Data-driven resolution of processability issues in technology scale-up

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During a technology industrialization, a processability issue has been critically analyzed and possible factors have been rationalized. By focusing on detection strategy, a methodology to address the solution was defined and improvements evaluated. Indeed, not relevant issues during development phase can have a significant impact upon new technologies industrialization as production volumes increase. The low frequency occurrence makes it difficult to correlate with a specific cause and a trial-and-error approach is inefficient. However, by performing attentive data analysis, the effects of corrective actions can be evaluated, reducing the number of required trials.

During the industrialization of a technology, a processability issue was observed in barrier and seed PVD deposition process due to sequencer failures. The process is done on multichambered cluster. When the handler moves wafers from and to different chambers, it determines whether the wafer is centered in the expected position or adjustments have to be made. The required adjustments are represented by the LCF (Local Center Finder) value in µm: when it exceeds 2500 µm, the tool shows a warning, when it exceeds 5000 µm, the tool issues a fault and wafer movement stops.

A first impact assessment was performed to address the magnitude and frequency of the faults. The worst performing tool exhibited ca.1% failure rate, resulting in 12 failures/day estimation in a scenario where only this technology is processed. To better understand the problem, a dedicated FDC (Fault Detection Control) was developed to extract and analyze LCF data for all wafers from every chamber. This data analysis enabled comparison of the failing parameter across different technologies, improving the process of root cause identification and providing a method to evaluate problem resolution effectiveness of corrective actions.

Comparing the failing technology to a reference technology, LCF data resulted more dispersed for the failing one as shown in Fig. 1. Comparing different chambers used in the barrier/seed process, only the ones using electrostatic chucking during the process were found to determine the increase in the LCF spread and cause the faults. Based on industrial knowledge of processability problems in chambers with chucks, different trials were proposed and evaluated by changing parameters related to de-chuck values. Chucking efficiency depends on various factors, such as differences in the wafer's back composition, which could also explain the different behaviors by technology. Dependence on specific substrates makes reproducing the problem difficult, as test wafers are not representative and only production lots can be used.

Trials were conducted to evaluate an improvement in the LCF data. As shown in Figure2, trials performed on chamber type "A" never lead to processability issue indeed LCF data distribution almost halved by reducing it below the warning value while for the chamber type "B" new trials have to be performed.

An effective approach to face with processability issues has been developed, including the definition of an effective detection strategy, of proper test vehicle and trial protocol, as well as a methodology for attentive data analysis and for setup of process optimization trials. Accordingly, a best practice has been acquired and it will be applied for all new technologies introduction.

References

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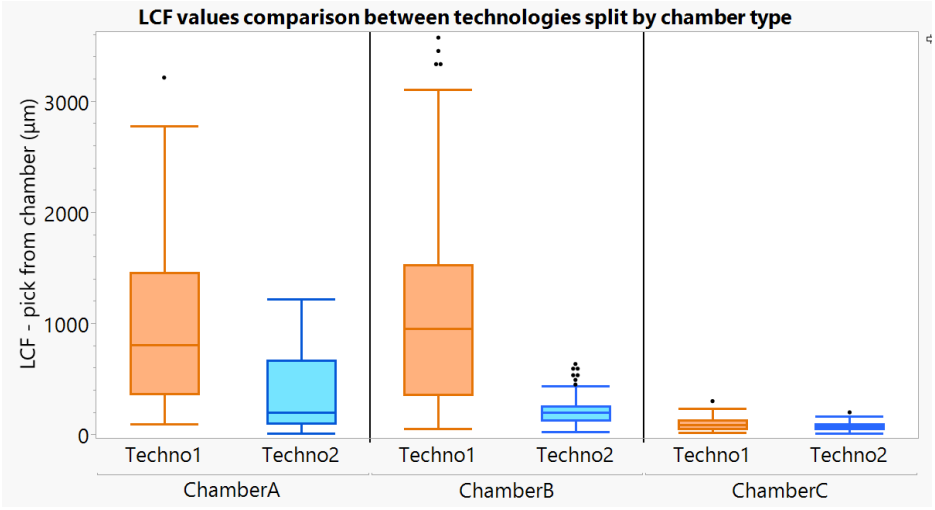

Fig. 1: LCF values extracted for two different technologies and plotted split by different chambers used in the barrier/seed process. Techno1= failing technology, Techno2= reference technology

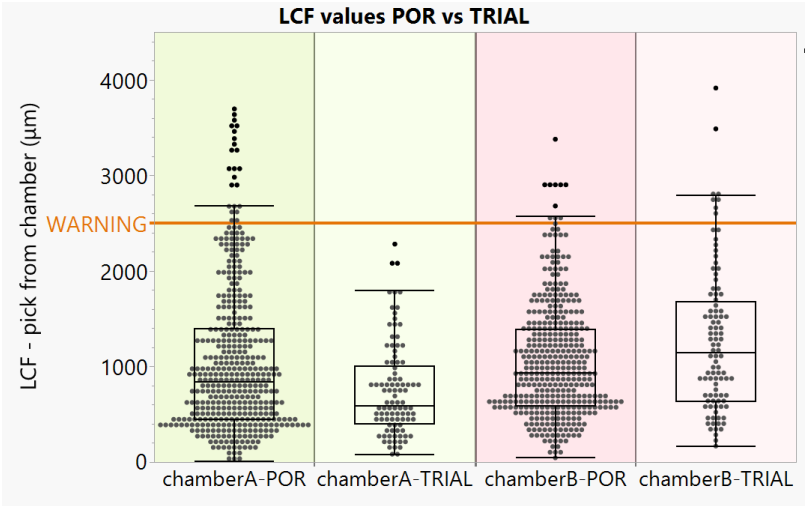

Fig. 2: LCF values collected from 430 samples by using POR recipes and 85 samples from TRIAL recipes divided by chamber type "A" and "B"