Study on Unusual Pattern Bridge and Its Mechanism

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We found unusual pattern bridge after patterning. We traced all possible sources not only materials used at photo mask step but also air borne contaminants. Finally, we found that wafers were contaminated from temperature control unit (TCU) for cooling lens. However, it is a question which one is directly related among motor oil and cooling gas used in TCU. Polyakylenglycol is the main component of TCU motor oil and chilling gas is 1,1,2-tetrafluoroethane (TFE). TFE can be changed into mist when it meets with H2O or other components in the air. They can have an effect on photosist pattern. Finally, we came to the conclusion that splashed motor oil is the origin of pattern bridging between the two. We solved this bridge issue by introducing acryl wall around TCU.

Keywords: Defect, Bridge, Lithography

1. Introduction
Defect is the most serious factor having an effect on device yield as feature sizes continuously shrink to sub-100nm. Engineers are fighting with unexpected defect generated in the fabrication of semiconductor everyday. There are hundreds of papers to deal with it [1-8]. Normal bridge in patterning is caused by materials such as photosist, TARC (Top Anti-reflective coating), and BARC (Bottom Anti-reflective Coating). Recently, most of them are immersion related ones. Undevelopable impurity inside photosist composition and dropped particle during a process can be the origin of bridged pattern. In addition to, basic components from substrate such as BARC components and SiON can create scum or bridge.

However our problem was quite unusual. Developed pattern was normal but bridged pattern was created after delay in the fabrication line (Fig. 1). We have never experienced this kind of defect. Here we will report several approaches to find the exact source of bridged pattern and their results.

2. Experimental
We gathered up motor oil from TCU and purchased Aldrich reagents, polyethylene glycol and polypropylene glycol. We used all commercial materials which are used in real fabrication line.

![Fig 1. SEM Image after delay](image)

All lithographic experiments were performed using a 193nm (0.85NA) and 248nm (0.85NA) ASML scanner interfaced with a TEL/Lithius track. Photoresists were successively coated on the Si substrate to the appropriate thickness from the simulated reflectivity curve. We used KLA-2800 for detecting defect level on the wafer. The pattern inspection after development and etch were observed by Hitachi CD-SEM (S-9260), and FEG-TEM (TITAN 80-300). Particle and metal impurity were checked by particle counter (MLPC-0710) and ICP-Mass (Agilent7500cs).

3. Results and Discussion
3.1. Phenomenon analysis
Bridged patterns were generated when we left patterned wafer at specific manufacturing line alone and most of them contained metal impurities such as Ni and Ca inside bridged part from TEM analysis (Fig. 2).

First, we had a doubt the air bone contamination of factory. Therefore, we checked organic particles of fabrication line such as amine, ammonia, sulfate ion, organic components but everything was normal. Second, we planned to check on common-use material such as developer and thinner. Their composition was analyzed. There was no problem on them. Therefore we changed all filters of center control supply system and tracks but this was not effective. We barely found the source of bridging. Pattern bridging occurred at wafer nearby scanner TCU when we left normal patterned wafers at several place in fabrication line (Fig. 3, 4).

In our investigation, particle level around TCU was exceptionally high compared to other positions (≤ 20EA) (Fig. 5, Table 1). Particle counts dramatically increased nearby at the bottom of TCU where motor and coolant tank are placed. Organic components such as leaked cooling gas and motor oil of TCU are possible sources. 1,1,1,2-tetrafluoroethane (commercial name: R-134a) was used for cooling gas of TCU.

(a) No delay (b) after 4 hours

Fig. 3. Particle increase after delay around TCU

Fig. 4. Particles reviewed by CD SEM

Fig. 5. Particle checked points nearby TCU
ICP-Mass data showed relatively high metal concentration inside TCU (Fig. 6). Metal itself can’t solve photoresist.

We tried to find which one is the main factor of pattern bridging among motor oil and leaked coolant. We dropped several kinds of materials on photoresist patterns to watch the change of them (Table 2). There was no bridging in pattern when metals and dust around TCU dropped on patterned wafer. We ejected 1,1,1,2-tetrafluoroethane to globe box containing patterned wafer and left it for 1 hour but there was no change in pattern profile except dropped particle during experiment. On the other hand, 30% NH3 damaged pattern profile. It created leaning and swelling. We wanted to check the effect of mixture of airborne ammonia with leaked cooling gas. Mixture was prepared by bubbling of 1,1,1,2-tetrafluoroethane in 30% NH3 aqueous solution. This mixed solution damaged more to pattern profile than 30%NH3 aqueous solution. However, ammonia concentration of our fabrication line was very low (<1ppb). Therefore leaked coolant is very difficult to meet with highly concentrated ammonia. From this result, ammonia can’t be the origin of bridged pattern. MSDS (Material Safety Dada Sheet) of motor oil says its main component is polyalkylene glycol. Therefore we made 1w% solution of polyethylene glycol and dropped it on patterned wafer using the tip of 0.1ml radius needle. Polyethylene glycol was well mixed with photoresist and solved it as shown in Fig.7.

Table 2. Pattern bridging generation after dropping on patterned wafer

<table>
<thead>
<tr>
<th>Dropped Materials</th>
<th>Bridge Generation</th>
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<tbody>
<tr>
<td>Stainless</td>
<td>×</td>
</tr>
<tr>
<td>Ni</td>
<td>×</td>
</tr>
<tr>
<td>Dust around TCU</td>
<td>×</td>
</tr>
<tr>
<td>R134a (1,1,1,2-Tetrafluoroethane)</td>
<td>×</td>
</tr>
<tr>
<td>30% NH3 aqueous solution</td>
<td>O</td>
</tr>
<tr>
<td>Polyethylene glycol</td>
<td>O</td>
</tr>
<tr>
<td>Grease</td>
<td>O</td>
</tr>
<tr>
<td>Mixture (30%NH3 aqueous solution + 1,1,1,2-Tetrafluoroethane)</td>
<td>O</td>
</tr>
</tbody>
</table>

Fig. 7. Effects of several materials on pattern

a: R134a
b: 30% NH3 aqueous solution
c: Mixture of R134a and 30%NH3 aqueous solution
d: Stainless powder
e: Polyethylene glycol
f: Grease

5. Conclusion

From these results, we came to the conclusion that splashed motor oil is the origin of pattern
bridging. This defect completely disappeared after we built acryl fence around TCU to protect wafers.

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References