Bridging the Defect Gap in EUV Photoresist

Tetsu Kohyama, Fumiya Kaneko, Alketa Gjoka, Jad Jaber – Entegris, Inc.

KEY TAKEAWAYS

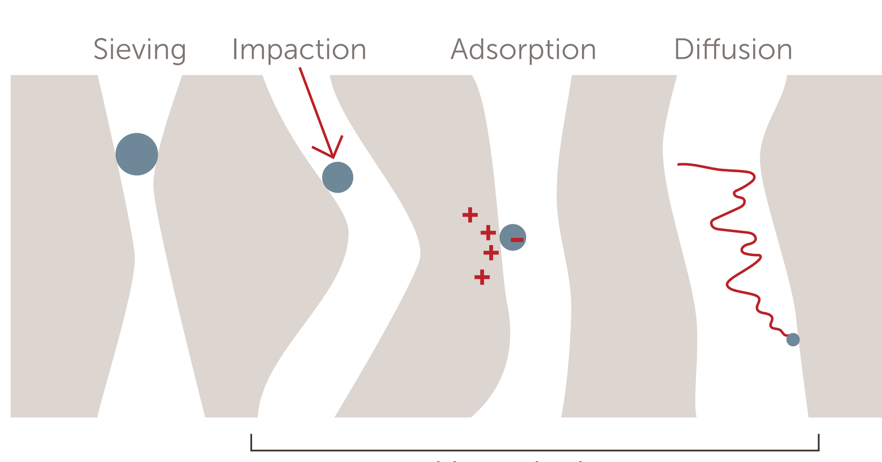
- Targeted phenol-rich polymers are related to microbridge defects in EUV photoresists
- Size exclusion alone is not effective to remove all contaminants; adsorptive forces are also important for polymer removal
- Entegris has assessed and developed membrane modifications that better target potential defect sources in EUV photoresists

ABSTRACT

Filtration technology is an important part of maintaining a material's purity. When choosing a filter, there are many factors to consider, starting with the membrane material. For instance, nylon filters effectively remove polar polymers through an adsorption mechanism. Particulate contaminants are often removed by size exclusion, most commonly observed with certain UPE (ultra-high molecular weight polyethylene) membranes. As lithography materials change and the smallest defects become even more challenging to detect, filtration technology innovation, such as the development of Oktolex™, is needed to meet the most stringent defect targets. In this paper, a tailored filter is introduced to enhance filtration performance and address specific defect sources in EUV photoresists. Results and possible mechanisms of the defect reduction will be discussed.

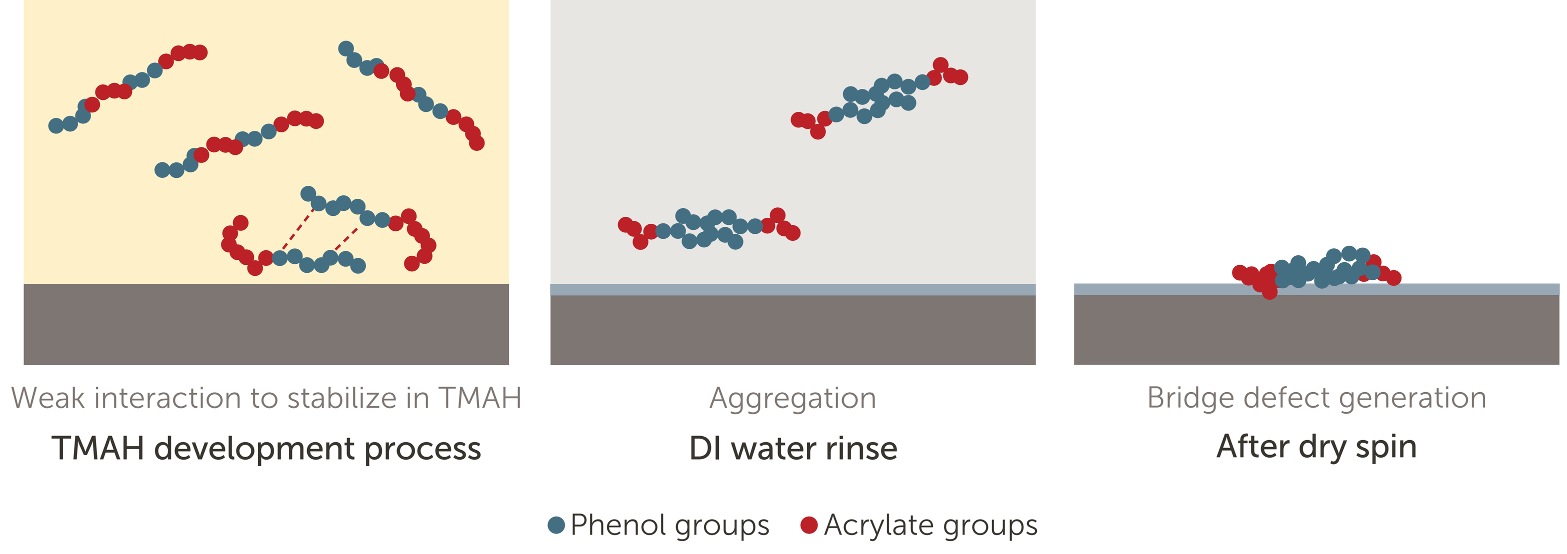
INTRODUCTION

There are many different membranes that make up the robust portfolio that addresses a wide range of photochemical filtration needs. These membranes are chosen to address different retention mechanisms for various contaminants.



Recent publications about EUV photochemicals indicate that these materials leverage acrylate and phenol block co-polymers as the chemical backbone of the material. Phenol groups play an important role in addressing stochastic issues in EUV lithography. Unfortunately, they have a negative impact on defectivity as they may be a source of microbridge defects. Because phenol moieties are less soluble than acrylates, these moieties can remain as agglomerates post-develop.

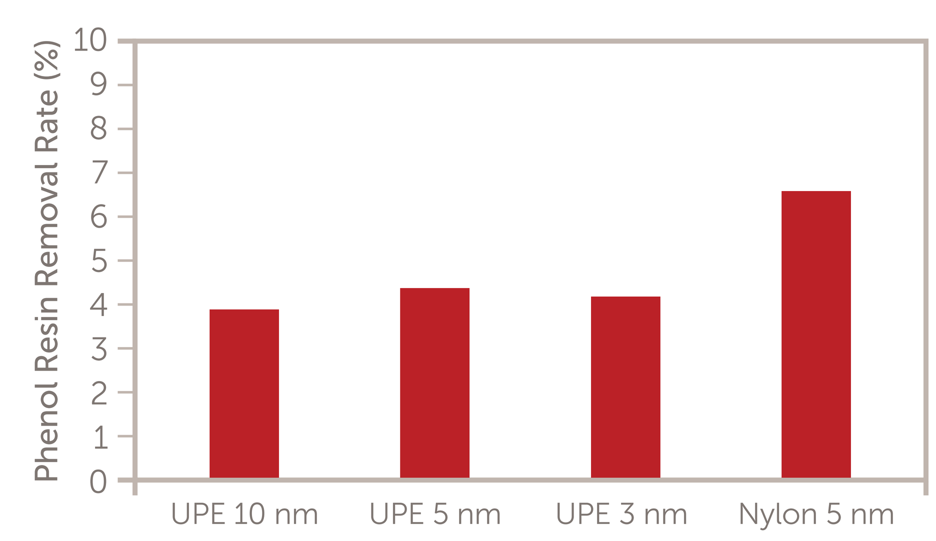
One hypothesis about the generation of bridge defects is that phenol-rich polymers, when agglomerated, may not be easily developed or rinsed away, leaving a bridge defect on the wafer surface.



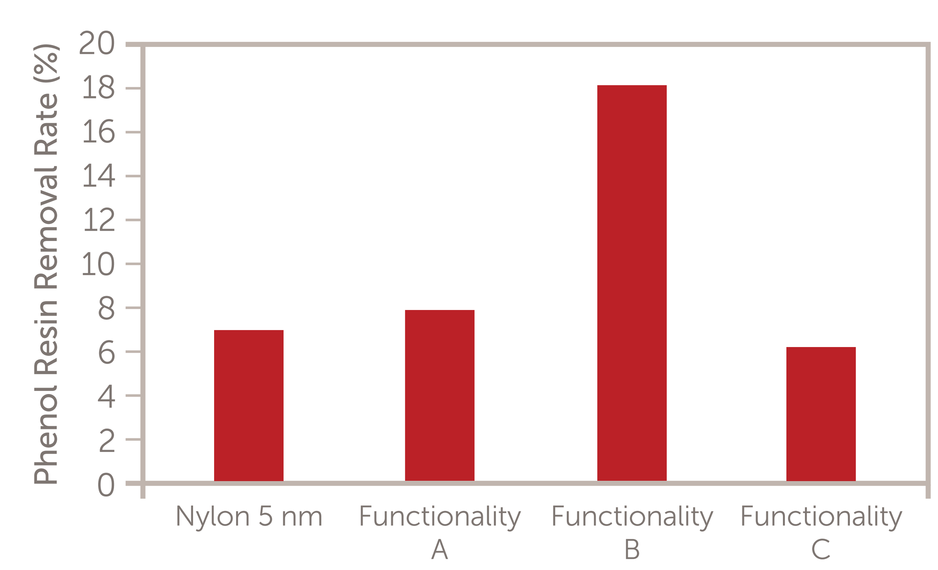
EXPERIMENT AND RESULTS

- A system of a pump, polymer solution, and membrane coupon was set up to recirculate the polymer solution through the membrane and test the phenol removal rate
- Size-exclusion membranes were chosen to study differences in the effectiveness of nominal pore size
- Membranes with adsorption properties were selected based on their polarity and Hansen parameter radius

Functionality	Normalized polarity	Normalized Hansen parameter radius
Nylon	1.0	1.0
A	0.9	2.1
B	1.2	0.5
C	2.2	3.8
Phenol	1.6	–



There is no significant difference between the results from UPE membranes with different pore sizes. The highest phenol removal level was from a nylon membrane.



While nylon naturally has very strong intermolecular forces with which it can capture contaminants, other modifications to UPE had an even stronger effect on removing phenols.

Functionality	Normalized polarity	Normalized Hansen parameter radius	Phenol removal rate (%)
Nylon	1.0	1.0	7.0
A	0.9	2.1	7.8
B	**1.2**	**0.5**	**18.1**
C	2.2	3.8	6.2
Phenol	1.6	–	–

Functionality A, B, and C are hydrophilic and have varied polarities and Hansen parameter radii. The result shows that Functionality B has the best performance to remove Phenol resin. The Hanson parameter radius of Functionality B is the shortest of all the membranes tested. A shorter radius equates to a higher affinity, resulting in a higher attraction to the phenol polymer.

CONCLUSIONS

- EUV resist materials are different than previous generations, and new filtration technologies are needed to address new sources of defects
- Deliberately designed filter membranes and surface modifications can target EUV-specific defect sources