All-Wet TSV Process Using Electroless Barrier and Seed Layers with Pd Nanoparticle Catalyst

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Metal filling of through-Si via (TSV) has been studied intensively as a key technology of 3D integration. TSV is generally filled by electroplating of Cu. However, most of studies utilize high cost and high temperature processes such as CVD in forming barrier layer before Cu electroplating. Reduction of fabrication cost is important for mass-production of Cu-TSV, and all-wet process is desirable for this purpose.

In this paper, we studied to form Cu-TSV with all-wet process using electroless barrier and seed layers with Pd nanoparticle (Pd-NP) catalyst, and evaluated barrier film properties such as adhesion strength and thermal stability. At first, TSV hole structure with a SiO₂ layer was immersed in a solution of 3-aminopropyltriethoxysilane (APTES) with toluene as a solvent. After the formation of APTES layer, Pd-NP catalyst were adsorbed on the substrate. Then electroless barrier plating was carried out by using Pd-NP catalyst, and electroless Cu seed layer was formed on the barrier film without catalyst. Furthermore, Cu filling was carried out by electroplating with superfill condition. We evaluated adhesion properties of barrier film by stud-pull test.

Figure 1 shows a cross-sectional FIB image of Cu-TSV with electroless barrier and seed layer. Cu was filled completely in the TSV with aspect ratio of 7 by all-wet process. Furthermore, we succeeded in the formation of conformal barrier and seed layers by adding inhibitors. Figure 2 shows a thickness dependence of adhesion strength of the Co-W-B barrier film. The adhesion strength is largest at 20nm, and it decreased linearly with an increase of film thickness. It is considered that the internal stress increases with an increase in the film thickness. Delamination occurs when the internal stress surpasses the adhesion strength of the film. The proposed method would be an important technology for realizing all-wet TSV formation process for high aspect ratio TSVs.