Adhesion and Removal of Silica and Alumina Slurry Particles During Cu CMP Process

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Due to the low resistivity and high electromigration performance of Cu, it is considered a much better interconnection material than the currently used Al-based alloys [1]. However, while there is a clear advantage in using Cu as an alternative material to Al, there are several challenges that must be overcome. One such challenge is the difficulty involved in patterning of Cu by dry etching. The damascene technology using chemical mechanical planarization (CMP) is the only technology that can provide global planar surfaces and patterned Cu interconnection with a large process window [2]. The other problem of Cu CMP is Cu contamination during device manufacture. Cu is considered a very serious metallic contaminant for silicon devices. The detrimental effects of Cu contamination of the inter-metal and inter-level dielectric are well known [3]. In this paper, the interaction forces between particles and surfaces during Cu CMP were calculated based on the DLVO theory [4] for different pH ranges. The adhesion forces between the particles and surfaces were also experimentally measured using an atomic force microscope (AFM). Likewise, the magnitudes of particle contamination on TEOS oxide and low-dielectric constant polymer, Cu, and TaN surfaces were observed after they were polished to confirm the resulting interaction forces.

Figure 1 shows the zeta potentials of particles and surfaces used in Cu CMP process. The change in the interaction force between the particle and a surface can be measured with an AFM as the cantilever approaches the substrate [5]. The attractive forces of silica particles on SiLK™, TEOS, Cu, and TaN surfaces in alkaline solutions were measured to be 0.23nN, -0.78nN, -2.02nN, and -2.04nN, respectively. The strongest attractive force was measured on the TaN surface, while the weakest attractive force was on the SiLK™ surface. The SiLK™, TEOS, Cu, and TaN wafers were more attractive in acidic solutions than in other solutions. Figure 2 summarizes the interaction forces of silica particles on wafers in solutions of different pH values.

In order to confirm the calculated and measured interaction forces, the SiLK™, TEOS, Cu and TaN wafers were polished using colloidal silica slurry. FESEM was used to observe the magnitude of particles left on each surface. FESEM images showed greater number of colloidal silica particles on TaN surfaces. The greatest numbers of particles were also found on the surface polished in acidic slurry. It could be concluded that TaN and Cu surfaces are very susceptible to particle contamination in acidic slurry during Cu polishing.

References