Dual-Function Filtration to Improve On-Wafer Defectivity Performance for EUV Applications

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ABSTRACT

With the progression of transistor miniaturization with mass production at the 3 nm process node,[3] the risk of contamination in photochemicals, such as photoresists, spin-on carbon (SOC)[1] and spin-on glass (SOG),[2] becomes increasingly significant, highlighting the essential role of contamination control systems such as filters (particle removal) and purifiers (organics, metals, etc.) in mitigating threats to electrical microstructures on semiconductor chips. Entegris has been at the forefront of developing advanced chemical integrity and performance tools to minimize wafer defects and enhance product yields.

Due to their widespread application, ultra-high molecular weight polyethylene (UPE) membranes have become vital at the point of use (POU) filtration. Their ability to eliminate typical sources of defectivity, such as particles and aggregates in photoresist materials, is a testament to their effectiveness. This has traditionally been achieved through sieving filtration, utilizing the tiny pores of UPE filters and their exceptional photochemical compatibility. Furthermore, for particles at the molecular level, adsorption filtration (non-sieving filtration) has grown to become instrumental in significantly reducing wafer defects.

This paper introduces our latest innovative, dual-functional filtration technology for photoresist POU filtration, which provides superior performance with both sieving and non-sieving filtration mechanisms. In addition to its advanced filtration capabilities, the new dual-functional filter demonstrates higher cleanliness standards than its predecessors, resulting in a notable reduction in wafer defectivity.

INTRODUCTION

With the progression of transistor miniaturization, the risk of contamination in photochemicals and contribution of liquid filter cleanliness has become increasingly significant as a source of wafer defects. Traditionally, UPE filters have focused on sieving capability, relying on its tiny pores to remove the contaminants. However, the continued miniaturization of ICs has led to demand for the removal of even molecular sized contaminants such as ions and monomers. To address the challenge, Entegris has developed the DUO 1 nm filter, which combines non-sieving capability with the conventional UPE sieving mechanism to achieve the removal of a wide range of contaminants. In this study, we present our newest filter, Impact® DUO G1, which enhances performance further. DUO G1 has improved not only sieving and non-sieving functionalities, but also filter flow rate by increasing the flow path efficiency in the system (Figure 1).

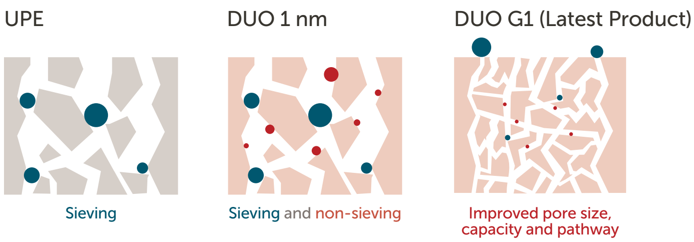

Figure 1. Feature of new dual-functional filter, DUO G1.

EXPERIMENTAL

Filtration Performance

Filtration performance was evaluated using 25 nm fluorescent PSL (polystyrene latex) beads. Details of analytical method are reported by Entegris.[4]

Flow Rate

Filter flow rate was measured at 2.0 kPa in water. Tests were performed using Impact 8G-L filter devices.

Cleanliness of Raw Materials

The determination of metal and organic extractables was evaluated by soaking the POU filters in OK73 for one day (PGME/PGMEA=7⁄3). The extract liquid was analyzed by inductive coupled plasma equipped with mass spectrometer (ICP-MS) to qualify and quantify metal extractables. For the organic extractables, gas chromatography (GC) was used as an index for the determination.

On-Wafer Particles

The filters were evaluated in the field by monitoring the amount of on-wafer particle (size ≥ 15 nm) with respect to solvent flushing volume.

RESULTS AND DISCUSSION

Filtration Performance

Figure 2 demonstrates filtration performance of DUO 1 nm and G1 in Impact 8G-L device. The result of DUO G1 maintained 100% retention, while DUO 1 nm lowered as filtration volume increased. It indicates that the larger non-sieving capacity and tighter sieving pore rating of DUO G1 contribute to the filtration improvement.

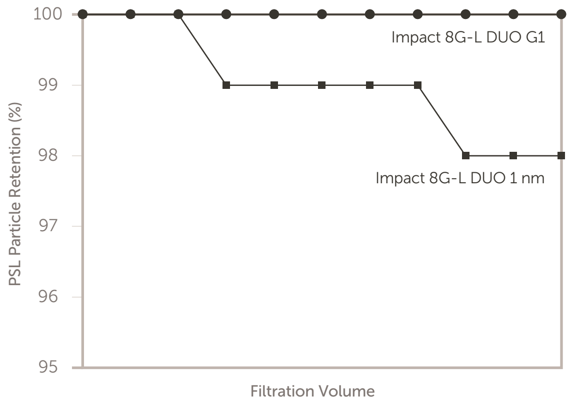

Figure 2. Comparison of filtration performance with DUO 1 nm and G1.

Flow Rate

The device flow rate of DUO 1 nm and G1 was shown in Figure 3. DUO G1 showed higher flow rate than DUO 1 nm.

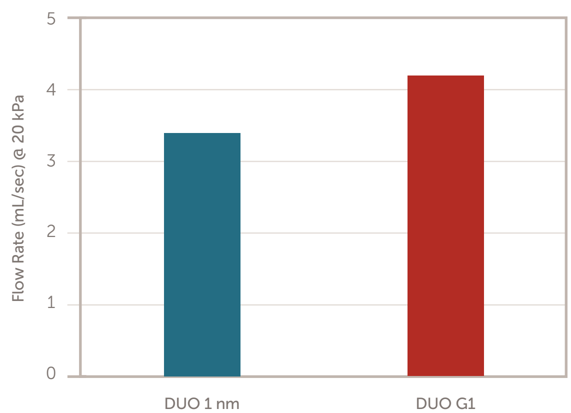

Figure 3. Comparison of flow rate with DUO 1nm and G1.

Cleanliness of Raw Materials

Figures 4 through 5 show metal and organic extractables after soaking in OK73 for 1 day.

The results showed that metal extractables released from DUO G1 were approximately 1⁄10, and organics were ½ from DUO 1 nm.

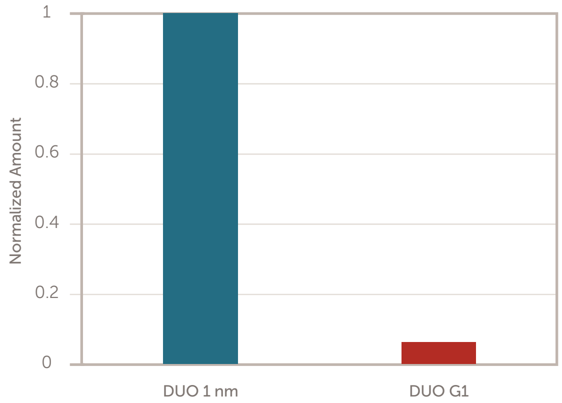

Figure 4. Comparison of metal extractables with DUO 1 nm and G1.

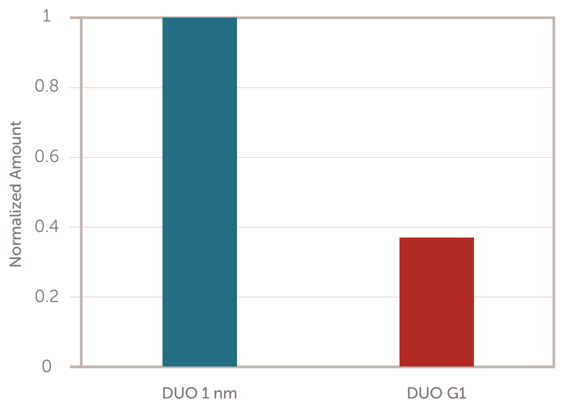

Figure 5. Comparison of organic extractables with DUO 1 nm and G1.

On-Wafer Particles

Figure 6 is On-Wafer Particles in OK73 (size ≥ 15 nm) comparing DUO 1 nm to G1. The results showed that DUO G1 gave faster flush-up time and reached the lower baseline after 2 L flushing while DUO 1 nm was higher than that. This demonstrates the enhanced dual function system of DUO G1, which effectively reduces on-wafer particles levels more efficiently than DUO 1 nm.

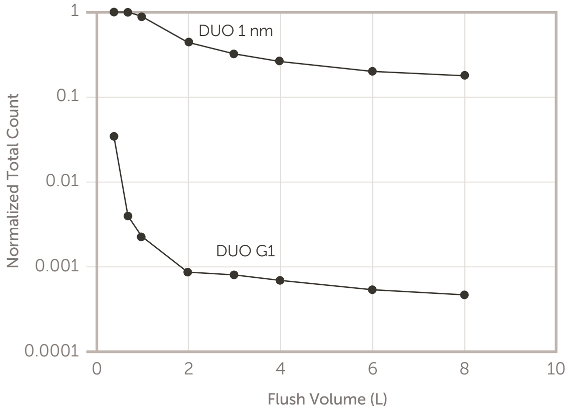

Figure 6. On-Wafer Particles in OK73 (size ≥15 nm).

CONCLUSION

The new dual-functional filter, DUO G1 represents the contribution for defect reduction.

Its design for advanced filtration technologies shows higher filtration performance, faster flow rate, lower extractables. This performance leads to better defect reduction compared to DUO 1 nm. The filter is expected to aid in the continued advancement of miniaturized IC technology.

ACKNOWLEDGEMENTS

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