CMP Slurry for Epoxy Mold Compound in Advanced Packaging

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Chemical mechanical polishing (CMP) process has been applied throughout the semiconductor manufacturing processes for decades. However, implementation of CMP process for advanced packaging has been slow due to its difficulties: such as low removal rate, poor selectivity, and elevated surface roughness and defects on the organic polymer film. Nonetheless, CMP process is becoming a crucial part of the advanced packaging and beyond in order to achieve smaller pitch and improve re-distribution layer (RDL) process. In this paper, we focus on CMP slurry with highly tunable removal rate and selectivity for epoxy mold compound (EMC) with silica filler and Cu pads. Figure 1 shows the effect of CMP process on EMC with silica filler and Cu pads. We have been able to polish and obtain a smooth surface for EMC and Cu with CMP slurry without dropping silica fillers.

We assumed polishing behavior of EMC materials containing silica filler would be similar to that of dielectrics, and would be polished as shown in figure 2. CeO_2 would come in contact with EMC with silica fillers to remove Ce-O-Si bonds that are formed through wettability control from a slurry, leaving the perforated EMC film that can be easily removed by the mechanical abrasion from the abrasive and pad. CeO_2 is known to have high chemical reactivity towards SiO_2 in CMP; therefore, CeO_2 was chosen as our base abrasive for the slurry. However, CeO_2 is not commonly used to polish Cu because abrasive size for dielectrics slurry is often large and Cu is easily scratched by mechanical process. Cu CMP often relies on formation of oxidized Cu from the slurry which is removed softly by abrasive particle and pad. Thus, Cu CMP slurry typically requires smaller abrasive particles in low concentration along with various chemical species in order to meet corrosion, protrusion/dishing, and defect requirements. As stated above, CeO_2 has high chemical reactivity and it is difficult to maintain slurry stability when mixed with Cu slurry. These challenging requirements for removing EMC and Cu simultaneously requires a novel approach for designing slurry.

We investigated particle sizes, and chemical composition, as well as polishing pad, slurry flow rate, downforce pressure, and linear velocity effect on EMC with silica filler and Cu. We experimentally learned that removal rate of Cu is highly modulated by pH of the slurry and Cu inhibitor concentration, while EMC is highly dependent on abrasive type, linear velocity, downforce pressure, and pad selection. We were able to tune the slurry formulation to meet the required target of removal rate greater than 500 nm/min, Cu dishing/protrusion of less than 150 nm, and mold roughness below 100 nm.

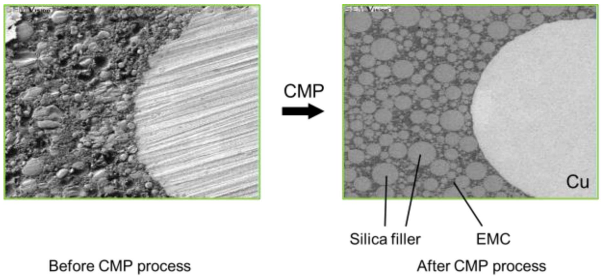

Fig. 1 SEM images of EMC surface with silica fillers and Cu before and after CMP process

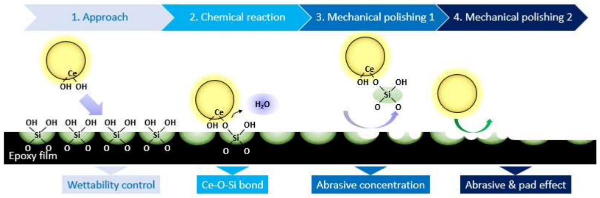

Fig. 2 EMC removal mechanism in the presence of CeO_2 abrasive.

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Preference: ■ Oral

Topic Area: 3D ICs/TSV/packaging applications