Photo-enhanced Electrochemical Mechanical Polishing for Cu Damascene

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INTRODUCTION

CMP is a key technology for Cu damascene wiring process. But Cu CMP has a very complicated mechanism and needs many chemicals.

In the conventional Cu CMP, Cu is oxidized by oxidizer and Cu(II)complex film is created with inhibitor. Then, this complex film is removed by abrasion. The complex film prevents wet etching and corrosion by oxidizer, and the film property is a dominant parameter for the removal rate and the planarity. And optimization of the film quality requires a great deal of work. Furthermore the valance of oxidation and protection by inhibitor is very critical for preventing Cu corrosion.

Also Cu CMP slurry contains many chemicals for oxidation, inhibition, pH adjustment and other purpose as additive. But use of chemicals is not preferable in view of environmental considerations.

Thus the possibility of chemical-free Cu CMP was examined using photocatalyst.

RESULTS AND DISCUSSION

The mechanism of photo-enhanced electrochemical mechanical polishing is explained by Fig.1. TiO_2 produces electron-hole pairs by photo-irradiation. Cu surface is oxidized by holes and a thin CuOx layer is created. And this thin CuOx layer is removed by TiO_2 abrasion. So, no oxidizer or other additive is required in this photo-enhanced electro-chemical mechanical polishing.

In the experiment, 3wt% TiO_2 disperse solution was used as CMP slurry. Also, SiO_2 and Al_2O_3 solution was examined for the reference. The pad surface was illuminated by mercury lump in the CMP process.

Fig.2 shows Cu removal rate dependence on the light power. In the case of TiO_2 abrasive, Cu removal rate was increased by photo-irradiation and was about 900nm/min at 500W light illumination. The band gap of the TiO_2 is 3.2eV and the irradiation by the mercury lump produced hole electron pairs. And hole oxidized Cu. On the other hand, SiO_2 and Al_2O_3 abrasive did not show the increase of Cu removal rate. Because the band gap of SiO_2 and Al_2O_3 is larger than 8eV and mercury lump did not produce hole electron pairs.

Photo-enhanced electrochemical mechanical polishing showed excellent planarity and the dishing was less than 50nm at 50um/85% density pattern as shown in Fig.3. The good planarity is thought to be attributable to the polishing mechanism of direct oxidation of Cu by TiO_2 abrasive.

From these results, it was confirmed that photo-enhanced electrochemical mechanical polishing is a good candidate for creating Cu damascene wiring in semiconductor manufacturing from the aspect of productivity, planarity and environmental.

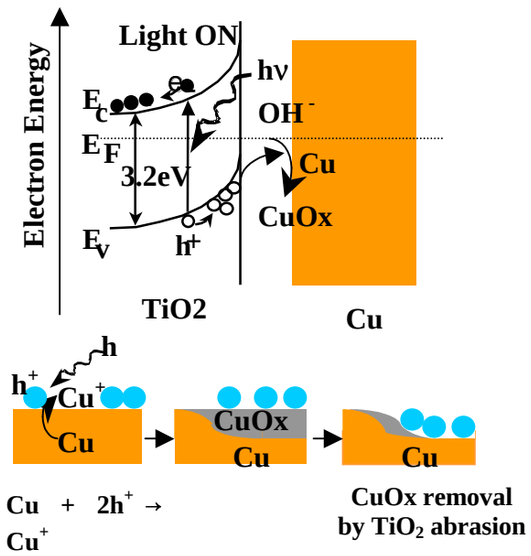

Fig.1 Mechanism of photo-enhanced electrochemical mechanical polishing of Cu

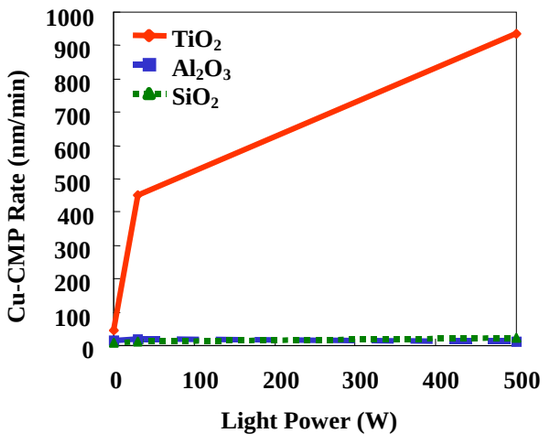

Fig.2 CMP rate dependence on light power

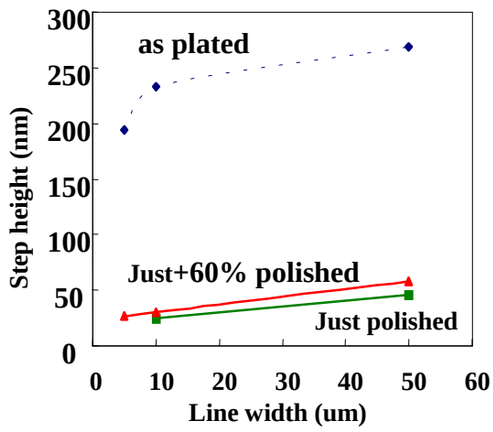

Fig.3 Planarity by photo-enhanced electrochemical mechanical polishing