MICROSTRUCTURE ANALYSIS OF ELECTRODEPOSITED NANO-SCALE COPPER WIRE BY EBSD TECHNIQUE

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Copper has been used as an interconnect material for high performance ultra large scale integrations (ULSIs) due to its low electrical resistivity and high reliability. Recent results have also shown that microstructure plays an important role in Cu wire resistivity due to grain boundary scattering because grain or subgrain sizes may become comparable to the mean electron free path (40nm) when wire width is decreased to less than 100 nm. Thus microstructural control becomes an important issue in advanced microelectronic devices. Up to now many important microstructural aspects remain unclear and obviously more research is needed for reliable microstructural control in the nano-scale copper electrodeposits.

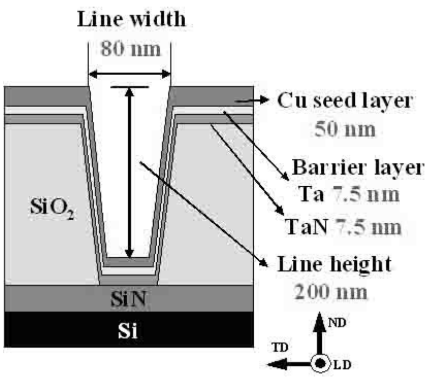

Fig. 1. Schematic representation of a cross-section of trench before electroplating

In present work damascene trenches of 80 nm width and 200 nm height were patterned in SiO_2/Si dielectric films using electron beam lithography and reactive ion etching. An ultra-thin TaN/Ta (7.5 nm/7.5 nm) layer was first sputter-deposited on the trenches as a diffusion barrier and adhesion layer, followed by sputter deposition of a 50 nm copper seed layer to serve as the cathode for electroplating (Fig. 1). We investigated the structure of electrodeposited copper wire after annealing at 0.1 deg per second and maximum temperature of 300°C for 10 min in vacuum ($5\text{x}10^{-5}$ Torr) through EBSD technique preceded by chemical mechanical polishing (CMP). To evaluate the possible variations of microstructure and texture in the thickness direction, the observations were made at the trench heights of 50, 100 and 200 nm, which correspond to bottom, mid-thickness and upper parts of the deposits, respectively.

The structure investigation revealed the following features:

1) The mean grain and sub-grain sizes were measured to be ~150 nm and ~100 nm, respectively. The volume fraction of the grains or sub-grains with the size equal to the mean free path of electrons (i.e. 40-50 nm) was found to be negligible small.

2) The microstructure featured a large fraction of annealing twins as well as a significant proportion of highly mobile 40°<111> boundaries. It seemed therefore that the formation of the investigated microstructure was significantly influenced by recrystallization and grain growth during post-deposition annealing. Also, it seemed that these annealing processes were somewhat hindered in the bottom part of the trench for an unknown reason.

3) The material was found have a strong {111}<110> texture. The <110> direction was always parallel to the wire axis whereas the {111} plane was aligned either with the side walls or the bottom surface depending on the trench height.