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Effect of Plasma Pretreatment on Superconformal Cu Alloy Gap-Filling of Nano-scale Trenches

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As the dimension of Cu interconnects has continued to reduce, its resistivity is expected to increase at the nanoscale due to increased surface and grain boundary scattering of electrons. To suppress increase of the resistivity in nanoscale interconnects, alloying Cu with other metal elements such as Al, Mn, and Ag is being considered to increase the mean free path of the drifting electrons. The formation of Al alloy with a slight amount of Cu broadly studied in the past. The study of Cu alloy including a very small Al fraction, by contrast, recently began. The formation of Cu-Al alloy is limited in wet chemical bath and was mainly conducted for fundamental studies by sputtering or evaporation system. However, these deposition methods have a limitation in production environment due to poor step coverage in nanoscale Cu metallization. In this work, gap-filling of Cu-Al alloy was conducted by cyclic MOCVD (metal organic chemical vapor deposition), followed by thermal annealing for alloying, which prevented an unwanted chemical reaction between Cu and Al precursors. To achieve filling the Cu-Al alloy into sub-100nm trench without overhang and void formation, furthermore, hydrogen plasma pretreatment of the trench pattern with Ru barrier layer was conducted in order to suppress of Cu nucleation and growth near the entrance area of the nano-scale trench by minimizing adsorption of metal precursors. As a result, superconformal gap-fill of Cu-Al alloy could be achieved successfully in the high aspect ration nanoscale trenches. Examined morphology, microstructure, chemical composition, and electrical properties of superfilled Cu-Al alloy will be discussed in detail.

Keywords: plasma pretreatment, gap-filling, MOCVD, nucleation