THE GRAIN SIZE DISTRIBUTION INVESTIGATION OF HIGH PURITY PLATING CU WIRE IN DEPTH DIRECTION

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Cu has been extensively used as interconnect material for advanced ULSIs due to its low electrical resistivity and high reliability. For very thin Cu wires, electron scattering at grain boundary significant influence the resistivity. It was found that the grain growth can be optimized by reducing the density of the impurities. For electroplating Cu wires, how the purity of plating materials affect the grain growth is not clear. In this research, electron back scattering diffraction (EBSD) analysis was used to investigate the grain size distribution in the trench depth direction.

Trenches used were 80 nm width and 200 nm height with a TaN/Ta (7.5 nm/7.5 nm) barrier and Cu seed (50 nm) layers inside. Cu was deposited into the trenches by the DC electroplating process at a current density of 5mA/cm^2. Both 99.9999% (6N) purity $CuSO_4 \cdot 5H_2O$ 99.999999% (8N) Cu anode, and 99.9% (3N) purity $CuSO_4 \cdot 5H_2O$ 99.9% Cu anode were used for comparison. After annealing at 573 K for 10 min, an advanced CMP technique was used to get the top (200 nm height of the trench) middle (100 nm height) and bottom (50 nm height) planes, as shown in Fig. 1, then the analysis of grain size was carried out by EBSD on these planes.

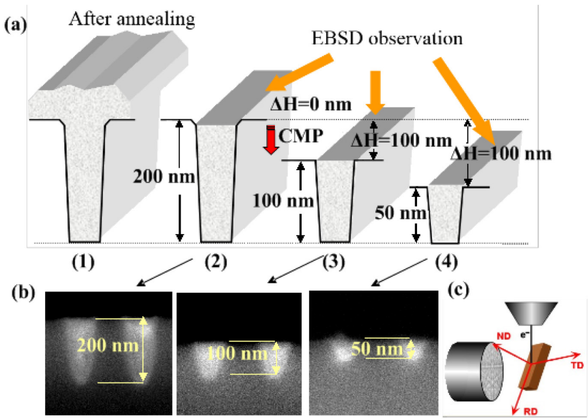

Fig. 1. (a) Schematic drawing of sample preparation by CMP for EBSD observation; (b) Cross-sectional SEM images of Cu wire with 50 nm, 100 nm and 200 nm height; (c) Normal direction (ND) of EBSD observation

We got the results as follows: the median grain size for the high purity process is slightly larger (3 %) than that for the conventional process at both 200 and 100 nm heights, and for the former it is about 13 % larger than that for the latter at the 50 nm height. It was also found that the ratio of small grains with diameters less than 45 nm (40 nm is about the mean free path of Cu). At both 200 nm and 100 nm heights, the ratios of small grains for the high purity process are slightly lower than those for the conventional process, while at the 50 nm height, the ratio of small grains for the former is about 50 % lower than that for the latter.

These results suggest the high purity process can significantly enlarge the grain size and reduce the ratio of small grains with diameters less than 45 nm at the bottom region of a trench, and that contributes to a uniform grain size distribution in the depth direction of the trenches.