APPLICATION NOTE

Using Multivariate Models for Practical Applications

INTRODUCTION

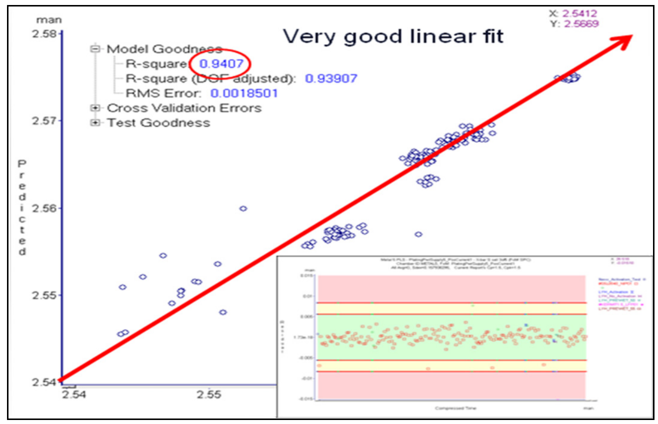
FabGuard® Integrated Process Monitor (IPM) has supported Multivariate Analysis (MVA) techniques for a number of years. While MVA use in the semiconductor industry has been experimental at best, there is an ever increasing desire to be able to predict metrology and other tool values accurately enough to detect excursions and possibly remove in situ metrology measurements. Under controlled environments, MVA methods such as Principal Components Analysis (PCA) and Partial Least Squares (PLS) have shown promising results for detecting excursions and predicting metrology.

USING PLS TO PREDICT ELECTROPLATE BATH CURRENT

Given constant bath chemistry, there should be an approximate linear relationship between applied voltage and the delivered current in an electroplate bath. For given bath conditions a PLS model can approximate the current given a voltage. This simple linear approximation can be used to compare against the actual current measured during the process to detect for changes in the bath properties or in coming substrates.

Significant differences between the predicted current and the measured current can highlight excursions or changes in the bath chemistry that require investigation. A report on the model residuals is used to make sure the voltage and current are both aligned with the expected resistance. (See Figure 1.) Deviation from the expected linear relationship may indicate an issue.

Figure 1 PLS model comparing voltage and current



USING PLS TO PREDICT IMPLANT ANALYZER MAGNET PERFORMANCE

The analyzer magnets in an ion implanter are used to separate out the desired charged species from an ion beam. A specific current is applied to the analyzer magnet to filter for specific masses. There is a linear relationship between the analyzer magnet current and the extraction voltage used for a specific mass and charge.

For each implanter a linear model can be built that will help predict the analyzer magnet current from the extraction voltage, mass, and charge. (See Figure 2.) This model can be used to determine if the implanter is having a tuning issue or a systematic issue/failure with the analyzer magnet. (See Figure 3.)

Figure 2 PLS model for predicting implanter analyzer magnet current

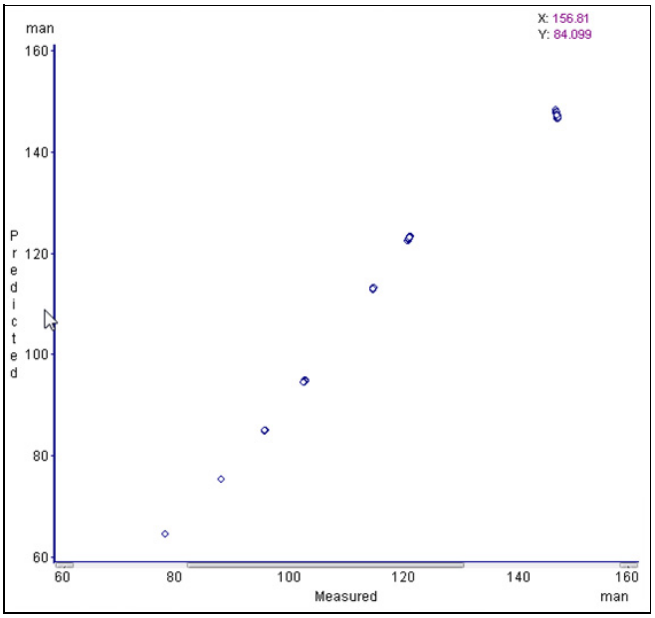
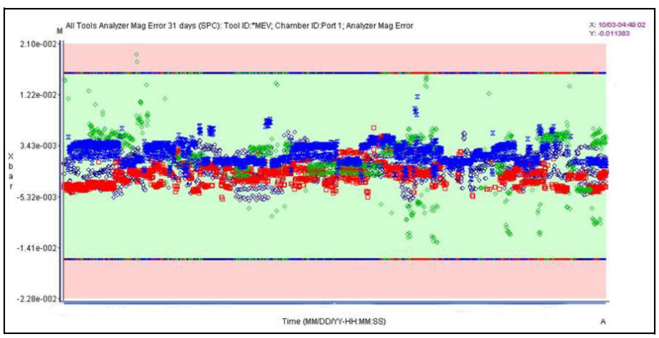


Figure 3 Resulting control chart showing deviation between predicted and measured magnet current



Models must be made for each implanter individually. This is due to differences in the analyzer magnet assembly and physical differences in the equipment. While this may appear like a lot of models, each tool only requires a single model and those models cover all the species processed through that analyzer magnet.

CONCLUSION

For the two applications discussed here, MVA methods have been shown to be effective for detecting excursions and predicting metrology. In particular, a single Implant Analyzer Magnet model is capable of providing fault detection across all operating regions of the equipment. In a typical fab, this model often provides subsystem monitoring for thousands of process recipes. Without MVA techniques, each recipe would have to be monitored independently for analyzer magnet excursions. Univariate techniques in this case would be impractical to configure and manage, resulting in increased risk to product.

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