Combination of AC Voltammetry and Chemometric Classification for Diagnosis of Disturbances of Electrodeposition Process.

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Electrochemical Deposition (ECD) has become a common metallization technique in both front-end-of-line (FEOL), and back-end-of-line (BEOL) stages of integrated circuits manufacturing processes. As ECD has entered new areas demanding higher standards and having increased expectations as compared to traditional applications, conventional univariate SPC (Statistical Process Control) methods are no longer sufficient. This presentation explores potential of multivariate SPC which allows maximizing the use of available experimental data (as compared to univariate SPC) for continuous chemical processes.

A system was developed utilizing a novel approach that combines advanced electroanalytical methods with graphical representation of various statistical discriminant multivariate data analysis techniques based on chemometric factor analysis. All measurements and calculations were performed using instrumentation and software custom-developed for this application.

An in-situ sensor employing AC-voltammetry techniques was designed [1] to provide a response strongly affected by various possible disturbances that are likely to occur in the real-life conditions and which may affect plating performance. These disturbances include a substantial increase or decrease in bath constituent concentrations beyond their normal operating parameters and are usually caused by control valve malfunctions A substantial deficiency of some bath additives can also be caused by improper new bath preparation or depletion of bath additive concentration due to active or passive consumption. Separate categories of bath disturbances are caused by the accumulation of degradation products, foreign contaminants, as well as out-of-target physical conditions of the plating process.

Similarities between measurements in proper conditions and measurements with upset behavior with known disturbances can be utilized to recognize a likely pattern of behavior. The shape differences between deformed and reference set voltammograms are quantified by MD-SIMCA (Mahalanobis Distance – Soft Independent Modelling of Class Analogy) [1,2] which elucidates the distinguishing characteristics of classes and provides both numerical and graphical analysis.

This presentation focuses on parallel development, training and subsequent validation of several classes distinctive corresponding to the proper calibration training set and to the disturbances of the copper electrometallization process caused by deficiency of chloride ion, excess of chloride ion, and foreign contamination with hydrogen peroxide, strong suppressor (different than the additive), and iron ions. Prompt diagnosis by chemometric classification analysis automates troubleshooting and therefore minimizes production time losses.

1. A. Jaworski, H. Wikiel, K. Wikiel, *Electroanalysis*, **2013**, *25 No. 1*, 278.

2. R. De Maesschalck, A. Candolfi, D.L. Massart, S. Heuerding, *Chemometrics Intell. Lab. Syst.* **1999**, *47*, 65.