Development for Molybdenum CMP Slurry

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Molybdenum (Mo) is used in many industrial applications because of its high melting point, low coefficient of thermal expansion, and high thermal conductivity. In the semiconductor field, Mo shows high electrical conductivity at the shallow pitch area.

Peng reported a high Mo removal rate (RR) CMP slurry using KIO_3 as an oxidizer at acidic pH[1]. Xin-Ping reported hydrogen peroxide can be used for high Mo RR CMP slurry[2]. In order to design a Mo CMP slurry, we consider two main aspects of performance: high Mo RR and low Mo SER.

In our work, chemical mechanical polishing (CMP) properties for Mo are investigated by using different abrasives, oxidizers, inhibitors, pH adjusters and pH regions.

Fig.1 shows the effect of different abrasive types at pH=2.0 and 7.5. The result shows that abrasive-02 shows highest Mo removal rate. Mo removal rate at pH=2.0 shows higher Mo removal rate than pH=7.5.

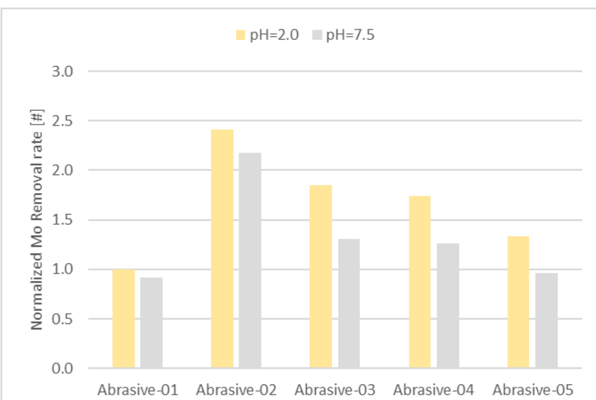


Fig.1 Molybdenum removal rate with different abrasives

Fig.2 shows the effect of different oxidizers for Mo removal rate and static etching rate (SER) at pH=2.0. Oxidizer-01 and -02 show 50% higher Mo removal rate. However, Mo SER is also higher than other oxidizers.

For suppressing Mo etching rate, we investigated a variety of acids and inhibitors. Fig.3 shows AFM images and R_a data after polishing. We checked the influence of acidic compounds during the polishing step. All samples were prepared by polishing slurries using abrasive-02 and oxidizer-4 on a 200mm polisher. The initial R_a value is 21Å. After polishing with a slurry that included acid-A, the R_a is 7.1Å, a reduction of 67% from the initial value. The slurry including acid-B show lowest overall R_a (3.2Å) in our testing. We selected acid-B as our pH adjuster at pH=2.0.

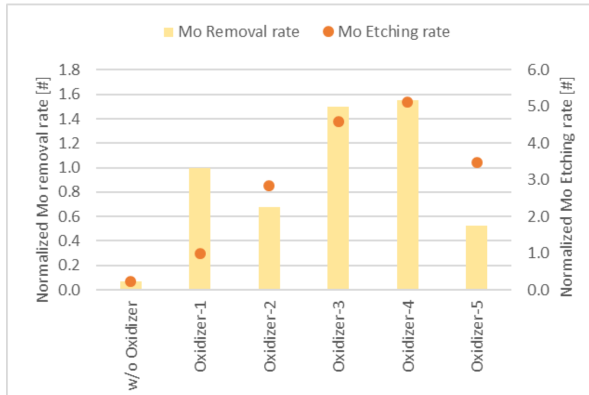


Fig.2 Molybdenum removal rate with different oxidizer types at pH=2.0

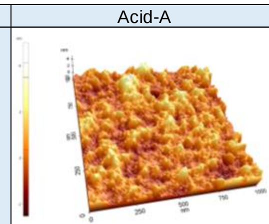
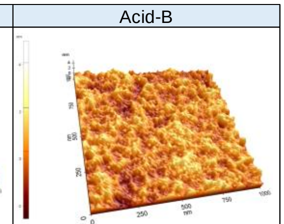
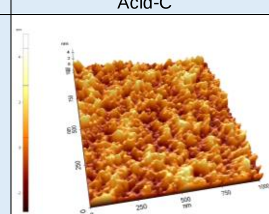
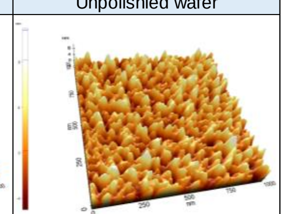
	Acid-A	Acid-B
AFM Image		
Ra	7.1Å	3.2Å
	Acid-C	Unpolishied wafer
AFM Image		
Ra	7.6Å	21Å

Fig.3 Atomic microscope image and roughness (R_a) with different pH adjusters on molybdenum

Fig.4 shows the effect of different inhibitors with oxidizer-4 for Mo etching rate suppression. Generally, cationic compounds (Inhibitor-05 and -

06) provide lower Mo etching rate. Significantly, these chemicals maintain Mo removal rate similar to slurries without inhibitor. The reason is that zeta potential at pH=2 is negative on Mo surface. Cationic compounds could use attractive force between Mo and inhibitor for forming inhibitor layer. Mo RR could control by hydrophobicity or steric hindrance of functional group in inhibitor.

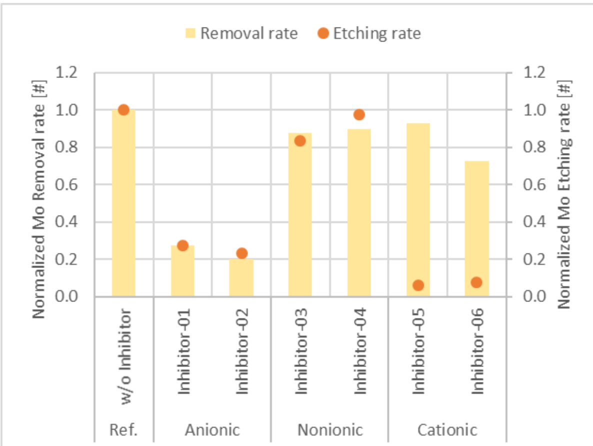


Fig.4 Mo Static etching rate suppression by different inhibitors with Oxidizer-4 at pH=2.0

Finally, we optimized a formulation using selected abrasive, oxidizer, pH adjuster and inhibitor. Fig.5 shows removal rate and selectivity data. Slurry A is our commercial FEOL slurry. Slurry B shows 60% higher Mo RR compared to slurry-A. We found this formulation could suppress Mo SER to 30% of slurry-A. Slurry-C shows 2.4x higher Mo RR compared to slurry A.

Our development for Mo CMP has produced a slurry which is shows high Mo RR while maintaining low SER. Finally, our slurry development shows appropriate control of dielectric film RRs using our existing technology[3].

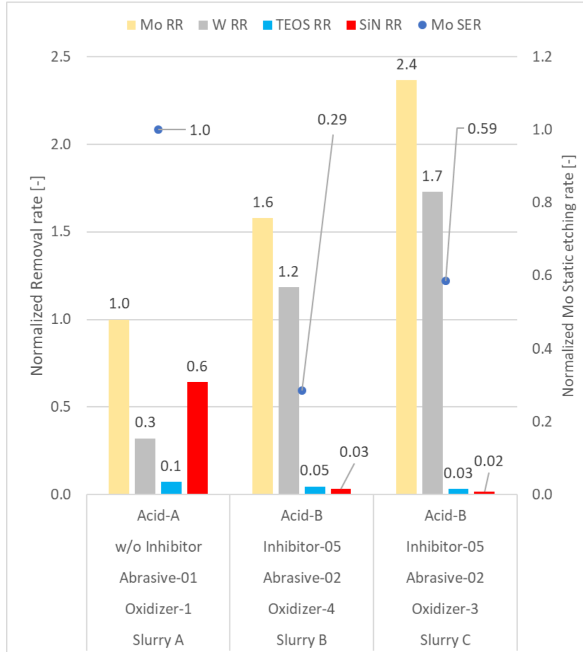


Fig.5 RR selectivity with Molybdenum slurries

Acknowledgements

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Reference

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[2] Xin-Ping Qu et al., ECS Journal of Solid State Science and Technology, 6(7) P470-P476 (2017)
[3] Kazusei Tamai et al., J. S. Advanced Production Technology, Vol.29, No.1 (2011).

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