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New Predictive Maintenance Method for High Volume Manufacturing Environment Prevents Wafer Handling Malfunction

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Abstract

Wafer handling issues are responsible for about 30% of the overall yield loss in the fab. Collision, skidding, rubbing and abrupt lifting and chucking cause wafer breakage, edge and backside defects. Any mechanical contact with the wafer is suspected to generate particles. The more aggressive such contact is, the higher the particle size and count are likely to be. In addition, troubleshooting and reactive maintenance of those handling issues impacts tool availability and disrupts production. Periodic monitoring of the entire wafer handling system by means of an instrumented wafer (Smart Wafer) has been shown to pinpoint the root cause of such issues and confirm the effectiveness of a corrective action taken. This method has been adopted and implemented by leading IC manufacturers and equipment suppliers. However, until recently, complex setup and high level of expertise required to acquire and analyze the data have limited its usage in high-volume manufacturing environment. The new method described in this paper offers enhancements that overcome those limitations.

When diagnosing wafer handling problems, it makes perfect sense to examine the various mechanisms and motions from the wafer's point of view. Traditionally this has been done by running batches of dummy wafers and watching for any event or evidence of trouble, such as scratches and particles. This method is somewhat analogous to a field commander checking a suspected route for an enemy ambush by sending soldiers through it and watching for casualties. A "Smart Wafer", instrumented with multi-axial accelerometer and autonomous data logging capabilities, is the equivalent of a robot equipped with cameras and sensors sent to scout that route. Such wafers were introduced over 3 years ago, and have been proven to detect not only occurrences of mechanical contact and excessive impact, but also provide tell-tale data about bearing deterioration and minute misadjustments. This data is the equivalent of an electrocardiogram in enabling early detection of developing heart problems. This early detection supports shifting from both reactive and preventive into predictive maintenance, triggering corrective actions when and where needed and avoiding unscheduled downtime. The benefits are improved tool MTBF and availability, reduced unscheduled downtime and spare part inventory, as well as the elimination of disruptions in production runs.

Unlike dummy wafers, which can be stored, loaded and returned to any FOUP, a smart wafer must interface with its dedicated docking station before and after each run. The docking station downloads the stored data and recharges the battery toward the next run. In the existing method the smart wafer is manually loaded from the docking station into a FOUP. This operation requires a special tool for opening the FOUP. It has to be done in a specific area in the clean room, and the wafer needs to be cleaned before the run. In contrast, the docking station in the new method is integrated into a dedicated FOUP. The data is downloaded and the battery is recharged via induction, with no mechanical contact. Hence the smart wafer never leaves its clean environment, no particles are generated and the tool can return to production immediately. The raw data recorded in the old method required expert analysis to return a meaningful diagnosis. The new method employs simplified routines that even a novice technician can analyze and act upon. The paper explains how these enhancements in the new method make it suitable for implementing in a high volume manufacturing environment without interfering with the normal production flow.

This ease of implementation opens more applications for the new method. Gathering periodic readings of every tool on the floor supports historical tracking and comparison of similar tools, enabling closer tool matching for tighter process and equipment control. It also allows harnessing the power of AEC (Automated Equipment Control) for managing the entire line through the central factory data system. Collaboration between the tool manufacturer and the user in sharing typical vibration signatures and indicative signals may facilitate reliable diagnosis and remote assistance. In the long run such collaboration will inevitably contribute to improving handling system designs and enhancing yields.

The paper reviews the enhancements of the new method over the background of the previous one, highlighting new applications in contrast to the already proven uses. Photographs and diagrams explain the principles of operation. Actual vibration readouts demonstrate the method's sensitivity to mechanical issues and potential value as an essential tool for monitoring the production equipment bill of health.

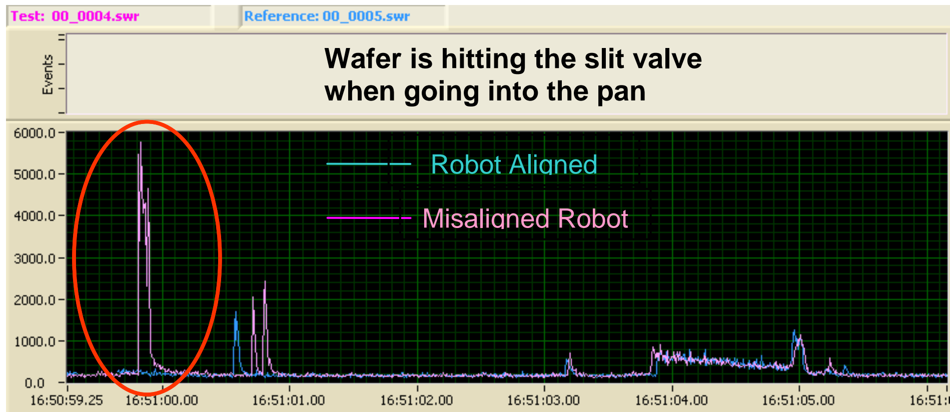

Figure 1: Verification of correct robot alignment

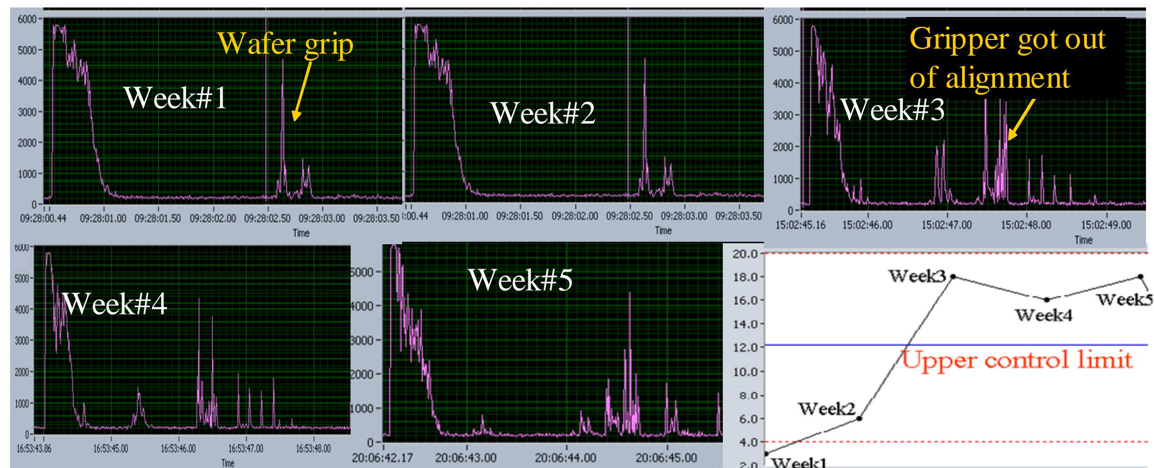

Figure 2: Week to week tracking enabled early detection of wafer gripper misalignment

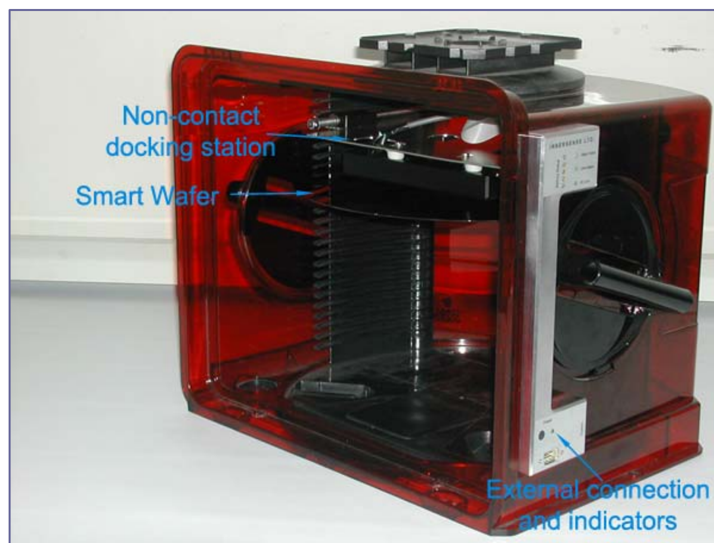

Figure 3: Smart Wafer docking station in a dedicated FOUP