

Corrosion Observations during the Processing of Cu Interconnects

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Because of its lower resistivity and improved electromigration resistance, copper has tended to replace aluminum as the metallization of choice for advanced integrated circuits (ICs). Based simply on the galvanic series, one might naturally assume that Cu should be much improved in corrosion resistance versus Al. However, Cu generally doesn't grow a stable self-passivating oxide layer whereas Al does in a chlorine-free environment¹. Therefore, copper corrosion can be observed during IC processing and this paper serves to describe at least three mechanisms observed for Cu corrosion.

Since pure Cu is generally not self-passivated, a few angstroms of protective material (e.g., BTA² or TAMH³) is intentionally added to the surface of the exposed Cu after chemical mechanical polishing (CMP). Generally, this temporary passivating film serves to protect the Cu from post CMP until its eventual removal just prior to the capping layer deposition onto the Cu. However, it is important that this thin passivating film be continuous in order to achieve the maximum corrosion protection for the Cu. This means that, intrinsically, the passivating film should have good adhesion to copper and, extrinsically, it should be very low in defect density. Thus, if either an intrinsic or an extrinsic issue develops during the formation of this passivating film then copper corrosion can be observed. This paper will focus on three mechanisms for copper corrosion: simple Cu oxidation, galvanic corrosion between Cu and its TaN barrier, and photo-induced copper redeposition (PICR).

Fig. 1 shows a correlation between dielectric breakdown voltages tested at 250C and the queue time post copper CMP with copper exposure to the clean room environment. As the queue time increases from 1hr to 7hr, the tail of the breakdown distribution becomes larger (from less than 10% to more than 30%). These results indicate that the copper has oxidized during the queue time. This oxidized Cu, when reduced back to elemental Cu during the processing of the cap layer, will serve to reduce the electrical breakdown strength between adjacent metal leads as indicated in Fig. 1. Since such oxidation is random, it shows up as a tail in the distribution. The image in Fig. 2 shows the galvanic corrosion which has occurred during CMP due to material differences between copper and its barrier. Fig. 3a shows the photo-induced copper redeposition (PICR) on test structures. This unique corrosion mechanism occurs when the Cu is contacted to p-n junctions and then exposed to light. The resulting photovoltaic voltage can be ~0.6V (see Fig. 3b) and this voltage drop can result in a depletion of Cu from the p-type contact region and an accumulation of Cu at the n-type contact region. In a summary, copper corrosion can occur during IC processing if tight controls over the process and process environment are not maintained. Tight corrosion control during IC processing will become increasingly important as we continue to scale devices below the 90nm technology node.

1. J. McPherson and S. Fan, IEEE-IRPS, 50 (1988).
2. V. Brusic, *et.al.*, J. Electrochem. Soc., Vol. 138, 1991.
3. W. H. Huang, *et.al.* MRS Proceedings Vol.566 p161-6.

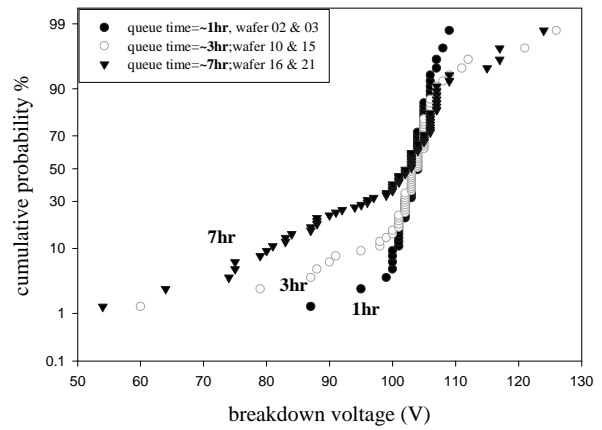


Fig. 1 queue time post Cu CMP clean and dielectric breakdown voltage

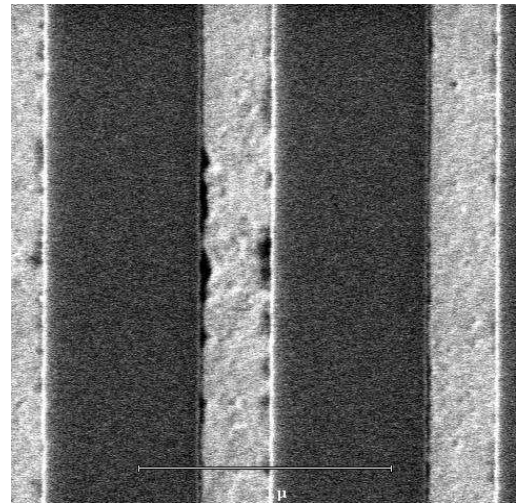


Fig. 2 Galvanic corrosion between Cu and its barrier

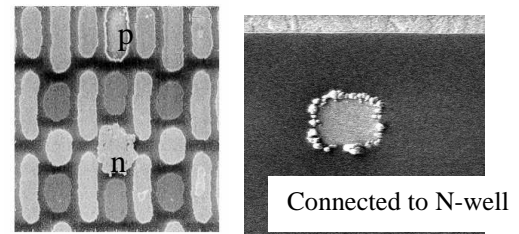


Fig. 3 (a) Photo induced copper redeposition on test structures

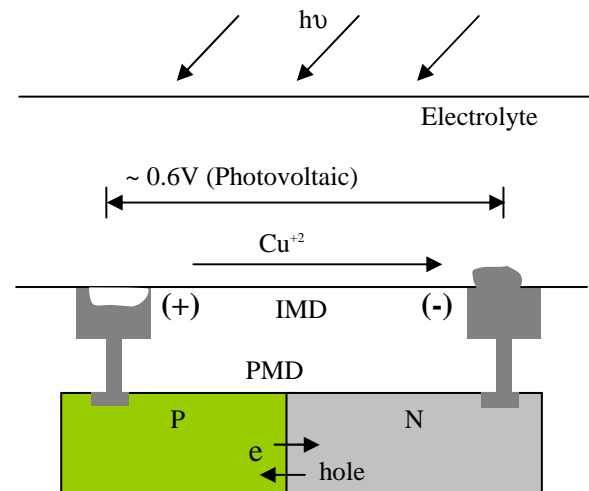


Fig. 3 (b) mechanism of PICR