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Developing smart FDC algorithms with domain knowledge and statistical methodologies

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As semiconductor fabrication technology progresses, we're facing tougher challenges from N40 and beyond. To achieve the engineering requirements of such delicate wafer productions, we have to put more restrictions on manufacturing operations, inspect tools with more items, enhance metrology capabilities and so forth to comprehensively tighten specifications of inline/offline/WAT/CP. Since production tools have direct impacts on wafer qualities, strict and effective monitoring and control of tool stability is definite the first task in hand we need to deal with.

The variation and differentiation of tool conditions in different production time periods, may induce unpredictable and unexpectable disturbances to process performances. For example, the lamp modules of a tool in EPI process would age over time and it usually results in unstable WtW even WiW performances in offline SPC charts when a lamp module gets close to the end of its lifetime, as shown in figure 1. Engineers may have to regulate the tool additionally and frequently to compensate the aging effect until lamp burns out unpredictablely. In order to prevent tools from biasing for any possible cause, we need to develop FDC algorithms to characterize tool information, detect excursions and diminish false alarms with much more effective and robust methods.

A good FDC algorithm we suggested should satisfies the ground rules listed below:

Rule 1: Automatically identifies abnormities

Rule 2: Adjustable sensitivities to warning signals

Rule 3: Combine with domain knowledge and easy to be maintained by users

In Rule-1, a smart FDC algorithm should be able to automatically identify abnormal behaviors of a tool. The definitions of abnormities can be given statistically, such as significance levels, or simply defined by users. So that it can provide a full-time protection without extra efforts of an engineer. In Rule-2, we strongly suggest that a good FDC algorithm should always come with a tunable sensitivity to possible warnings. Different levels of warning signals should be properly handled and filtered before triggering a real alarm. In Rule-3, we suggest that it will be much better to combine statistical methods and domain knowledge to enable a real time online FDC algorithm.

We have successfully demonstrated a case in N28 EPI tools for lamps monitoring. In this case, the Lamp modules show significant variations in certain FDC charts which are characterized and detected by the proposed algorithm shown in figure 2. The results in figure 3 reveal promising evidences to monitor tools qualitatively and quantitatively.

Figure 1. Lamp burn-out issue

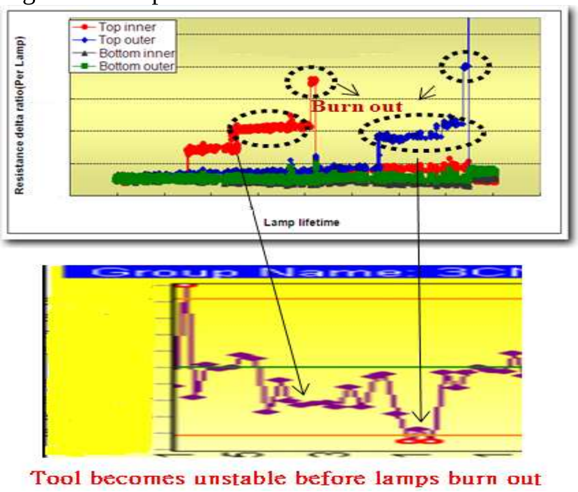

Figure 2. Example of proposed FDC algorithm in EPI

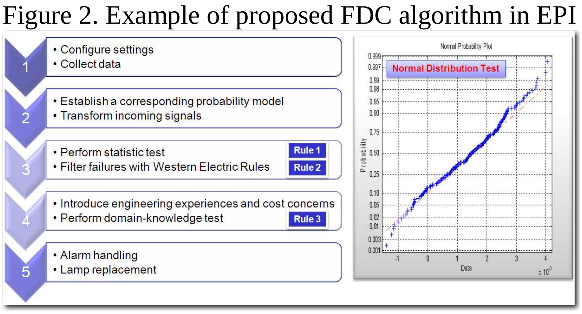

Figure 3. Example of N28 EPI