PALL Microelectronics

Filter Selection for Optimized Photoresist Filtration

The photolithography process is complex and difficult with numerous challenges, including shrinking line widths, multi-layer resist chemistries, precision dispense pump choices, and decreasing defect tolerances. Understanding the effect filter characteristics will have on these and other process issues has become increasingly important. Selecting the optimal filter requires careful consideration of these challenges and awareness of the role filter performance plays in achieving process optimization.

Pall Corporation has been studying the effect of filtration on photolithography fluids for many years. Through experimentation and on-site evaluations, we have refined our recommendations to help lithography engineers make the optimal filtration decision.

Challenges in photolithography applications

Several aspects of a photolithography filter, when properly selected, can positively affect the photolithography process. These include:

- Chemical compatibility and cleanliness
- Wettability and filter start-up
- Differential pressure
- Hard and soft (gel) particle removal (Defect reduction)

Chemical compatibility and cleanliness

Filters used in the lithography process are not usually purged for long periods of time due to the high cost of the photochemical. Furthermore, the small volume pumps used to dispense photoresist accurately and repeatably are not typically optimized for long purge cycles. Filters designed for these high value fluids, should not release particles, organic material or metals into the process stream.

Wettability and fast start-up

The critical wetting surface tension (CWST) of the filter membrane determines how readily liquid flows through it. A membrane having poor wettability can impede air displacement resulting in microbubble formation and longer purge times.

Differential pressure

Utilizing a filter having a low pressure drop is important for the photolithography process. It allows for lower operating pressures, which improve soft (gel) particle retention, and reduces the likelihood of microbubble generation in the photoresist fluid.

Hard and soft (gel) particle removal (defect reduction)

Complex photoresist chemistries are designed to be extremely sensitive to temperature and ultraviolet radiation, and as a consequence are inherently unstable. This instability can result in the formation of particles as the resist ages. In addition to particles, undissolved polymer can also cause defects in the photoresist films. Selecting the proper filter can essentially remove or minimize these contaminants without altering the sophisticated chemistry of the resist.

*Filtration. Separation. Solution.*SM

Benefits of using cast membrane technology

Chemical compatibility and cleanliness

There are many different types of membranes available for the filtration of photoresist. PTFE membranes are known for their excellent chemical compatibility and minimal contribution of extractables to process fluids. However, a major drawback is the membrane's hydrophobicity, requiring pre-wetting for use with aqueous chemicals. Both nylon 6,6 and high density polyethylene (HDPE) membranes are fully compatible with the typical liquids employed in lithography, are extremely clean with respect to extractables and, most importantly, offer improved wettability.

Superior wettability and faster start-up

Native nylon 6,6 membrane is naturally hydrophilic, meaning it is not modified in any way to achieve a hydrophilic surface. With a critical wetting surface tension of 77 dynes/cm, nylon 6,6 membrane does not need to be pre-wet, surpassing other lithography membrane material choices.

HDPE membranes also have better wettability than PTFE but lower than nylon 6,6, spontaneously wetting with liquids with a surface tension of less than 36 dynes/cm.

HDPE membrane may be recommended for chemistries with a low pH or containing unprotected acid groups.

Low differential pressure

In the photolithography process, it is very important to minimize microbubble formation and maximize soft (gel) particle retention. This can best be achieved by using a filter with a low pressure drop such as Pall's asymmetric, cast membrane.

Superior Defect Reduction

Slightly soluble polymer gel precursors have been identified as the cause of microbridge defects in 193 nm resist. These materials may originate as degradation or by-products of the various polymers used in the resist formulation. These gel components typically exist as polar molecules. These polar gels will readily adsorb onto the structure of the nylon 6,6 membrane, greatly reducing bridge defects on the patterned wafer[1]. Nylon 6,6 membranes have also demonstrated the ability to reduce cone defects in bottom anti-reflective coating (BARC) chemistries. Future application bulletins will focus on identifying the cause of cone defect formation and identifying how to remove or reduce them.

[1] Defect Reduction by using Point-of-use Filtration in a New Coater/Developer SPIE Advanced Lithography 2009 7273-54

<table>
<tr><td></td><td>ArF</td><td colspan="6"></td></tr>
<tr><td></td><td colspan="7">KrF</td></tr>
<tr><td></td><td colspan="7">I-line</td></tr>
<tr><th>Filter Grade</th><th>~10 cP</th><th>10 ~ 20 cP</th><th>20 ~ 30 cP</th><th>40 cP</th><th>60 cP</th><th>80 cP</th><th>100 cP</th></tr>
<tr><td>AN01 (Asymmetric P-Nylon 10 nm)</td><td colspan="2">PHD12</td><td colspan="2">PHD22</td><td colspan="3"></td></tr>
<tr><td>ANM (Asymmetric P-Nylon 20 nm)</td><td>PHD11</td><td colspan="2">PHD12</td><td colspan="4">PHD22</td></tr>
<tr><td>AND (Asymmetric P-Nylon 40 nm)</td><td colspan="3">PHD11</td><td colspan="2">PHD12</td><td colspan="2">PHD22</td></tr>
<tr><td>UG001 (HDPE 10 nm)</td><td colspan="2">PHD11</td><td colspan="2">PHD12</td><td colspan="3">PHD22</td></tr>
<tr><td>UG003 (HDPE 30 nm)</td><td colspan="2">PHD11</td><td colspan="2">PHD12</td><td colspan="3">PHD22</td></tr>
<tr><td>UG005 (HDPE 50 nm)</td><td colspan="3">PHD11</td><td colspan="2">PHD12</td><td colspan="2">PHD22</td></tr>
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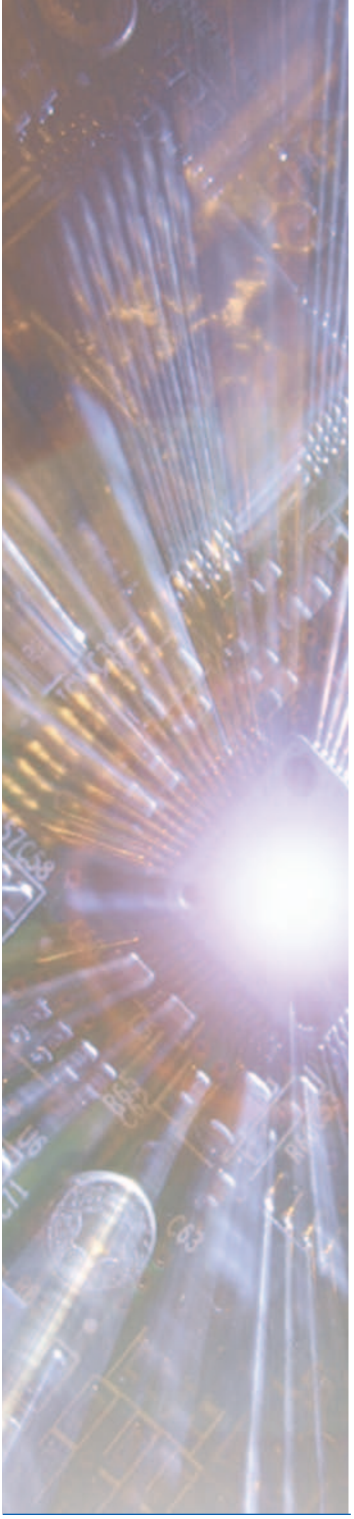
Filter Recommendations for Photoresist Point-of-Use, based on Fluid Viscosity (given in centipoise)



Pall recommends the Asymmetric P-Nylon filter for photoresist filtration

Pall's Asymmetric P-Nylon filter, consisting of an asymmetric nylon 6,6 membrane, has proven benefits in 193 nm lithography. Filters built around asymmetric nylon 6,6 membranes are offered in a wide variety of assembly configurations, suitable for all lithography applications. Asymmetric P-Nylon filters are available with removal ratings ranging from 0.15 µm down to 10 nm. The table on the previous page lists Pall product recommendations, as a function of resist viscosity.

This guideline assumes a typical lithography flow rate of approximately 1 ml / sec. For higher flow rates contact Pall Microelectronics.

Pall Corporation

Microelectronics

25 Harbor Park Drive
Port Washington, NY 11050
+1 516 484 3600 telephone
+1 800 360 7255 toll free US

Portsmouth - UK
+44 (0)23 9230 3303 telephone
+44 (0)23 9230 2507 fax
processuk@pall.com

Visit us on the Web at www.pall.com/micro

Pall Corporation has offices and plants throughout the world. For Pall representatives in your area, please go to www.pall.com/contact

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