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Atomic Migration of Cu in Ti/Ni/Cu/Ag Backside Metallization on Si Substrate

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Extended Abstract

To improve the adhesion between the Ni and Ag films in the traditional Ti/Ni/Ag backside metallized Si wafer, an additional layer of Cu was added between the Ni/Ag interfaces. The thicknesses of the Ti/Ni/Cu/Ag layers in this study were 1-3-1-9 kÅ. It was observed that, during heating at 200 °C for durations of up to 8 hours, the Cu layer remained largely unchanged. However, when the high temperature storage was extended to 9 hours, slight fluctuation was observed in the Cu layer, which formed a wavy layer. As no Cu was found on the surface of the Ag layer, it was speculated that the thermal energy at 200 °C was insufficient to overcome the energy barrier for the transition, and hence the Cu atoms could not cross over the Ag layer. In this case, EDS mapping showed that the Ag/Cu interface was still intact and no diffusion reaction had occurred. When the temperature was increased to 300 °C, the cross-sections of the Ti/Ni/Cu/Ag metallization showed significant growth of the Ag grains, while the Cu layer showed no signs of fluctuation. As the heating time increased, the Ag/Cu became uneven, and some Cu atoms diffused to the surface of the Ag layer while the Ag grains continued to grow. At 4 hrs 30 min[JR2], most of the Cu atoms had migrated to the surface and the intermediate Cu layer had decreased in thickness. The EDS mapping revealed that the Cu layer had split into two distinct layers after heating for 4 hrs. When the heating time was increased to 4 hrs 30 min, the Cu layer eventually migrated to the surface of the Ag layer. The Cu layer became wavy and discontinuous after holding at 400 °C for 2 hrs and for 2 hrs 30 min. After holding at 400 °C for 2 hrs 30 min, partial migration of Cu atoms to the surface had occurred. The same phenomenon was observed with increases in heating time. However, the Cu layer had completely migrated to the surface after holding at 400 °C for 3 hrs. At 500 °C, however, the Cu layer quickly became discontinuous clusters. The high temperature destroyed the metal stack structure, where voids started to appear within the layers. It is preliminarily speculated that the film adhesion was degraded by the high temperature, and the weakened interface caused subsequent signs of peeling within the metal films, causing the diffusion of Cu to become slow and inconspicuous. Summarizing the observations in this study, it can be speculated that, as heat was applied to the metal stack, the aggressive Ag grain growth initiated void formation near the grain boundaries. The Cu atoms were energized by the heat energy and started to diffuse through the Ag grain boundaries and voids to the surface, where they eventually spread over the Ag layer to form a uniform layer. The Cu atomic migration phenomenon can be inhibited through the deposition of a Sn layer on the surface of Ti/Ni/Cu/Ag metallization and the bonding strength at the Ni/Ag interface can be effectively increased.

References

[1] Resnik, D., Kovač, J., Vrtačnik, D., Aljančič, U., Možek, M., Zalar, A. and Amon, S., 2007. "Investigation of interface properties of Ti/Ni/Ag thin films on Si substrate." *Vacuum*, 82(2), pp.162-165.

[2] Roy, R. and Sen, S.K., 1993. "The study of diffusion of copper in thin films of silver and Ag-Al alloys as a function of increasing aluminium concentration." *Thin solid films*, 223(1), pp.189-195.

[3] Chamberlain, M.B., 1982. "Diffusion of copper in thin TiN films." *Thin Solid Films*, 91(2), pp.155-162.

[4] Kehoe, R.B., Newman, R.C. and Pashley, D.W., 1956. "The migration of copper atom on the surface of silver." *Philosophical Magazine*, 1(8), pp.783-785.