THE EFFECT AND DETECTION OF SHORT CHAIN PEGs IN COPPER DAMASCENE ELECTROPLATING PROCESS

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Copper damascene electrochemical deposition is commonly used in the metallization process of silicon wafers during the fabrication of ULSI integrated circuits. One of the major factors determining the quality of the copper deposit is the plating solution composition. In order to obtain continuously the proper deposit, plating tool operators strive, with the help of analytical instrumentation, to maintain the concentrations of all nominal components of the plating bath as close as possible to their target values. However, the presence of bath contaminants can destroy the plating tool performance even if the nominal bath components are on their target concentration levels. Contamination of the plating bath can be caused by the presence of foreign contaminants and/or the accumulation of degradation products of organic additives.

Surfactants like polyglycol ethers are often used as suppressors in commercial copper damascene plating bath. Although relatively stable in sulfuric acid plating solution, polyethylene glycol (PEG) chain can be cleaved, yielding shorter chain PEGs [1]. As the degradation progresses the concentration of short-chain PEG increases in the plating solution.

The purpose of this investigation was to develop a method coupling electroanalysis with chemometric techniques to detect the presence of bath contaminants before the plating performance is impeded. In order to study plating bath contamination, a system was developed containing an electroanalytical probe immersed in-situ, on-line in the plating tank.

In the research presented, the tetraethylene glycol (TEG) was chosen as a model degradation product. The shape of the recorded voltammograms was increasingly deformed as the concentration of manually administered TEG was increased (Figure 1). Employing numerous factor-analysis-based chemometric outlier-detection techniques [3,4,5], the TEG-deformed voltammograms were found outlying as compared to the training set consisting of voltammograms for contaminant-free plating solutions (Figure 2).

The chemometric quantification of the contamination-induced voltammogram shape deformation is correlated with the plating performance of the bath, serving as a base for establishing acceptance criteria of metallization solutions.

Figure 1. The effect of TEG on voltammograms obtained in the copper plating bath of nominal concentration.

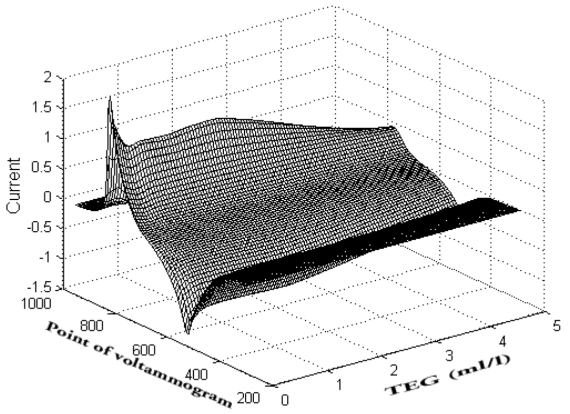

Figure2. Graphical PCA analysis of the copper plating bath w/o TEG (□ training set) and in the presence of TEG (▲).

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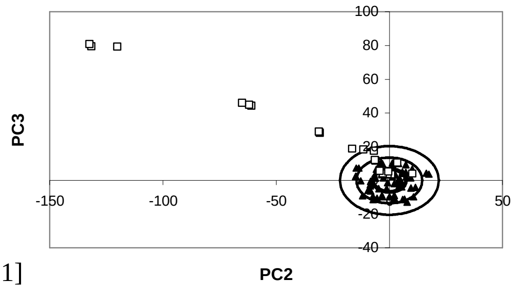

[1] Dietz, K.H. CircuTree, 13(3) (2000) 54.

[2] Bard, A.J. and Faulkner, L.R. Electrochemical Methods. Fundamentals and Applications. 2nd Ed., Wiley, New York, 2001.

[3] Sharaf, M.H.; Illman, D.L. and Kowalski, B.R. Chemometrics, Wiley, New York, 1986.

[4] Malinowski, E.R. Factor Analysis in Chemistry. 2nd Ed., Wiley, New York, 1991.

[5] Kramer, R. Chemometric Techniques for Quantitative Analysis, Dekker, New York, 1998.