Texture Evolution in Cu Films and Lines

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INTRODUCTION AND EXPERIMENT

The microstructural character of Cu lines evolves within a confined trench and varies with line width and dielectric material. Evolution of crystallographic texture within such lines depends upon the geometrical parameters of the trench in that the stress state during annealing changes with height to width ratio (h/w). Copper damascene lines of various widths were fabricated using standard industrial procedures and analyzed by EBSD.

MODEL

Texture evolution is controlled by surface energy, interface energy, grain boundary energy and strain energy. Twin boundaries can replace the higher energy large angle boundaries to lower the system energy even though the twins are not {111} oriented. A model for twin boundary development was developed wherein twin boundaries replace high angle boundaries. For ease of calculation, the twins are assumed to have a rectangular cross-section. This assumption is illustrated below.

RESULTS AND DISCUSSION

The textures of 6000 and 2000 nm wide lines were strong {111} out of plane textures, while the strength of {111} out of plane texture for the 320 nm wide lines was less than half of that for 6μm and 2μm lines. The average grain diameter for all grains decreased with decreasing line width. Also, the width of annealing twins slightly decreased with decreasing line width.

CONCLUSIONS

Strong {111} textures were observed in the pads and wide lines, while relatively weaker {111} texture combined with twin orientations was found in the 0.32 μm-wide lines. The reason for the observed behavior is due to the additional constraints in the narrow lines. Small line width alters the stress state in the lines and limits grain growth and the preferential texture.

The elastic moduli used to this point have assumed a biaxial stress state, while the problem being dealt with in trenches involves triaxial stresses. The minimum energy {100} texture due to strain energy considers only the biaxial modulus. Since the stress states in narrow lines are largely triaxial, a bulk modulus should be used in future simulations.

REFERENCES