Photoresist Filtration Design Advancements for Process Throughput Performance and Defect Reductions

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ABSTRACT

Next-generation lithography processes require leading edge filtration solutions capable of capturing sub-20 nm contaminants without compromising process efficiency.[1] In this paper, we present a device comprising of 1) a newly developed retention media with refined pore structure to enable optimum retention of sub-15 nm particles and 2) a new device configuration to enable optimum access to the retentive media while keeping an acceptable flow. Comparative evaluations confirm superior consistency in impurity removal, particularly in the critical sub-15 nm range, addressing the escalating purity challenges of advanced photoresist filtration. These results demonstrate the Entegris Impact 8G-L Plus DR5 point-of-use (POU) filter as a robust next-generation solution, balancing enhanced contamination control with sustained device throughput.

INTRODUCTION

With the continuous reduction of critical dimensions in advanced technology nodes, lithographic fidelity increasingly relies on rigorous control of particulate and colloidal contamination within photoresist. Even small-size impurities play a crucial role in lithographic processes by generating micro-defects or contributing to line-edge/line-width roughness.[2] Consequently, photoresist filtration has emerged as a key strategy for reducing these contaminants. However, efforts to enhance retention ability are constrained by the persistent trade-off between reducing membrane pore size and maintaining acceptable pressure drop or flow rate, presenting a significant challenge for process optimization.

Addressing this trade-off requires innovations at both the material and device level[3]: a membrane with a refined pore structure to selectively capture nano-size particles, and a device configuration that minimizes dead zones, evens out shear profiles, and maximizes membrane utilization under realistic dispense flow conditions.

This study presents a next generation photoresist filtration solution – Impact 8G-L Plus DR5 – featuring a refined UPE based membrane and a co-designed internal flow configuration engineered to deliver high retention rate for 15 nm wafer particles.

EXPERIMENT

The equipment used to study the new filter included various lab and fab equipment, depending on the required experimental procedure and result.

Membrane filtration efficiency

Membrane filtration efficiency was evaluated by SNP (single nanoparticles, polymer bead with uniform particle size) retention testing in deionized water. The test was performed with a 47 mm coupon membrane.

Flow performance

Flow rate was tested for both the Impact 8G-L and Impact 8G-L Plus devices under water-pressure of 0.2 kPa.

Filter cleanliness by static soaking

Filter cleanliness was determined by static soaking using OK73 (PGME/PGMEA = ⅔) with the device, followed by analysis of metal and organic extractables. The resulting extract was analyzed using inductively coupled plasma mass spectrometry (ICP-MS) to identify and quantify metal extractables. For organic extractables, gas chromatography (GC) was employed as an index for determination.

On-Wafer retention performance

A filter flush-up test was performed on a TEL ACT12 Clean Track system using OK73 to determine baseline particle counts using a KLA Surfscan SP7 (size ≥15 nm).

RESULTS AND DISCUSSION

Membrane filtration efficiency

Reducing membrane pore size has long been a key strategy for improving filtration performance. In the latest Entegris POU products, the DR5 membrane demonstrated the highest retention rate compared to DR4 and D01A in SNP retention testing. Even as filtration volume increased, DR5 maintained a significantly higher retention rate than the other two membranes, as shown in Figure 1. These results confirm that membranes with smaller pore sizes deliver superior retention capability.

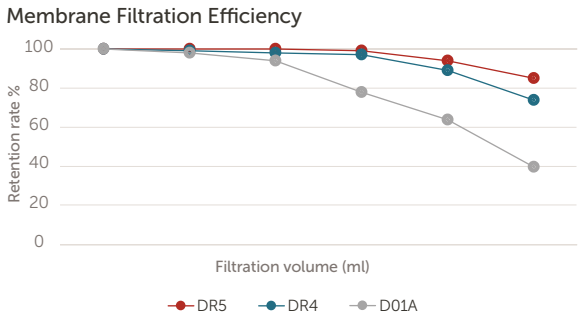

Figure 1. Comparison of filtration performance among DR5, DR4, and D01A membranes.

Flow performance

When developing new filter products with tighter membrane pore sizes, flow rate is often compromised. Flow performanceWhen developing new filter products with tighter membrane pore sizes, flow rate is often compromised. For example, compared to D01A, the DR4 membrane provided improved filtration performance, but its flow rate in the Impact 8G-L device was significantly lower, as shown in Figure 2. To overcome this trade-off, a new device configuration – Impact 8G-L Plus – was introduced. By optimizing the flow path, the new design enabled DR5 to deliver not only the best filtration performance but also a higher flow rate than Impact 8G-L with DR4, as illustrated in Figure 2.

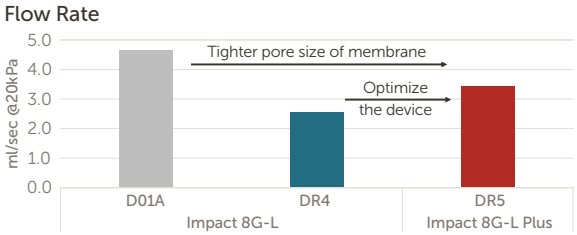

Figure 2. Comparison of flow rate among DR5, DR4,and D01A devices.

Filter cleanliness by static soaking

Figures 3 demonstrates that, following device configuration optimization, Impact 8G-L Plus achieved significantly improved cleanliness for both metal and organic extractables. This indicates that the new configuration delivers higher cleaning efficiency under the same cleaning process, resulting in a superior cleanliness level.

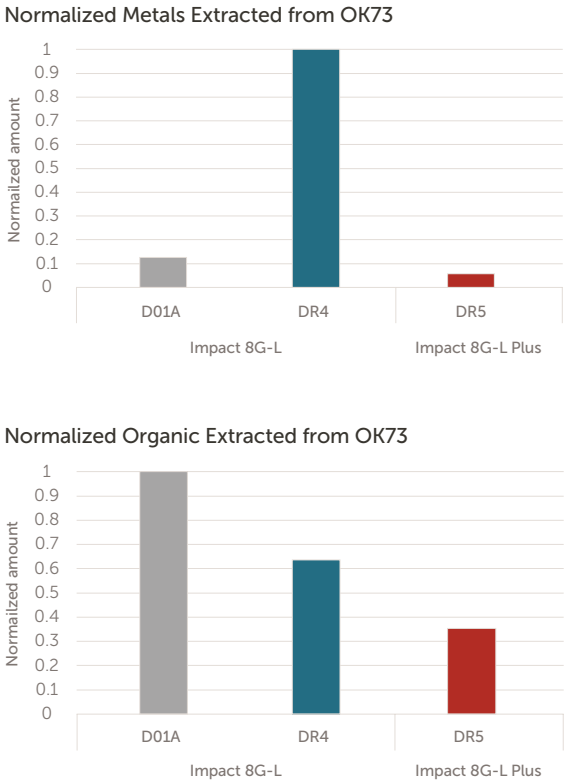

Figure 3. Comparison of metal and organic extractables among DR5, DR4,and D01A devices.

On-wafer retention performance

To evaluate the wafer-level retention performance by eliminating the influence of filter cleanliness, Impact 8G-L D01A and Impact 8G-L Plus DR5 were flushed to 14 L of OK73, followed by on-wafer particle analysis (size ≥15 nm), as illustrated in Figure 4. The results indicate that Impact 8G-L Plus DR5 achieved a significantly higher retention efficiency of 56%, compared to Impact 8G-L D01A. This improvement demonstrates that reducing membrane pore size combined with optimizing the device configuration provides a substantial advantage in reducing on-wafer particle contamination.

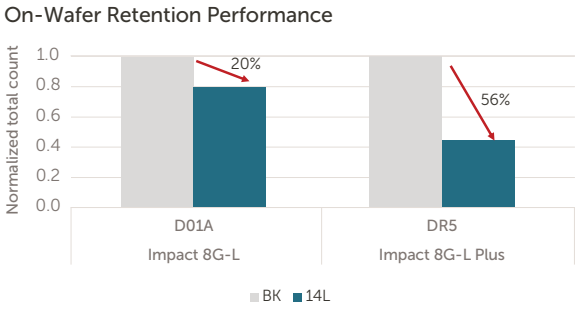

Figure 4. On-wafer retention performance in OK73 (size ≥15 nm).

CONCLUSIONS

The next-generation Impact 8G-L Plus DR5 filtration solution integrates a refined UPE media with an optimized device configuration to deliver exceptional retention ability for 15 nm wafer particles, maintain an acceptable flow rate, and achieve superior cleanliness. These advancements meet the stringent purity requirements of advanced technology nodes, improving yield and process reliability.

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

References

[1] Manouras T, Argitis P. (2020, Aug. 14). High Sensitivity Resists for EUV Lithography: A Review of Material Design Strategies and Performance Results. Nanomaterials (Basel). 2020;10(8):1593.

[2] Mack, C. A. (2006). Line Edge Roughness. Field Guide to Optical Lithography, SPIE Press, Bellingham, WA.

[3] T. Kohyama, F. Kaneko, K. Miura, A. Gjoka, J. Jaber,. (2019, March 25). "Filter technology developments to address defectivity in leading-edge photoresists". Proc. SPIE 10960, Advances in Patterning Materials and Processes XXXVI, 109601X.

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