A New Tailored Point-of-use Filter to Reduce Immersion Lithography Downtime and Defects

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KEY TAKEAWAYS

- It is a challenge to increase retention using size-exclusion mechanisms while being able to maintain appropriate flow rates
- Entegris Oktolex™ membranes utilize membrane functionalization technology to deliver enhanced removal efficiency via both sieving (size-exclusion) and non-sieving (adsorption) retention mechanisms

ABSTRACT

To address the demand for new chemistry compatibility, reduced defectivity, and increased productivity in advanced lithography processes, Entegris has tailored a membrane as part of its Oktolex family of technologies. The new membrane is cleaner, more retentive, and has an enhanced non-sieving particle capture capability when compared to a standard nylon membrane. In an evaluation of the newly developed membrane using 45 nm line/space patterning, the new membrane significantly outperformed both UPE and nylon filters in microbridging defectivity. In addition, the new membrane also achieved baseline significantly faster than the other filters.

INTRODUCTION

In previous POU filter generations, the ability to remove small particles from a fluid stream using size exclusion was the primary method for protection against contamination. As the contaminants of interest have decreased in size, membrane manufacturers have been challenged to increase retention using size-exclusion mechanisms, while also being able to maintain flow rates that keep up with modern track designs and productivity.

To enhance retention without sacrificing flow rate, one must understand the intermolecular forces that are determined by the base membrane or its modification. UPE is a polymer which, as manufactured, only has short-range dispersion forces that can be used to capture contaminants. On the other hand, nylon has both long- and short-range intermolecular forces that act as strong adsorbents of contaminants. These strong intermolecular forces are very useful to capture different types of contaminants, but have also been shown to negatively impact some photochemical performance.

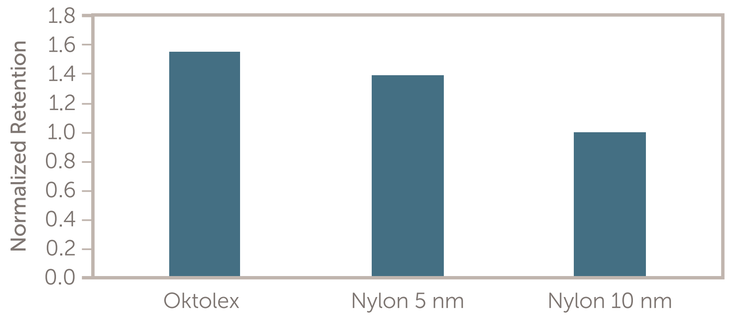
	Oktolex	Nylon
Membrane materials	UPE	Polyamide
Metal removal capability	+	+
Size exclusion performance	++	+
For use with immersion top coats	+	–
For use with acidic under-layer materials	+	–

Relative comparisons: ++ Excellent; + Good; – Poor

Membrane modification can therefore be used to maximize flow rate, size-exclusion contaminant retention, and intermolecular forces. For example, a membrane like UPE can be enhanced to have electrostatic and dipole forces.

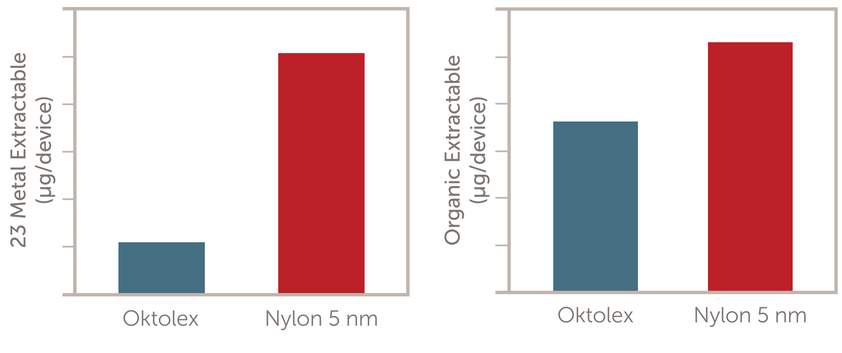
EXPERIMENT AND RESULTS

5 nm Gold Particle Retention



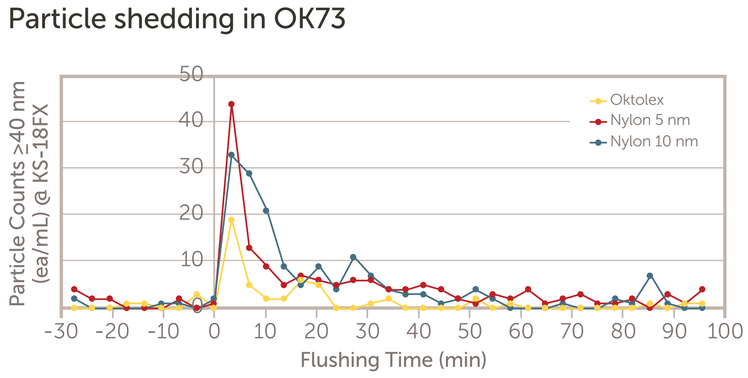
The Oktolex membrane has additional particle capture capabilities due to the membrane modification, making this membrane more retentive than either nylon membrane.

Total extractables in OK73 – metals and organics

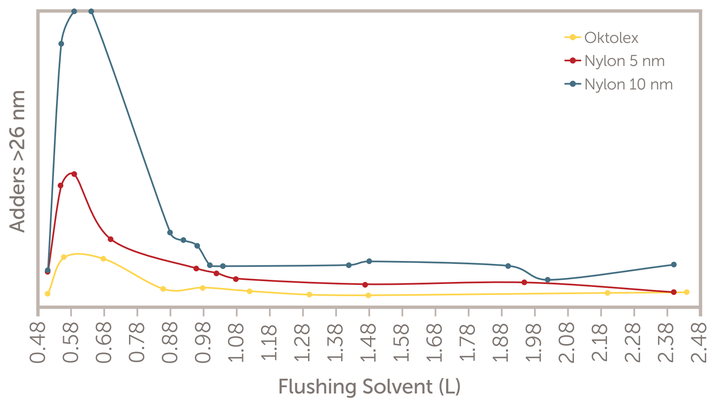


The Oktolex membrane showed lower extractables than the 5 nm nylon, suggesting that the nylon membrane released more undesirable contaminants into the solution, potentially leading to either long flush-up times to achieve baseline, or coating defects.

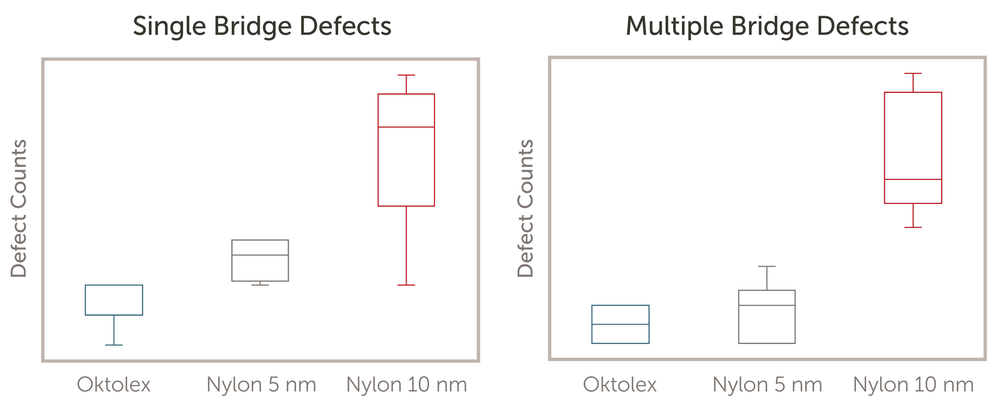
Particle shedding in OK73



The Oktolex filter not only had the lowest level of particle counts at start-up, but also reached baseline more quickly than the comparison nylon filters.



The Oktolex filter had a much lower number of 26 nm particles at startup, and reached baseline more quickly than the comparison point-of-use filters.



Further patterned defect studies on a 45 nm line, 100 nm pitch mask confirmed the performance of the Oktolex filter with significantly fewer single-bridge defects than the nylon filters.

CONCLUSIONS

Membrane functionalization is an innovative technology which allows enhanced retention performance without need of pore shrinking. In this work, we demonstrated the superior performance of a new tailored Oktolex membrane in cleanliness, filter start-up, and on-wafer defect reduction.