Cross-sectional Crystallographic Analysis of Copper Electrodeposits for ULSI Metallization by EBSD

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This study focused on the cross-sectional crystallographic analysis of submicron scale feature by EBSD (Electron Backscatter Spectroscopy Diffraction) and FIB (Focused Ion Beam). Compared to TEM and XRD, this EBSD is a useful method for the configuration analysis of the grain structure by measuring the grain orientation. For this effective EBSD analysis, FIB-milling and gold-coating are developed to smooth the rough cutting surface and decrease the charging effect caused by IMD (Inter-metallic Dielectric) deposits. The copper electrodeposits in trench plug are figured as a single crystal having a few of twinnings. Interestingly, the crystallographic orientation of the overplating region is also founded to be same as that of trench plug. Additionally this experiment shows that the texture of overplating region also as the \{111\}<110> texture, as same as that of in trench plug. This experiments have been carried out to statistically characterize the texture of copper in wide area of pattern wafers by ODFs (orientation distribution functions). Namely the recrystallization, which has initiated at the specific point in trench plug, can be propagated into the overplating region. Conversely, the movement of grain growth in a trench plug during self-annealing can be inferred by measuring that in the overplating region. Therefore, the in-situ planar EBSD analysis for a self-annealed specimen shows that the grain growth is initiated at the pattern area and the grain usually grows isotropically. The cross-sectional crystallographic analysis by EBSD may be applicable to the electromigration failure in the submicron pattern.

Figure 1. Cross-sectional EBSD maps of 0.5 \( \mu m \) trench pattern after annealing at 200°C for 10 min. SD, ND and LD stand for width, normal and line directions, respectively.

Figure 2. Texture (plane-view ODFs) of copper electrodeposits over trench plugs of 0.14 to 1 \( \mu m /0.2 \mu m \), trench/space gratings. Left ODFs are from self-annealed deposits without removing the overplating region. Middle ODFs are from deposits after annealing at 200°C for 10 min without removing the overplating region. Right ODFs are from specimens after annealing at 200°C for 10 min and subsequently their overplating region being removed by CMP.

Figure 3. In-situ planar EBSD maps of over-plated copper electrodeposits in 0.5/0.5 \( \mu m \) width/space patterns as a function of holding time at room temperature.