An Investigation of The Effects of Wafer Curvature Changes During Copper Damascene Processing

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There is a recognition in the importance of understanding wafer shape changes during chemical mechanical polishing in order to gain a more fundamental understanding of the mechanisms involved in CMP (1,2). In the case of copper damascene processing, such an understanding is being sought to help prevent film delamination when low K dielectric films are employed.

Early studies of the wafer shape changes that take place for oxide, tungsten, and copper chemical mechanical polishing were conducted using the capacitance probe technique (3,4). These studies were principally based upon measurements which were performed prior to and after complete chemical mechanical polishing. In this paper, measurements were made after short partial polishes of the copper until the copper had been totally removed, and then measurements were again made after barrier removal. A new optical technique for curvature and stress measurements which is based upon coherent gradient sensing is utilized (5).

It is shown that the largest changes in wafer curvature during copper damascene processing occur as a consequence of the metallization processing steps. The change in curvature, which is thickness dependent and similar for both 200 and 300 mm wafers, is largest during the initial stages of copper CMP and then becomes linear for the remainder of the copper removal for the polishing conditions employed. The wafers enter CMP under tensile stress which reverts to a more compressive state during the polish process. The shape changes from concave to convex as is shown in Figure 1. The copper removal rate increases substantially during this curvature change, as is shown in Figure 2 with the largest changes taking place initially and at the wafer edges (Figure 3) which are more prone to delamination than the wafer center. The across wafer uniformity improves during the later stages of the copper removal process.

Comparisons will be provided for the behavior of 200 mm wafers with different Cu plating thicknesses in which the films are polished with and without a furnace anneal. In addition, comparisons will also be included for 300 mm damascene wafers.

References
2. J. McGrath and C. Davis, Abs. 932, 204th Meeting of the Electrochemical Society, Inc.