CONTEMPORARY METALLIC MATERIALS

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Chapter 006

Influences of Additives on Copper Film Quality and Gap Filling Capability of Plating Process

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Abstract: In this work, investigations of the effect of additives such as suppressor (S) and accelerator (A) on the deposition rate and gap filling capability of plating process were carried out by cyclic voltammetry stripping (CVS) analysis, FIB, TEM and FESEM. In addition, the impact of additives on physical characteristics of electroplated Cu film was also studied. We found that CVS analysis was very useful in predicting and explaining the change of the plating process with different electrolytes. Cu film with big grain, rough surface finish, and poor gap filling was observed for Cu sulfate electrolyte (CSE). Addition of A alone has minimum effect in altering the plating process. Addition of S alone, however, changes both the plating process and Cu film characteristics. If the plating is done in CSE with both S and A, the electroplating process gives bottom up growth (BUG) and the Cu film consists of very fine grain microstructure with a very smooth surface. We also observed that the onset of the BUG process and BUG rate are strongly dependent on the concentrations of S and A.

Introduction

Cu electroplating has become a critical metallization process for the next generation IC device fabrication. It provides bottom up gap filling capability, high throughput and low cost of ownership [1-3]. As reported [4-8], with appropriate amounts of S and A, it can alternate the bottom up growth (BUG) process and lead to void free gap filling. Many researchers [9-12] have suggested different models to explain this BUG phenomena. In this paper, an in-depth characterization study is performed to understand the impact of different electrolytes on the deposition rates and the physical properties of Cu film plated on blanket barrier surfaces. These findings are also used to examine and to understand the gap fill capability of different electrolytes.

Experimental

In this work, electrolytes such as CSE, A_x + CSE, S_y + CSE and A_x + S_y + CSE were mixed and characterized using CVS technique. Among the electrolytes, CSE, 1ml/l A + CSE, 25ml/l S + CSE, 1ml/l A + 25ml/l S + CSE, 10ml/l A + 25ml/l S + CSE and 1ml/l A + 40ml/l S + CSE were used. This study was mainly focused on the Cu film properties and gap fill capability using contact opening with 2.5:1 aspect ratio and 0.2μm wide trenches. The Cu film was plated on 2cm x 2cm samples with 2000Å Cu seed/ 300Å TaN barrier/ 5000Å undoped SiO_2/ Si substrate. A current density of 10mA/cm^2, stirring rate of 400 rpm, and various plating times (10, 30 and 120s) at room temperature was applied for the plating process in a laboratory scale electroplating system. The grain size and surface morphology of