Updated UPE Filter Design for Point-Of-Use EUV CAR Photoresist Filtration for Defect Improvement

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INTRODUCTION

This paper discusses the role of extreme ultraviolet lithography (EUV) in semiconductor technology, focusing on the use of Chemically Amplified Resists (CARs). As the demand for high-performance EUV CAR resists increases, so do the challenges associated with EUV lithography, such as exposure to energetic EUV photons and the presence of molecular contaminants. The importance of effective filtration in achieving optimal resist performance and defect reduction is also highlighted. Furthermore, this paper presents a comparative study of the patterning performance of various point-of-use (POU) filters, aiming to optimize filtration and improve defectivity in an EUV CAR photoresist. The goal is to examine the efficacy of optimized filter design in reducing defects and provide recommendations for achieving lower defect density.

EXPERIMENT

The coating process of an EUV CAR was accomplished in the module of a TEL Clean Track LITHIUS Pro™ Z series. The filter installation and testing procedure were identical for all testing filters. Before starting the defect study, a filter was primed to achieve baseline particle counts using PGME/PGMEA (7:3). The dispense recipe and coat recipe were kept constant as the filter was changed.

Developer Rinse Defects

This testing was adopted as a new indicator to increase wafer coating defect intensity and inspect the defectivity at a highly sensitive level. Si wafers were spin-coated with imec standard EUV CAR photoresist, followed by solvent washing to remove the coated photoresist and spin-drying. Afterward, the wafers were baked and inspected for defect counts using a KLA Surfscan® SP5 at 19 nm resolution.

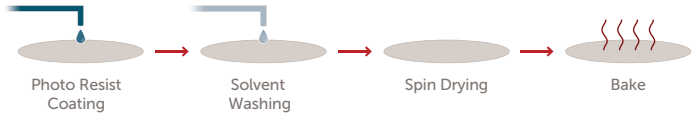

Figure 1. Process flow of thinner wash defect testing.

After Etched Inspections (AEI) of Bridge Defects

The photoresist material was spin-coated on wafer with the stack below (Figure 2) to prepare an inspection vehicle for defectivity studies. The exposure process was carried out using an ASML NXE3400 full field EUV scanner (0.33 NA) at 32 nm pitch size. The bridge defects on each wafer were then reviewed on KLA2935 and classified by defect review tool eDR7380.

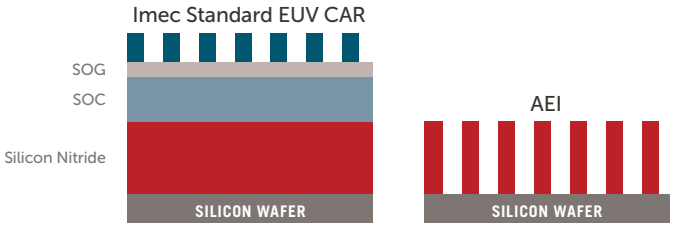

Figure 2. Inspection layer stack of AEI test vehicle.

Point-of-Use Filters

Impact 8G style POU UPE filters with varied retention ratings, membrane architecture, and filter design were tested in this study. Table 1 provides a comparison of the filter attributes.

ATTRIBUTE	DUO 1 nm	PROTOTYPE OF AZORA G3	RO2	DO1A	DO1
Filtration area (cm^2)	1,200	3,000	3,000	3,000	3,000
Membrane characteristics	Conventional membrane architecture	Polyimide membrane with honeycomb architecture	Enhanced UPE surface filtration architecture	UPE surface filtration architecture (Design #1)	UPE surface filtration architecture (Design #2)
Primary retention mechanisms	Sieving (size exclusion) + non-sieving	Sieving (size exclusion) with impaction and collision effects	Sieving (size exclusion)	Sieving (size exclusion)	Sieving (size exclusion)

Table 1. Comparison of new UPE filter attributes.

RESULTS AND DISCUSSION

In the first experiment, three filters – Duo 1 nm, a prototype of Azora G3, and R02 – were tested. The results showed that the R02 filter outperformed the other two in terms of reducing solvent rinse defects and etched bridge defectivity (Figure 3).

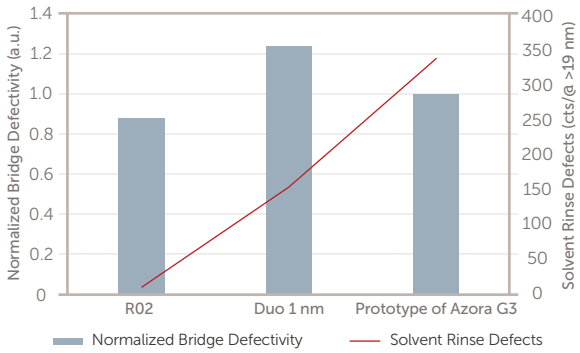

Figure 3. A comparative data of solvent rinse particles and bridge defectivity.

The R02 filter is designed to maximize filtration capability by enhancing membrane morphology tortuosity, while keeping the membrane film thickness constant (Figure 4).

Although further investigation is needed to clarify the defect mechanism in this EUV CAR case, it can be concluded that the membrane characteristics of the R02 filter provided greater benefits than the other two filters. Therefore, the sieving mechanism is dominant in improving bridge defectivity by removing some defect sources.

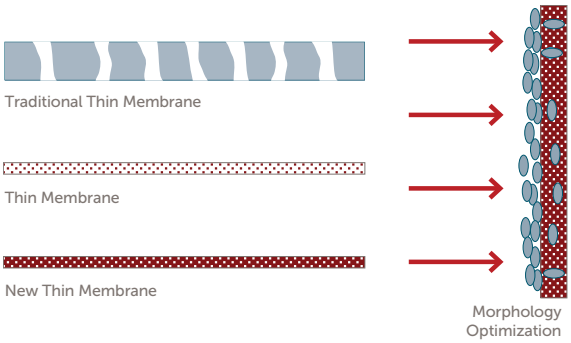

Figure 4. Schematic of R02 membranes.

- Continue to shrink absolute pore sizes to improve removal via size exclusion
- Continue to improve pore size uniformity to enhance removal efficiency and consistency
- Enhance the tortuosity of membrane morphology to enhance gel trap capability

A further study was conducted to explore the efficacy of R02 filters. The AEI defect testing is underway, but the results of the rinse defect study demonstrated that R02 filters were still by far the most promising option among our advanced filters (Figure 5). The subsequent bridge defect study will provide more insights into the filtration mechanism, which can lead to the direction of new filter development.

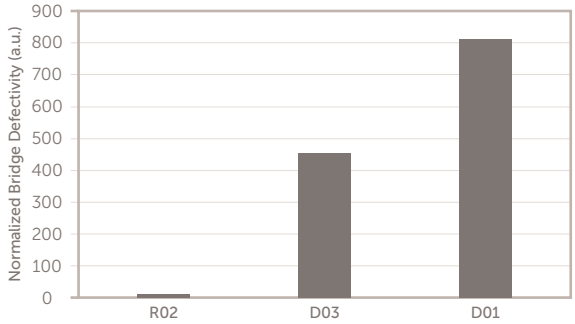

Figure 5. A comparative data of solvent rinse particles among advanced UPE filters.

CONCLUSION

This paper emphasizes the crucial role of filtration strategies in the context of EUV CARs. Filtration is critical in reducing defects that can affect pattern accuracy. In EUV lithography, where precision at the sub-nanometer level is essential, the effects of unfiltered contaminants on resist properties are amplified. This necessitates a thorough understanding of filtration techniques that are tailored to the unique challenges of EUV lithography. This paper explores various filtration methodologies, from traditional approaches to advanced technologies. By shedding light on the complex relationship between filtration and EUV CAR resist performance, this paper aims to provide valuable insights to enhance the robustness and reliability of EUV lithography processes.

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