

Research of appropriate filter membrane for reducing defects of ArF lithography.

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ABSTRACT

We varied aging term of ArF photoresist from 0 to 24 weeks as well as membrane material of Point-of Use filtration to find appropriate membrane for reducing bridging defects, then found that bridge defect count on ArF photoresist pattern did not increase if Point-of-use filtration was utilized even though the photoresist had been aged for 24 weeks, also found that the most appropriate filter material to reduce bridging defect was Nylon 6,6 and the mechanism thought to be responsible was its hydrophilicity. Additionally, we confirmed that newly developed 0.02 μ m rated nylon 6,6 asymmetric pore membrane is capable in photoresist spin-coat process without any sacrifices of lithographic performance.

1. INTRODUCTION

As microlithography patterning continues in size reduction, defects in the thin films become more apparent. Bridging defect in resist patterns is one of the defectivity problems that has appeared in 248nm lithography. Particularly in 193nm lithography, this defect has been getting more serious due to the continuous CD reduction. To reduce these bridging defects, implementation of improved micro-filtration in both the photoresist manufacturing process and in the Point-Of-Use spin-coating process at the coater-developer has been shown to be effective. [1]

However, development of finer and finer

filter membranes seems to be reaching a limitation due to smaller pore size, in other words, the finer the pore size, the higher the differential pressure, and this causes problems such as pump overloading. Alternative filter designs are required to keep up with the rapid progress of micro lithography. Pall Corporation has developed two alternative design solutions to deal with the above problems.

One is utilizing the adsorptive effect of the membrane surface with defect precursors in lieu of utilizing a smaller pore size. Nylon 6,6 is thought to be one of those filter materials because it has hydrophilic amide bond in its formula while conventional High Density Poly Ethylene (HDPE) or Poly Tetra Fluoro Ethylene (PTFE) has no such polar group. (Figure 1)

The other one is utilizing an asymmetric pore construction of the filter membrane to reduce differential pressure of the membrane. Figure 2 is a Scanning Electron Microscopy (SEM) image of Pall asymmetric nylon 6,6 membrane which shows coarse to fine pore size change from upstream side to downstream side and Figure 3 is a flow rate improvement data of asymmetric construction compared with isotropic construction.

FUJIFILM ELECTRONIC MATERIALS CO., LTD. and Nihon Pall Ltd. have been working together to explore the appropriate filter membrane using the above methods to reduce bridging defects in ArF lithography and report the obtained results in this paper.

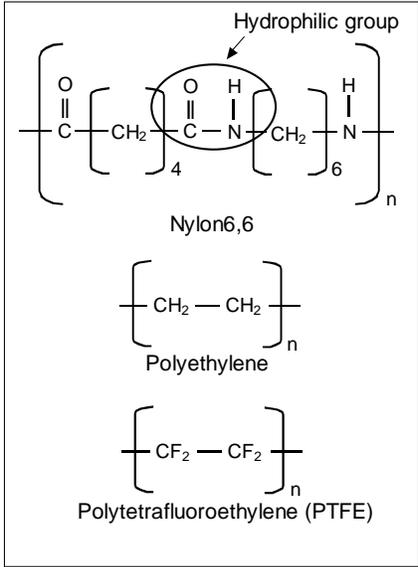


Figure 1 Chemical formula of filter membrane materials

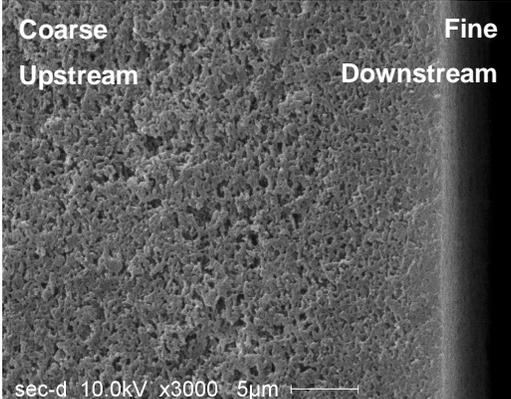


Figure 2 SEM image of the cross section of the asymmetric nylon6,6 membrane.

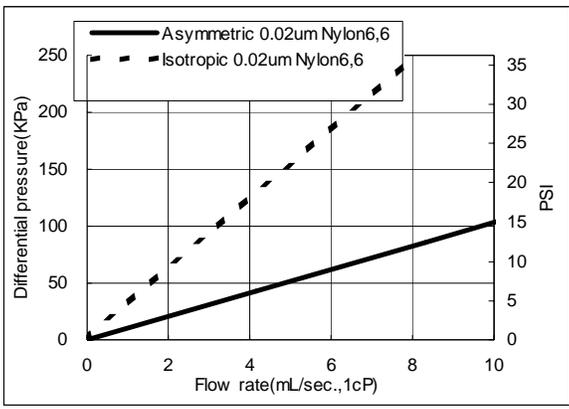


Figure 3 Flow - differential pressure of the asymmetric nylon6,6 filter and the isotropic nylon6,6 filter

2. TEST METHODS

2.1 Confirming the filtration effect for intentionally produced bridging defect by aging the resist.

In order to increase bridging defectivity, ArF photoresist was filtered by a 0.1 μ m rated filter (this is coarser than is standard for ArF lithography). Then the photoresist was aged at room temperature for 0, 4, 8, 10, 16 and 24 weeks. (Figure 4) The test process from BARC coating through pattern inspection is described in Table 1. Photoresist was patterned in 110nm line and space on 8 inch Si wafer using coater-developer varying the Point-Of-Use filter membrane. (Figure 5) The tested filter membranes were HDPE 0.05 μ m, Nylon 6,6 0.04 μ m, Nylon 6,6 0.02 μ m asymmetric pore structure and a Dummy capsule (capsule without filter membrane). (Table 2) Then, inspection and analysis of defects using High Resolution Imaging Inspection System and SEM on the patterned wafers was performed. Bridging defects which bridge only between 1 line to line were categorized as “Micro bridge”

and those more than two spaces were categorized as “Large bridge”. (Figure 6)

2.2 Research of appropriate filter membrane for intentionally produced bridging defect.

ArF photoresist was prepared in the same way as described above except for the aging time, which was not varied and only aged for 4 weeks. ArF photoresist was patterned by spin coating the ArF photoresist while varying the Point-Of-Use filter membrane including HDPE, Nylon 6,6 and Poly Tetra Fluoro Ethylene (PTFE) as well as a surface modified PTFE. (Table 3) Then, inspection and analysis of defects using High Resolution Imaging Inspection System and SEM on the pattern wafer was performed.

2.3 Adaptability of new nylon 6,6 asymmetric pore media to spin-coat system.

Newly developed 0.02 μ m rated nylon 6,6 asymmetric pore membrane was also tested in trials as described above.

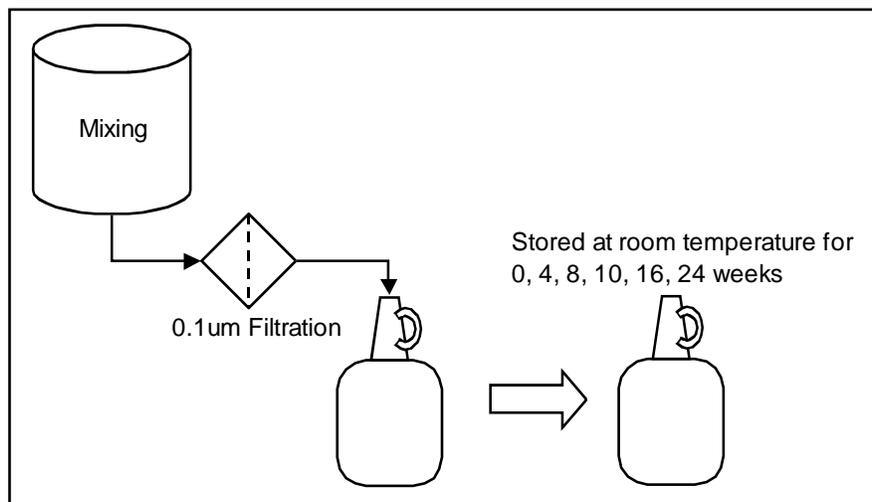


Figure 4 Photoresist preparation for increasing defectivity

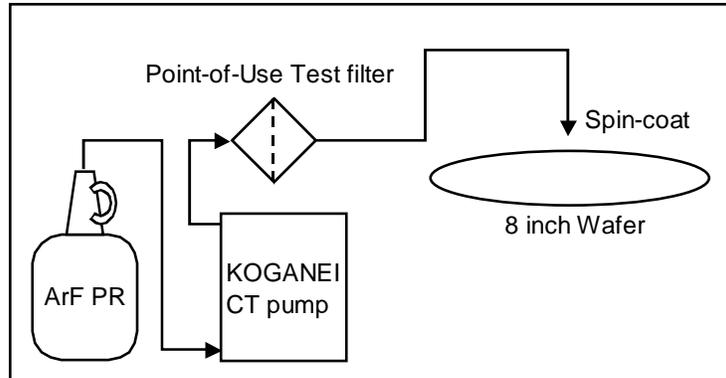


Figure 5 Set up of each components in spin-coat system.

Table 1 Test process

Process	Equipment
Organic BARC	TEL ACT8/ HDPE filter
ArF PR	TEL ACT8/ Filter testing
Exposure	ASML PAS 5500/1100
Develop	TEL ACT8
Inspection	KT 2360
SEM	HHT S-8840

Table 2 Test filters for confirming the filtration effect for intentionally produced bridging defect by aging the resist

No.	Media material	Removal rating /micron	Pore structure	Part number
1	High density polyethylene (HDPE)	0.05	Isotropic	PHD11UG005EH11
2	Nylon 6,6	0.04	Isotropic	PHD11UNDEH11
3	Nylon 6,6	0.02	Asymmetric	PHD11ANMEH11
4		Dummy capsule		PHDC11HC

3. RESULTS AND DISCUSSIONS

3.1 Confirming the filtration effect for intentionally produced bridging defect by aging the resist.

The results were shown in Figure 7 and Figure 8. As a result, in both micro bridge and large bridge, many these defects were observed when the dummy capsule was used, i.e., no Point-Of-Use filtration. Coarse filtration before aging, aging, and room temperature conditions were believed to increase these defects. There seemed tendency that the number of micro bridge varies time to time while the number of large bridge is rather even as well. It was also clear that these defects were reduced by Point-of-use filtration, especially by Nylon 6,6 0.02 m asymmetric membrane.

3.2 Research of appropriate filter membrane for intentionally produced bridging defect.

The results in Figure 9 and Figure 10 showed the trend that filters constructed

with Nylon 6,6 and surface modified PTFE membranes had the lowest generation of bridging defects, followed by HDPE and PTFE membranes. Also observed was that membranes with hydrophilic surfaces generate lower defectivity. Based on these results, it can be said that utilizing the adsorptive effect in filtration can reduce bridging defects on ArF lithography.

3.3 Adaptability of new nylon 6,6 asymmetric pore media to spin-coat system.

The results in Figure 11 and Figure 12 showed that there seemed no difference between conventional HDPE 0.05 m membrane and new nylon 6,6 0.02 m asymmetric pore media in terms of photoresist thickness uniformity. Also, Figure 13 showed that Critical Dimension (CD) of these two membranes were almost the same value. These results conclude that there seemed to be no issues for standard operation in photo resist coating process.

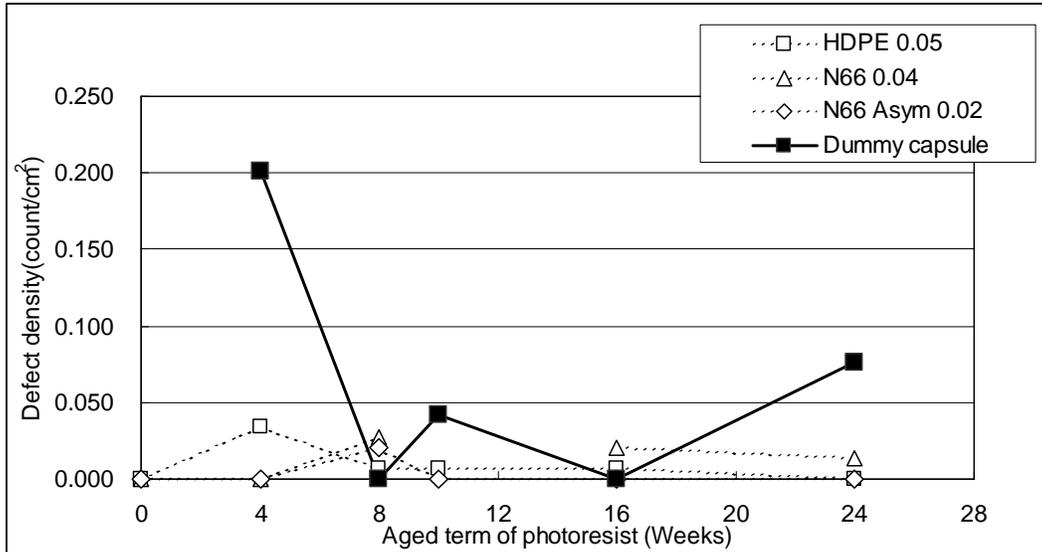


Figure 7 Micro bridge defect density on ArF photo resist pattern on 8 inch Si wafer versus preserved term of the ArF photo resist. Each point is average of 3 wafers. Intentionally, the ArF photo resist was preliminary filtered by 0.1um rated filter (coarser than standard process) then aged for 0,4,8,10,16 and 24weeks at room temperature in order to gain numbers of bridging defects.

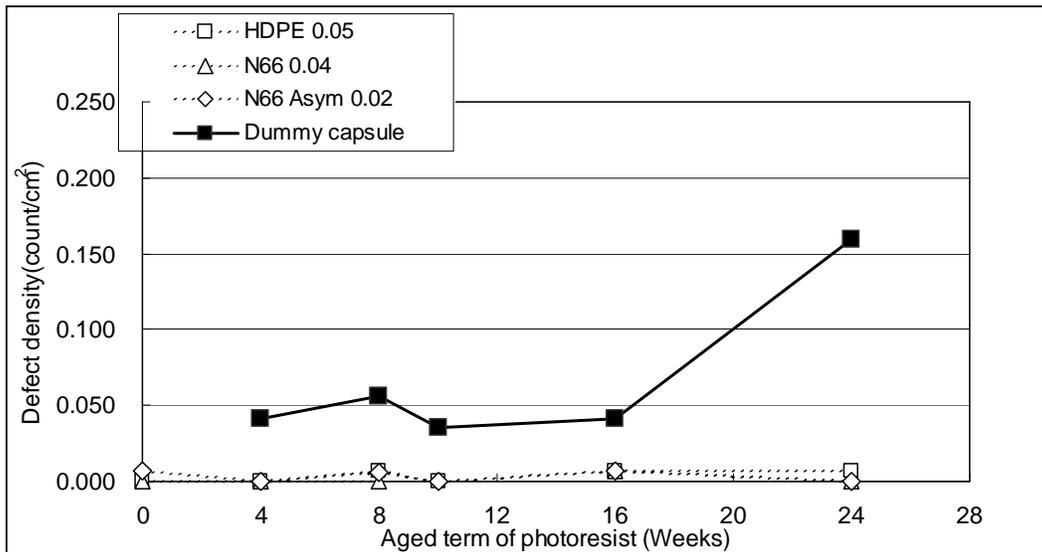


Figure 8 Large bridge defect density on ArF photo resist pattern on 8 inch Si wafer versus preserved term of the ArF photo resist. Each point is average of 3 wafers. Intentionally, the ArF photo resist was preliminary filtered by 0.1um rated filter (coarser than standard process) then aged for 0,4,8,10,16 and 24weeks at room temperature in order to gain numbers of bridging defects.

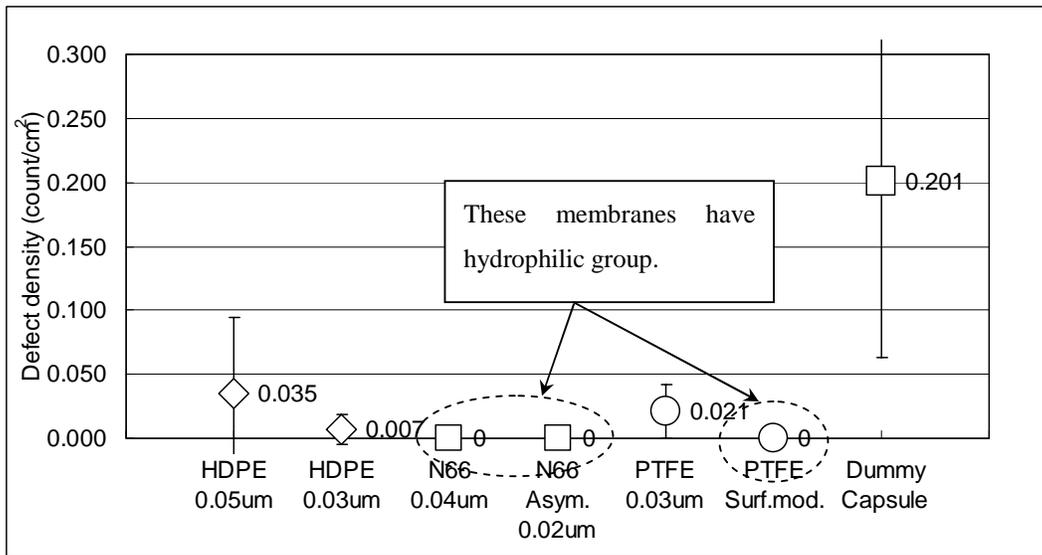


Figure 9 Micro bridge defect density on ArF photo resist pattern on 8inch Si wafer among various Point-of-use filter material. Points are averaged value in 3 wafers. Error bar is standard deviation. Intentionally, the ArF photo resist was preliminary filtered by 0.1 μ m rated (coarser than standard process) filter then aged for 4weeks at room temperature in order to gain numbers of bridging defects.

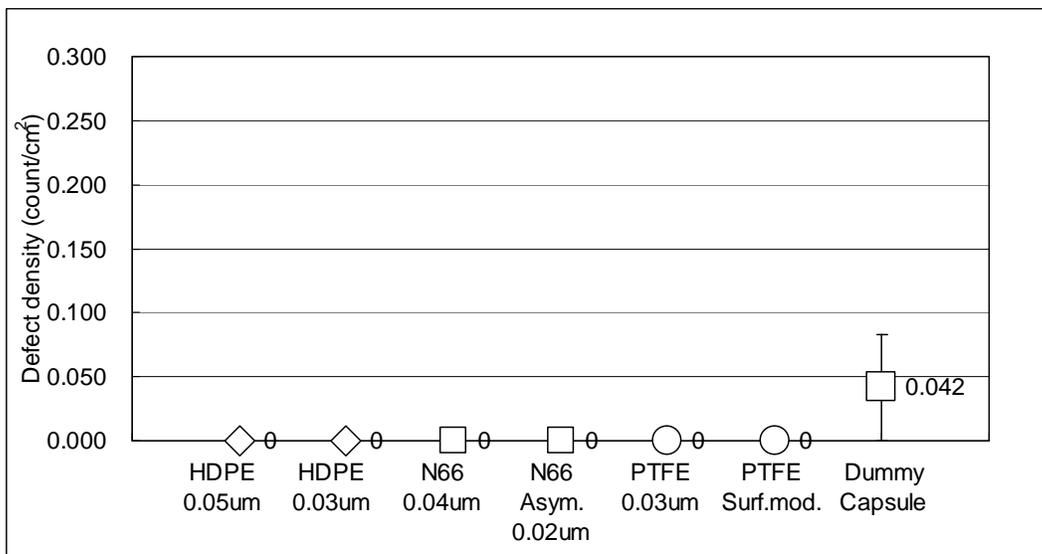


Figure 10 Large bridge defect density on ArF photo resist pattern on 8inch Si wafer among various Point-of-use filter material. Points are averaged value in 3 wafers. Error bar is standard deviation. Intentionally, the ArF photo resist was preliminary filtered by 0.1 μ m rated (coarser than standard process) filter then aged for 4weeks at room temperature in order to gain numbers of bridging defects.

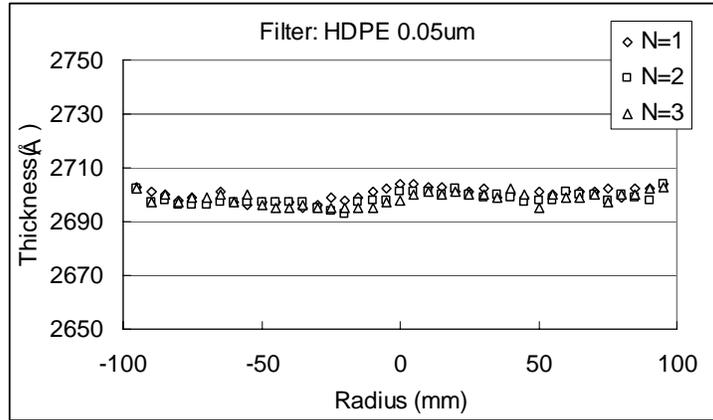


Figure 11 ArF photoresist thickness uniformity in using HDPE 0.05µm filter at Point-of-Use filtration in photoresist spin-coat system.

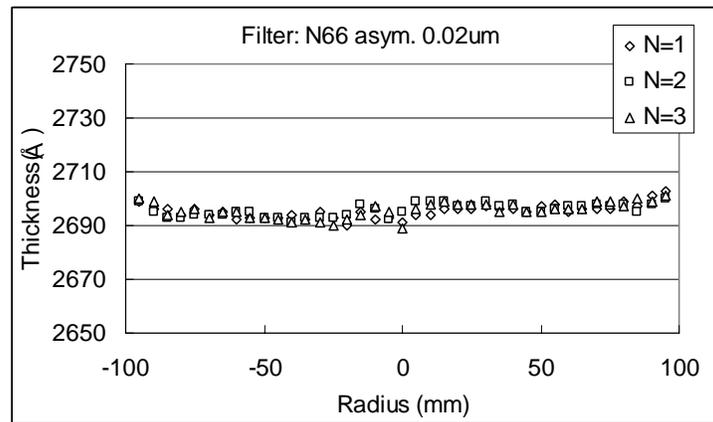
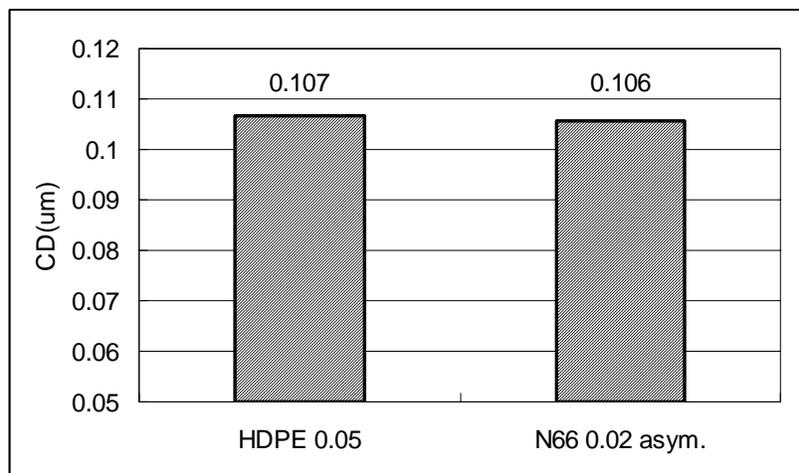


Figure 12 ArF photoresist thickness uniformity in using Nylon6,6 0.02µm asymmetric filter at Point-of-Use filtration in photoresist spin-coat system.



*Interface*²⁰⁰⁵ **Figure 13** CD comparison between conventional HDPE 0.05µm filter and Nylon6,6 0.02µm asymmetric filter used at Point-of-Use filtration in photoresist spin-coat system. ArF photoresist, 110nm line and space pattern.

4. CONCLUSION

It was found that bridge defect count on ArF photoresist pattern did not increase if Point-of-use filtration was utilized even though the photoresist had been aged for 24 weeks. Also, it was found that the most appropriate filter material to reduce bridging defect in ArF lithography was Nylon 6,6 and the mechanism thought to be responsible was its hydrophilicity. Additionally, it was confirmed that newly developed 0.02 m rated nylon 6,6 asymmetric pore membrane had an advantage of good flow rate capability as a 0.02 m rated filter in photoresist spin-coat process without any sacrifices of lithographic performance.

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REFERENCES

- [1] D. Hall, B. Gotlinsky, M. Mesawich, "The Effectiveness of sub 50nm Filtration on Reduced Defectivity in Advance Lithography Applications," ARCH Interface, Sept. 2003.