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Effect of slurries on the dishing of Shallow Trench Isolation structure during CMP process

Hoon Lee[1] and Dae-Soon Lim[2]

[1,2]*Department of Material Science and Engineering, Korea University,*
1, 5-ga, Anam-dong, Sungbuk-gu, Seoul 136-701, South Korea

Sang-Ick Lee[3]

[3]*Memory Research & Development Division, Hynix Semiconductor Inc.,*
San 136-1, Ami-ri, Bubal-eub, Ichon-si, Kyoungki-do, 467-701, South Korea

The uniformity of field oxide is critical to isolation property of device in STI, so the control of field oxide thickness in STI-CMP becomes enormously important. The loss of field oxide in shallow trench isolation comes mainly from dishing and erosion in STI-CMP. In this paper, the effect of slurries on the dishing was investigated with both blanket and patterned wafers were selected to measure the removal rate, selectivity and dishing amount. Dishing was a strong function of pattern spacing and types of slurries. Dishing was significantly decreased with decreasing pattern spacing for both slurries. Significantly lower dishing with ceria based slurry than with silica based slurry were achieved when narrow pattern spacing were used. Possible dishing mechanism with two different slurries were discussed based on the observed experimental results.

Keywords : Chemical mechanical polishing, CMP, STI, slurry, dishing mechanism, pH

1. INTRODUCTION

Shallow trench isolation (STI) is an enabling technology for the fabrication of advanced sub-0.25micron integrated devices [1,2]. Requirements for STI planarization are much more severe than those for inter-layer dielectrics (ILD) planarization [3]. Chemical-mechanical polishing (CMP) has been accepted in recent years as a critical step in mainstream IC fabrication technology [4-6], and has enabled the fabrication of multi-level interconnect up to five or six metal levels. However, for STI planarization, CMP is essential, but typically insufficient by itself in meeting all the requirements. As the devices scale down, trench filling becomes more difficult due to its high aspect ratio, thus the key issues are the optimized thickness control. In shallow isolation trench, the role of STI-CMP is to planarize wafer surface and remove oxide on nitride to make field oxide height uniform. The uniformity of field oxide is critical to isolation property of device in shallow trench isolation, so the control of field oxide thickness in STI-CMP becomes enormously important. The loss of field oxide in shallow trench isolation comes mainly from dishing and erosion in STI-CMP.[7~10]

In this study, dishing, particularly their impact as a function of field oxide width, and erosion have been investigated. Also, to prove mechanism of dishing during the STI-CMP, various experiments were carried out.

2. EXPERIMENTAL

Test condition is summarized in Table. 1. The blanket wafer with HDP-CVD oxide of 6700Å and silicon nitride of 1200 Å was polished in LGP381-Lapmaster. The polished oxide thickness of blanket wafer was measured with ellipsometer. To measure dishing and erosion amounts, patterned wafer was used. Because ceria-based slurry is easily agglomerrated than silica- based slurry, slurries were fed to prevent agglomeration of slurry in stirring. To prove mechanism of dishing during STI-CMP, material removal rate(MRR) and selectivity were tried to measure as a function of pH. Also the various supplement test was accomplished.

3. RESULTS and DISCUSSION

As shown in Fig. 1, MRR of HDP-CVD oxide and silicon nitride are 4900Å and 810Å in silica based slurry. But from ceria based slurry, MRR of HDP-CVD oxide and silicon nitride are 4200Å and 198Å. Consequently, selectivities of silica-based slurry and ceria-based slurry are 6:1 and 21:1. As shown in Fig. 5, at pH7 of ceria-based slurry, zeta-potential of HDP-CVD oxide is negative, whereas that of SiN is positive. So that electronegative sufactants adhere only to the SiN and interrupt reaction with the abrasive.[11] Figure. 2 and Figure. 3 show dishing and erosion with trench width and pattern density after sufficient polishing with ceria-based slurry and silica-based slurry. As trench width gets wider and pattern density gets lower, dishing becomes more severe. As shown in Fig. 2(a), high selectivity slurry shows less dishing at narrow field region, whereas low selectivity slurry shows more dishing. Figure. 4 shows SEM profiles in 2 ㎛ trench width with two type slurries. Lower dishing and erosion amounts could be explained by the increase of selectivity due to the variation of pH during CMP.

4. CONCLUSIONS

It was shown that high selectivity slurry shows less dishing at narrow field region, whereas low selectivity slurry shows more dishing. It should be noted that dishing mechanism is due to relations of MRR and selectivities as a function of pH and slurry. The amounts of dishing and erosion in both silica and ceria based slurry depended on trench width and pattern density as expected. Dishing is dependent upon the trench width, but erosion is not dependent upon the trench width in both silica and ceria based slurry. Much lower amounts of dishing and erosion were observed in ceria based slurry when the specimens with narrower trench width and all different pattern densities. Minimum dishing and erosion were explained by the variation of selectivity.

5. REFERENCES

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Table. 1 Test condition

slurry A	silica-based slurry(pH 11.5)
slurry B	ceria-based slurry(pH 7)
pad	IC1000/SUBAⅣ stack pad
plate rpm	30
head rpm	30
down force	4psi
slurry flow rate	50cc/min
solid loading	silica-based slurry(12wt%)
	ceria-based slurry(1wt%)

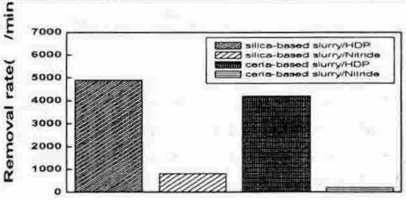
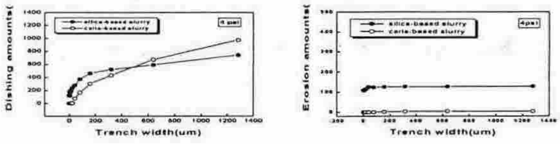
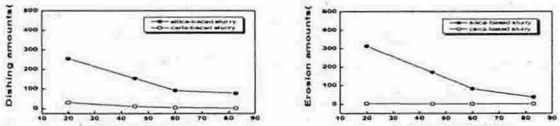


Fig. 1 Material removal rates of HDP-oxide and silicon nitride after CMP with silica-based and ceria-based slurry.



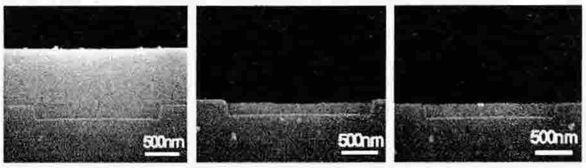
(a) (b)

Fig. 2 Variation of (a)dishing and (b) erosion amounts with trench width.



(a) (b)

Fig. 3 Variation of (a)dishing and (b) erosion amounts with pattern density.



(a) (b) (c)

Fig. 4 SEM images of 2 μm pattern ; (a)before CMP, (b)after CMP with silica-based slurry and (c)after CMP with ceria-based slurry.

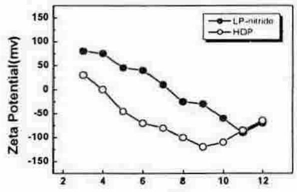


Fig. 5 Zeta-potential of LP-nitride and HDP as a function of pH.