Effects of the Slurry Chemicals on the Planarization Mechanism of W CMP

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The basic mechanism of tungsten CMP has been reported as the repeated process of surface passivation by slurry chemicals and abrasion by slurry abrasives. It is very important to understand the effect of oxidant on metal passivation, which is essential step to achieve higher removal rate and good planarity during CMP.[1,2)]

In this study, two different kinds of oxidants, hydrogen peroxide and ferric nitrate, were used individually or in combination to investigate the effects of oxidant on tungsten CMP process. The electrochemical red-ox properties of metal surface layer were investigated in CMP slurry by general electrochemical polarization test in static and dynamic situation. Figure 1 shows the typical potentiodynamic curves of tungsten under various slurry chemical conditions in static situation without polishing. Three oxidant systems showed different oxidation behaviors on tungsten surface. According to the investigation, $Fe(NO_3)_3$ showed rather stronger oxidation capability and faster oxidation kinetics than other oxidant systems. Meanwhile, oxidation capability of H_2O_2 - $Fe(NO_3)_3$ was greatly enhanced because H_2O_2 was decomposed by Fe ion and produced reactive hydroxyl radical, eventually resulting in the enhanced passivating effect. The decomposition rate of H_2O_2 could be controlled with complexing agent and workable pH range of H_2O_2-$Fe(NO_3)_3$ system could be extended.

Oxidation state and microstructure of surface layer were also greatly influenced by the chemical composition of slurry. CMP slurry containing ferric nitrate induced more dense oxide layer on tungsten surface while the other compositions induced rather porous oxide layer. According to the real CMP test, the oxidation kinetics and corresponding microstructure of the surface oxide layer were very critical factors to determine the removal rate and planarity of tungsten wafer (Table 1).

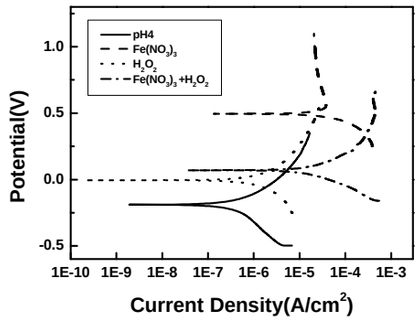

Fig. 1 Potentiodynamic polarization curves for tungsten in different oxidants systems.

Oxidants	Removal Rate (Å/min)
Reference	21
H_2O_2	136
$Fe(NO_3)_3$	1244
H_2O_2+$Fe(NO_3)_3$	2390

Table 1. Removal rate of tungsten wafer obtained in different slurry chemical conditions

References

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2. F. B. Kaufman, D. B. Thompson, R. E. Broadie, M. A. Jaso, W. L. Guthrie, D. J. Pearson, and M. B. Small, J. Electrochem. Soc., 138, 3460 (1991).