Void-Free Copper Pillar Hybrid Bonding Using a Polymer Adhesive and Chemical Mechanical Polishing

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Abstract

To maintain the industry goal of increasing performance with every new generation of technology, it is necessary to further shrink the package size in the z-dimension through the use of 3D-TSV and copper pillar structures. Previously, Niklaus et al[1] and McMahon et al[2] demonstrated the ability to bond copper-polymer structures using a copper dual damascene integration scheme. In this approach, copper slurries removed the copper overburden and, although bonding of the copper areas was achieved, gaps between the polymeric adhesive layers were visible after bonding. To overcome this issue, we have developed two approaches to planarize both the copper pillar as well as the polymeric adhesive. The first approach relies on non-selective CMP of the two materials; the second approach relies on sequential steps of polymer and copper removal.

Planarization studies were performed on a commercial tool using experimental slurries that were tuned to be non-selective and have similar removal rates for both copper and polymer, or to be selective and remove only one of the materials. By optimizing the polishing process conditions, we were able to achieve selectivity as low as 1.6:1 for the non-selective slurries and as high as 1000:1 for the selective slurries on blanket wafers. Once optimized, the goal of the CMP process will be to completely remove the polymer from the top of the pillar and planarize the copper pillars while leaving them protruding by less than ~100 nm above the surface of the polymeric adhesive.

Currently, we are performing chip-to-chip bonding trials of partially cured polymeric adhesive after various CMP methods. In addition, copper to copper hybrid bonding using singulated dies with a commercial flip chip bonding tool are also in progress to demonstrate the electrical continuity and void free bonding. Preliminary reliability studies will start once the bonding process is fully optimized.

[1] F. Niklaus et al, Journal of the Electrochemical Society, 2006, 153, G291.
[2] McMahon et al, IEEE Electronic Components and Technology Conference, 2008, 871.