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Process Fault Probability Generation via ARIMA Time Series Modeling of Etch Tool Data

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Semiconductor industry has been taking the advantage of improvements in process technology in order to maintain reduced device geometries and stringent performance specifications. This results in semiconductor manufacturing processes became hundreds in sequence, it is continuously expected to be increased. This may in turn reduce the yield. With a large amount of investment at stake, this motivates tighter process control and fault diagnosis. The continuous improvement in semiconductor industry demands advancements in process control and monitoring to the same degree. Any fault in the process must be detected and classified with a high degree of precision, and it is desired to be diagnosed if possible. The detected abnormality in the system is then classified to locate the source of the variation. The performance of a fault detection system is directly reflected in the yield. Therefore a highly capable fault detection system is always desirable. In this research, time series modeling of the data from an etch equipment has been investigated for the ultimate purpose of fault diagnosis. The tool data consisted of number of different parameters each being recorded at fixed time points. As the data had been collected for a number of runs, it was not synchronized due to variable delays and offsets in data acquisition system and networks. The data was then synchronized using a variant of Dynamic Time Warping (DTW) algorithm. The AutoRegressive Integrated Moving Average (ARIMA) model was then applied on the synchronized data. The ARIMA model combines both the Autoregressive model and the Moving Average model to relate the present value of the time series to its past values. As the new values of parameters are received from the equipment, the model uses them and the previous ones to provide predictions of one step ahead for each parameter. The statistical comparison of these predictions with the actual values, gives us the each parameter's probability of fault, at each time point and (once a run gets finished) for each run. This work will be extended by applying a suitable probability generating function and combining the probabilities of different parameters using Dempster-Shafer Theory (DST). DST provides a way to combine evidence that is available from different sources and gives a joint degree of belief in a hypothesis. This will give us a combined belief of fault in the process with a high precision.

Keywords: Fault detection and classification, ARIMA