Electrochemical View of Copper Chemical Mechanical Polishing Process

Vimal Desai and Tianbao Du

Advanced Materials Processing and Analysis Center
University of Central Florida
Orlando, FL 32816

Copper is regarded as the material of choice for interconnects in integrated circuits (ICs) manufacturing due to its low resistivity and high electro-migration resistance. Integration of copper into an IC manufacturing process can be implemented by using the dual Damascene technique [1,2], in which chemical mechanical polishing (CMP) technique has been applied to remove the overburden material and planarize the wafer surface. There are several challenges that must be overcome before copper can be fully used in integrated circuit technologies. Although the CMP of copper has been investigated extensively in recent years, which can be conducted in either acidic or neutral or alkaline media [3,4], the CMP mechanisms of copper is still not fully understood due to the poor electrochemical characteristics of copper. Electrochemical dissolution plays a very important role not only in acidic slurries but also in alkaline slurries with complex agents. Therefore, the present investigation was aimed at studying the CMP characteristics of copper and tantalum in various dynamic and static conditions by using electrochemical techniques as well as surface analytical techniques. The electrochemical behavior of Cu and Ta in the test solutions, topography of dissolved surface, and mechanism of Cu and Ta CMP will be discussed.

The work was carried out using bulk copper and tantalum target 1” in diameter and 0.25” in thickness. The effect of several chemical parameters (oxidizer type, concentration, pH etc.) was studied through static and dynamic tests using advanced electrochemical techniques and surface analysis techniques. Electrochemical measure- ments were performed using *in-situ* open circuit potential, potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) methods. The surface chemistry and morphology of static etched samples were characterized by using a Perkin-Elmer 5400 PHI ESCA (XPS) and JEOL 6400 F Scanning Electron Microscopy (SEM). The surface planarity study was performed by Digital Instruments Dimension^{TM} 3100 Atomic Force Microscope (AFM).

Our electrochemical and CMP results indicate that:

(1) At pH 4, the copper removal mechanism changes from electrochemical dissolution at low peroxide concentration to mechanical abrasion of oxide film at high peroxide concentration.

(2) At 5% peroxide concentration, copper removal rate decreases with an increase in pH and reaches a minimum at pH 6, and then it increases under alkaline conditions.

References:

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