Robust Multivariate Process Control of Multi-Way Data with Root Cause Analysis

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Abstract

The evaluation of the manufacturing process condition is a crucial challenge in modern semiconductor fabrication. With growing complexity large numbers of process variables are recorded during equipment operations of every process step. For monitoring these processes, traditional fault detection and classification methods were implemented, but they are mostly univariate. Multivariate techniques such as Principal Component Analysis and Hotellings T^2 are capable of advanced process control but are mainly applied on statistically calculated indicators such as means or standard deviations of one wafer over its process time. Thereby, information of the time variation of the variables is omitted. In this work, we present a generalized methodology for multivariate process control that considers the whole recorded information of a wafer by using multi-way principal component analysis (MPCA). The use of Hotellings T^2 statistics makes outcomes easy to monitor as it can be summarized into one control chart. By grouping similar variables into reasonable functional groups and by applying decomposition methods for the T^2 signal, a root cause analysis is possible. Furthermore, special attention is paid on the robustness of the MPCA and T^2 procedure as an analysis independent of frequently observed outliers is crucial. In a case study of production data from Austrian semiconductor manufacturer ams AG an observed production machine error can be detected and its root cause can be tracked down successfully.

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