High Throughput Ultraclean UPE Filters for Sub-5 nm Node Aqueous Applications

Patricia Chen, Amy Chang – Entegris Taiwan
Aiwen Wu, Gregg Conner – Entegris USA

INTRODUCTION

It is well known that selecting the best liquid filter for an application can be a momentus challenge. Multiple factors must be considered when deciding the best filter to use in a specific semiconductor application. Selecting an inappropriate filter type can cause insufficient defect reduction, or worse, can increase the defect levels or contaminate systems leading to the need for flushing and requalification. Therefore, the cleanliness and retentive ability of a membrane is the most important factor when choosing a proper filter.[1]

In this study, we present a novel development: the ultraclean UPE sub-1 nm membrane designed for critical aqueous solutions. In prioritizing safety and ease of inline shedding experiments, we selected 200 ppm $NH_4OH_{(aq)}$, closely mimicking FIRM (finishing-up by improved rinse materials) application conditions. This study employs static soaking tests to evaluate filter cleanliness, providing insights into contamination levels through continuous soaking. Additionally, shedding performance and retentive ability are assessed using a dynamic mechanical analyzer (DMA), capable of inspecting proprietary 2 nm particles.

EXPERIMENT

Filter Cleanliness Determination by Continuous Soaking

The determination of metal extractables was evaluated by soaking 10-inch filter cartridges continuously in 200 ppm $NH_4OH_{(aq)}$. The cartridge was put into a 2-liter jar and then soaked in 200 ppm $NH_4OH_{(aq)}$ at room temperature. After 24 hours, the extraction solution was collected and replaced by new 200 ppm $NH_4OH_{(aq)}$. After the next 24 hours at the same condition, the extracted solution was collected again for metrology analysis. The extracted liquid was analyzed by inductive coupled plasma equipped with mass spectrometer (ICP-MS) to qualify and quantify metal extractables (Figure 1).

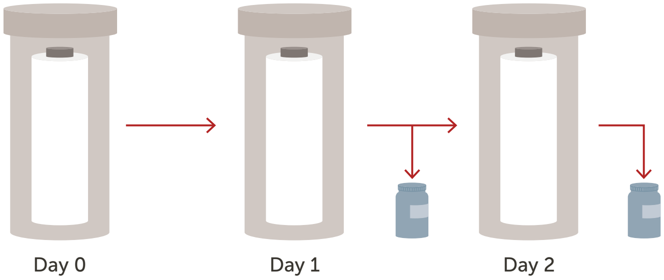

Figure 1. New 10-inch filter cartridges soaked in 200 ppm NH4OH(aq) for two continuous days.

Particle Shedding Performance and Retention by Inline DMA

A 10-inch prewet cartridge was installed in a flush stand with 200 ppm $NH_4OH_{(aq)}$ and connected with an inline DMA from the outlet of the filter, as shown in Figure 2. Real-time inline particle shedding data was collected by a DMA. To eliminate bubbles in the matrix, we installed a debubbler before the inlet of the filter to prevent bubbles in the testing system.

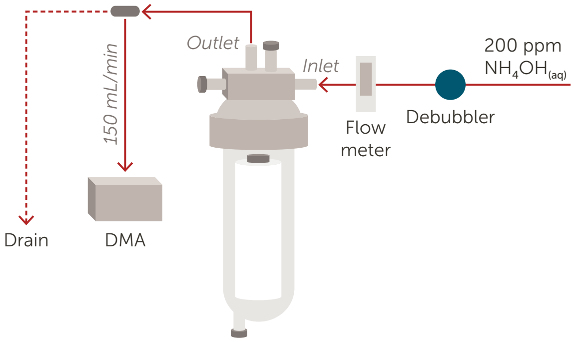

Figure 2. Connection of a 10-inch prewet cartridge into a DMA to observe shedding performance.

RESULTS

Extractables Determination

Figure 3 demonstrates metal extractables from ultraclean UPE sub-1 nm and UPE 5 nm filters after soaking in 200 ppm $NH_4OH_{(aq)}$ continuously for two days. The results showed that metal extractables released from the UPE 5 nm filter were higher than the ultraclean UPE sub-1 nm filter, even on the second day.

Normalized Metal Amount of a 10" Cartridge Soaked in 200 ppm $NH_4OH_{(aq)}$

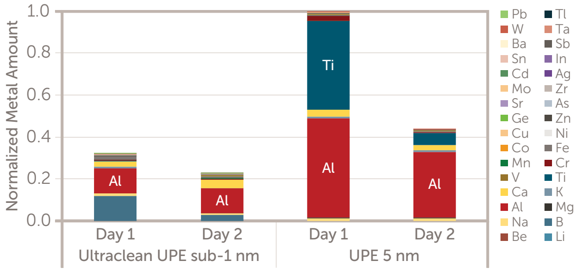

Figure 3. Normalized metal amount of a 10-inch cartridge soaked in 200 ppm NH4OH(aq).

Particle Shedding Performance and Retention by Inline DMA

Figure 4 demonstrates the particle shedding performance of ultraclean UPE sub-1 nm and UPE 5 nm filters by an inline DMA. The results showed that the ultraclean UPE sub-1 nm has a faster flush-up performance than the UPE 5 nm filter at the initial stage. After flushing 1.5 L, the ultraclean UPE sub-1 nm filter showed a lower baseline than the UPE 5 nm filter. Therefore, the ultraclean UPE sub-1 nm has better retention in the base aqueous solution.

Normalized 200 ppm $NH_4OH_{(aq)}$ Inline DMA Shedding and Retention

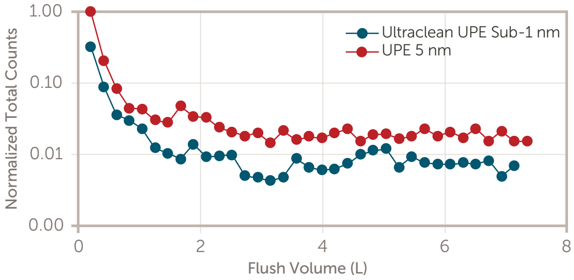

Figure 4. Normalized total counts of the ultraclean UPE sub-1 nm and UPE 5 nm filters by inline DMA.

CONCLUSION

The introduction of the ultraclean UPE sub-1 nm membrane represents a significant advancement in semiconductor liquid filtration technology. Our comprehensive study demonstrates its effectiveness in maintaining cleanliness, shedding performance, and retentive ability under challenging conditions relevant to semiconductor applications. This novel membrane holds great promise for improving the efficiency and reliability of semiconductor manufacturing processes.

Acknowledgements

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References

[1] Gregg C., et al., Benefits of UPE Filtration in BEOL Applications, Entegris Newsletter Article, Microcontamination Control (2023).

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