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In-situ Electrochemical Measurements for Detecting Effect of Pad Groove on Copper Chemical Mechanical Polishing

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1. Introduction

Chemical mechanical polishing (CMP) process is necessary to form damascene structures in ultra-large scale integrated circuits (ULSI), while the polishing mechanism is not well understood. Recently, to understand the polishing mechanism, the friction phenomena have been investigated using the in-situ frictional force measurement techniques[1)-2)]. Furthermore, several groups have reported on the electrochemical measurements to evaluate metal CMP characterization[3)-4)].

In this study, the influence of pad groove on Cu CMP process is investigated by the in-situ electrochemical measurement during CMP using glycine/quinaldic acid/H_2O_2 base slurry.

2. Experimental

Polishing and in-situ electrochemical measurement apparatus are schematically shown in Fig. 1. The motor rotates a shaft attached to a polishing head at 200 rpm. The polishing pad, which has the contact area of 1 cm^2 with the Cu sample holder, is fixed to the polishing head. The polishing pressure is applied to the Cu sample holder and adjusted by lifting the jack. The pressure is varied from 0 to 60 kPa and measured using a load cell. A Cu bulk sample, which acts as a working electrode, is mounted to the sample holder by use of epoxy resin. A saturated calomel electrode (SCE) and a Pt wire are used as a reference electrode and a counter electrode, respectively. The open circuit potential (OCP) of this system is monitored by electrochemical instruments. The composition of slurry employed in this study is shown in Table I.

3. Results and Discussion

The variation of OCP is thought to reflect the change in the polishing surface condition. Figure 2 shows the temporal variation of OCP with and without pressure. The steady-state OCP is observed in 180 sec where the passivated layer on Cu surface is removed and surface roughness is reduced. The rise of potential under the released pressure indicates the formation of the Cu-quinaldic complex. A large oscillation of OCP occurs when a contact pressure exists between the Cu sample holder and the polishing pad. This means that repeated formation and removal of the Cu-quinaldic complex occurs during CMP. Figure 3 shows the variation of OCP and calculated contact area of pad with Cu electrode as a function of polishing time. The contact area is decreased once by every rotation of the pad, because the pad has single groove structure. When the pad groove reaches the Cu electrode surface, the pressure applied to the Cu electrode is released. Accordingly, the OCP is expected to increase from the results of Fig.2. However, the measured OCP decreases with decreasing the contact area. This phenomenon indicates that the removed Cu-quinaldic acid complex can be drained through the pad groove. As a result, the removal of the Cu-quinaldic complex from the Cu surface occurs more efficiently.

4. Conclusions

The measurement of OCP during Cu-CMP using glycine/quinaldic acid/H_2O_2 base slurry was investigated by the in-situ electrochemical measurement. It was electrochemically found that the removal of the Cu-quinaldic complex from the Cu surface occurs more efficiently because the groove of pad acts as a drain. Consequently, the pad groove can control the polishing rate.

Acknowledgements

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References

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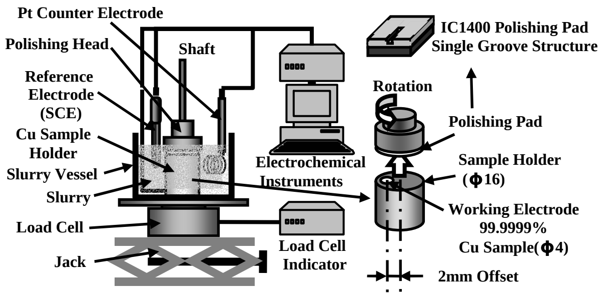

Fig. 1 Schematic diagram of apparatus

Table I Composition of slurry

Chelating agents	Glycine	0.1 M
	Quinaldic acid	5.61 mM
Oxidizer	30%-H_2O_2	2.9 vol%
Abrasive	SiO_2 (AEROSIL OX-50)	1 wt%
Inhibitor	BTA	0.5 mM
Electrolyte	Na_2SO_4	0.01 M

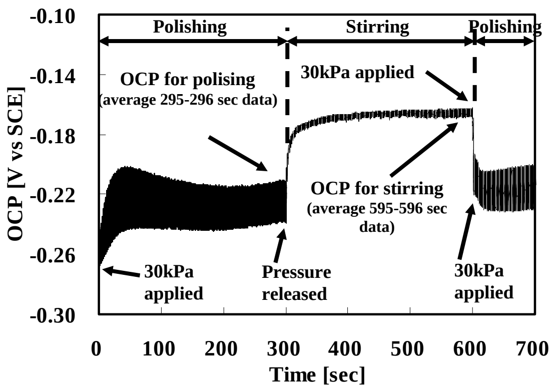

Fig.2 Variation of OCP with time with/without pressure of 30 kPa using single groove structure pad.

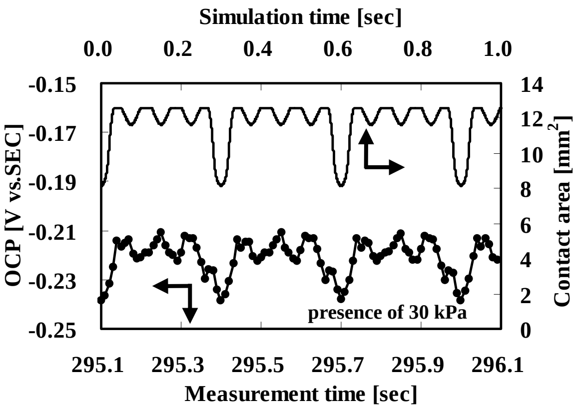

Fig.3 Variation of OCP and contact area of pad with Cu electrode versus time using single groove structure pad.