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Development of Ceria-Based Slurry with High Selectivity for STI CMP

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Nano-Crystalline CeO_2 particles were dispersed in deionized water with controlled slurry chemicals for CMP test. According to the CMP test, the removal rate of SiO_2 layer was mainly controlled by the size and crystallinity of CeO_2 particles which can be controlled by the heat-treatment condition during CeO_2 synthesis. In contrast, the removal rate of Si_3N_4 layer was significantly influenced by the passivation reagent which protects the Si_3N_4 surface layer from excessive dissolution during CMP.

Keywords: Nano-Crystalline CeO_2, CMP, Slurry, Removal rate, Selectivity

1. INTRODUCTION

STI (Shallow Trench Isolation) CMP (Chemical Mechanical Planarization) is a newly developed and very effective isolation scheme to isolate the active areas in CMOS circuit. STI CMP can accomplish a high degree of planarity and a dramatic reduction in the chip area for isolation by eliminating the defect with low packing density, named bird's beak, which cannot be avoided in the existing technology like well known LOCOS isolation process.

Ceria based slurry is known to be very effective for STI CMP because of its excellent removal rate for SiO_2 and high selectivity between SiO_2 and Si_3N_4 layer. [1] Such CMP characteristics are normally controlled by the physico-chemical nature of the abrasive particles and adopted slurry chemicals.

In this study, we used nano-crystalline ceria as abrasive for CMP slurry and investigated the effect of abrasive particle and slurry characteristics on CMP performance. Some useful tips to develop ceria based CMP slurry with high selectivity will be given.

2. EXPERIMENTAL

Nano-crystalline CeO_2 was synthesized from $Ce(OH)_4$ by mechanical milling [2] and subsequent heat-treatment at various temperatures (400~700°C) with different duration time, where NaCl was added as a diluents during synthesis. After heat-treatment, powder mixture of CeO_2 and NaCl was washed by deionized water to eliminate NaCl. In order to make CMP slurry, remaining nano-crystalline CeO_2 was dispersed in deionized water with controlled slurry chemicals including 1wt/o glycine as the passivation reagent. The particle size, shape and crystallinity of synthesized nano-crystalline CeO_2 were characterized with XRD and TEM. We used 4-inch SiO_2, Si_3N_4 wafers for the CMP test that was performed in desktop type CMP machine (LPG-15AF, Lapmaster SFT Corp.). We investigated the effect of abrasive characteristics and slurry chemicals on the removal rate of each SiO_2 and Si_3N_4 wafers and evaluated the selectivity of removal under our test conditions.

3. RESULTS AND DISCUSSION

Fig. 1 shows the results of XRD analysis on the synthesized nano-crystalline CeO_2 from different heat-treatment temperatures. As shown in Fig.1, as the heat-treatment temperature increases, peak intensity and sharpness were increased, indicating the increase of particle size and crystallinity.

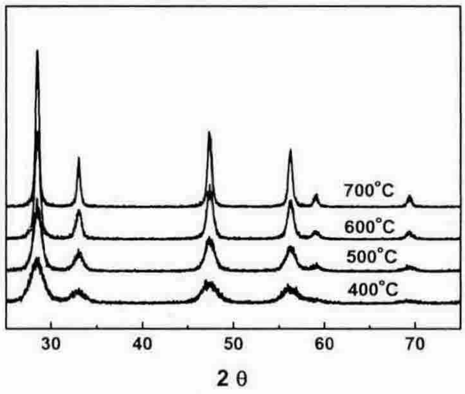

Fig. 1 X-ray diffraction patterns of sample heat-treated at various temperatures for 1hr.

CMP test results with different abrasive conditions (synthesized from 500 and 700°C) were given in Fig. 2. According to CMP test, the removal rate of SiO_2 was greatly influenced by the surface state and the dispersability of abrasive particles while the one of Si_3N_4 was not so much. Consequently CeO_2 particles with low crystallinity and small size were more effective to increase the removal rate of SiO_2, resulting in the increased selectivity in STI CMP.

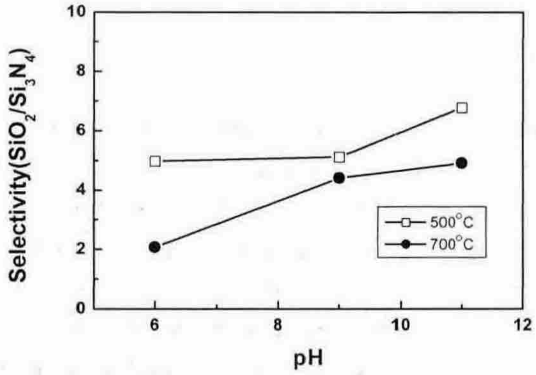

Fig. 2 Selectivity of CMP test with respect to annealing temperature of abrasive and pH of slurry

In the meanwhile, removal rate of Si_3N_4 was rather influenced by the passivation effect against dissolution of Si_3N_4 in chemical solution than particle characteristics itself. According to our experiment, passivation effect of the passivation reagent (in our study, glycine) was varied with respect to the pH of solution because the dissociation and adsorption characteristics of glycine were strongly dependent on pH. [3]

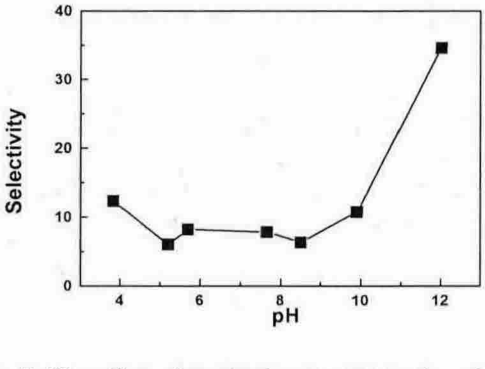

Fig. 3. The effect of passivation reagent on the selectivity of removal at different pH conditions of slurry

According to the results in Fig.3, passivation reagent, glycine, was more effective in alkaline condition than other pH region, which suggests that the proper use of passivation reagent might be one of the key solution to develop CMP slurry with higher selectivity. [4]

4. CONCLUSION

According to the CMP test, the removal rate of SiO_2 layer was mainly controlled by the size and crystallinity of CeO_2 particles which can be controlled by the heat-treatment condition during synthesis. On the other hand, the removal rate of Si_3N_4 layer was greatly influenced by the passivation reagent which might protect the Si_3N_4 surface layer from excessive dissolution during CMP.

5. REFERENCE

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