Next-Generation Ultraclean Nylon Filter for On-Wafer Defects Reduction Enhancement

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INTRODUCTION

Over the past few decades, typical chemistries used in the semiconductor industry have been developed to successfully deal with the demands for various lithography techniques. The composition of the chemistries sometimes includes organic solvents with a strong extraction capability, such as ethyl lactate or hydrochloric acid.[1] The unique characteristics of lithography chemistries result in high metal and organic extractables from media such as filters, tubing, fittings, etc., when they come into contact with these chemistries. It is widely known in the industry that lithography chemistries containing metal and organic extractables may cause defects on wafers. Therefore, the cleanliness of media is crucial. Chip patterns on the order of nanometers can be critically damaged with only traces of defect sources.[2]

In this study, we conducted a cleanliness evaluation of the newly developed next-generation ultraclean nylon filter in various organic and acidic solvents recently used in EUV and ArF photoresist, SiARC, and BARC applications. The cleanliness of the next-generation ultraclean nylon filter reported in this paper has reduced metal and organic extractables when compared to the standard nylon. Moreover, results of cleanliness in raw material also show that the next-generation ultraclean nylon is comprised of fewer metals than the standard nylon membrane, thus ensuring that there will be fewer metal extractables.

EXPERIMENT

Extractables Determination

The determination of metal and organic extractables was evaluated by soaking 10-inch filter cartridges for one day in EL (ethyl lactate), the mixture of EL and PGMEA (propylene glycol 1-monomethyl ether 2-acetate) in the ratio of EL/PGMEA: 7/3, and PGME (1-methoxy-2-propanol) with 0.01% HCl. The extracted liquid was analyzed by inductive coupled plasma equipped with mass spectrometer (ICP-MS) to qualify and quantify metal extractables. For the organic extractables, the amount of non-volatile residue (NVR) was used as an index for the determination.

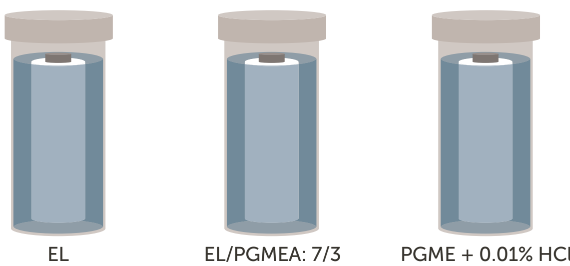

Figure 1. Dry 10-inch filter cartridges soaked in solvents for one day.

Cleanliness of Raw Materials

The cleanliness of raw materials was considered in terms of the presence of metals in the membranes. The ashing technique was applied for the metal analysis. Membranes were cut out from a dry Optimizer® D filter device into coupons weighing approximately 0.2 grams, put into platinum crucible, and then burnt to ashes at a high temperature inside a furnace. Then, the ashes of the membranes were dissolved in a strong acid solution of 60 mL before a metal analysis by ICP-MS.

On-Wafer Particle Evaluation

Standard nylon and next-generation nylon filters were evaluated in the field by monitoring the amount of on-wafer particle (size >19 nm) with respect to the number of flushing times.

RESULTS

Extractables Determination (Metals)

The results showed that metal extractables released from the next-generation ultraclean nylon were approximately ⅕ of the metal extractables released from a standard nylon when the soaking liquids were organic solvents (EL, EL/PGMEA: 7/3) and were approximately ⅒ when the soaking solvent was acidic (PGME + 0.01% HCl) (Figures 2, 3, and 4).

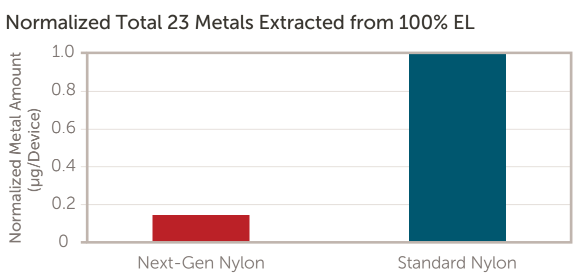

Figure 2. Metal extractables from the next-generation ultraclean nylon (left bar) and standard nylon (right bar) when the soaking solvent was EL (ethyl lactate) after one day.

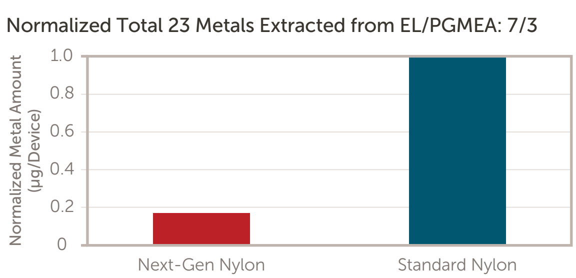

Figure 3. Metal extractables from the next-generation ultraclean nylon (left bar) and standard nylon (right bar) when the soaking solvent was EL/PGMEA: 7/3 after one day.

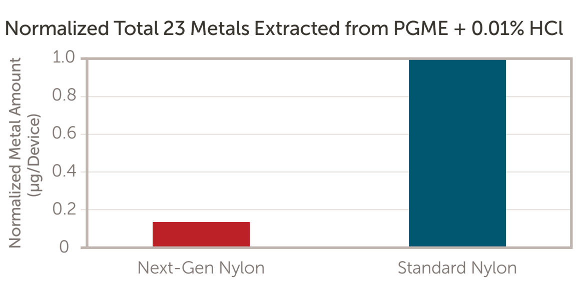

Figure 4. Metal extractables from the next-generation ultraclean nylon (left bar) and standard nylon (right bar) when the soaking solvent was PGME + 0.01% HCl after one day.

Extractables Determination (NVR)

The results showed that non-volatile residue released from the next-generation ultraclean nylon was approximately ⅒ of the non-volatile residue released from a standard nylon when the soaking solvent was 100% EL and approximately ⅕ when the soaking solvent was EL/PGMEA: 7/3 (Figures 5 and 6).

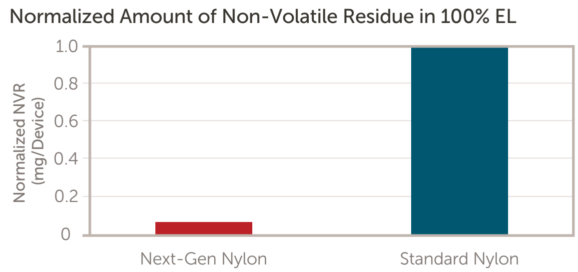

Figure 5. Non-volatile residue from the next-generation ultraclean nylon (left bar) and standard nylon (right bar) when the soaking solvent is EL after one day.

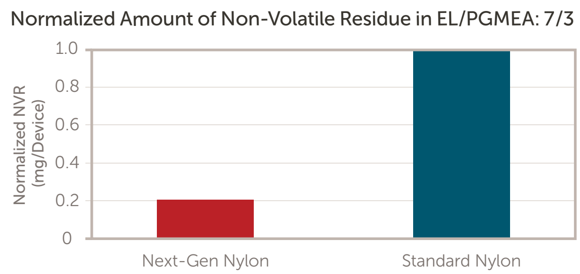

Figure 6. Non-volatile residue from the next-generation ultraclean nylon (left bar) and standard nylon (right bar) when the soaking solvent is EL/PGMEA: 7/3 after one day.

Cleanliness of Raw Materials

The results showed that metals in raw material of next-generation ultraclean nylon were approximately ⅒ of metals in raw materials of standard nylon.

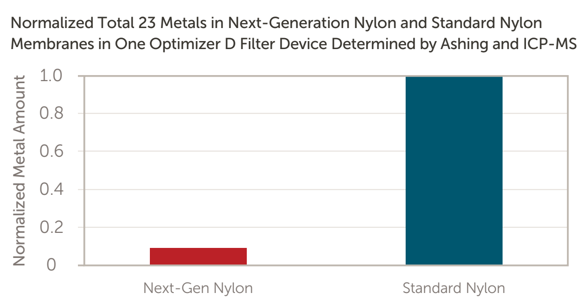

Figure 7. Metals in raw materials of the next-generation ultraclean nylon (left bar) and standard nylon (right bar).

On-Wafer Particle Evaluation

The comparison showed that the next-generation ultraclean nylon gives faster flush-up time to reach baseline when compared to standard nylon.

Comparison of the On-Wafer Particles (Size >19 nm) between Standard Nylon and Next-Generation Nylon During Flushing Period

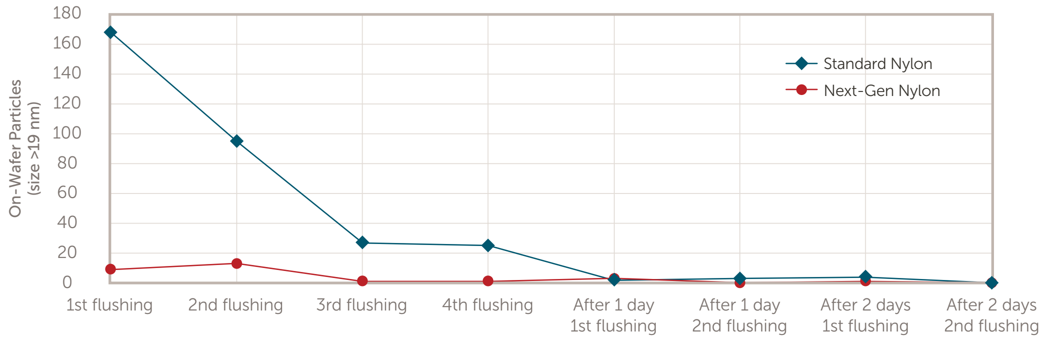

Figure 8. Amount of on-wafer particles of a standard nylon (blue line) and the next-generation nylon (red line).

CONCLUSION

Innovations in membrane technology and cleaning technology developed by Entegris have proved that the newly developed next-generation ultraclean nylon is vastly superior to standard nylon in terms of cleanliness. Results achieved in this study will enable confidence from lithography chemistries manufacturers and semiconductor device manufacturers to use the filters with less concern about potential defect sources which may come from extractables of filter media. This significant improvement is expected to enhance productivity and defect reduction in advanced lithography processes.

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References

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[2] Kohyama, T., et al., The Intrinsic Role of Membrane Morphology to Reduce Defectivity in Advanced Photochemicals, Entegris Applications Note, Microcontamination Control (2018).

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