoresist filtration", Proc. Of SPIE Vol. 13428 (2025)

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