Real-time Wafer Inventory Quality Assessment Using FDC Data

Tom Ho / Gabe Villareal / Weidong Wang / Joe Lee
tomho@bistel.com / gabevillareal@bistel.com / weidongwang@bistel.com / joelee@bistel.com
BISTel America, Inc.
3151 Jay Street, Suite 201, Santa Clara, CA 95054, USA
Phone: +1 -408-855-8212 Fax: +1-408-855-8213

Motivation

In semiconductor manufacturing, metrology testing is implemented to identify potential problems so that the process can be maintained for high quality products and optimal yield. These tests are typically done in samples that are supposed to represent the wafer population. However, depending on the sampling size, one cannot guarantee the quality level of every wafer in the entire wafer inventory. Increasing metrology test coverage and sample size could help to increase the confidence level, but it would also add significant cost to production, increase handling, and increase production cycle time.

For a manufacturer to be certain of the quality level of their wafer inventory, they must have visibility on real-time quality information for every wafer throughout the manufacturing process.

Solution Approach

To address the above, the proposed solution focuses on two key values:

1) Quality assessment of every wafer in the inventory

2) Real-time wafer quality assessment at every process step

The fundamental concept of the solution is to use existing streaming sensor trace data from the processes as signals to forecast the end quality of a product. At each process step, sensor data from each wafer are compared against data from peer wafers to detect process variations. With the premise that the majority of the wafers (90+%) would yield good products in an established production line, the method of comparing sensor trace data amongst peer wafers provides an efficient way to assess sensor data quality. During this process, the solution examines sensor trace data from a previous group of wafers and intelligently establishes a “dominant group” as baseline which is used as the comparison reference model for the upcoming wafer. Advanced techniques that are used in determining the dominant group include Dynamic Time Warping (DTW) and Dendrogram. This is done dynamically in real-time for every wafer in every process step.

Once the sensor trace comparison is completed for a wafer, a corresponding quality assessment score is assigned to that wafer which is an aggregation of all the sensor quality scores during the processing of that process step. To calculate the quality score, a normal-distribution-like methodology is utilized. Scoring is based on an analogy scale from 0 to 1, where 0 indicates that the wafer data are the same or very close to the data from the dominant group, and the score of 1 indicates the opposite (see Figure #1). An overall quality score is also continuously calculated for each wafer by aggregating all the available step scores as the wafer goes through the production process. This overall score provides a measurement for an engineer to gauge the quality of that wafer no matter where it is in the process.

Solution Scope

This solution is designed to be process and product independent and can be applied to a variety of wafer production applications. Since the objective of the solution is to provide real-time quality assessment information on each individual wafer in inventory based on its own sensor trace data, this solution is more appropriately suited for single-wafer processes. It is possible to apply the solution on a batch-wafer process; however, the accuracy of the quality information would be degraded.

Results

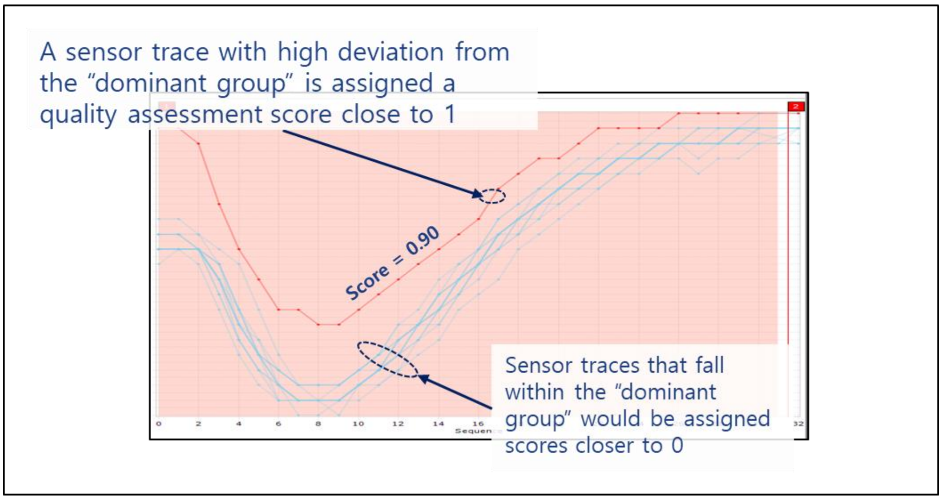
By using this solution, quality information on every wafer in production can be made available which provides a complete view of the entire production inventory in near real-time (see Figure #2). This allows engineers and managers to make timely process and production adjustments to assure end quality for every wafer.

Furthermore, based on the assessment scores of the wafers in process, engineers can more intelligently select sample wafers for metrology testing; for example: perform testing only on wafers with questionable quality (those with scores close to 1). This will improve the value of sampling and potentially reduce the number of needed measurements.

Lastly, since the solution leverages existing FDC data, there is no addition hardware or system modification required, making this a cost-effective complementary system to any existing metrology practices.

Next Step

Future work will include incorporation of the capability to validate quality assessment scores and to identify the attributing yield impact parameters. This will help to further increase the precision of the quality information.


A sensor trace with high deviation from the "dominant group" is assigned a quality assessment score close to 1

Sensor traces that fall within the "dominant group" would be assigned scores closer to 0

Figure #1: An illustration on how Sensor Quality Assessment scores are determined

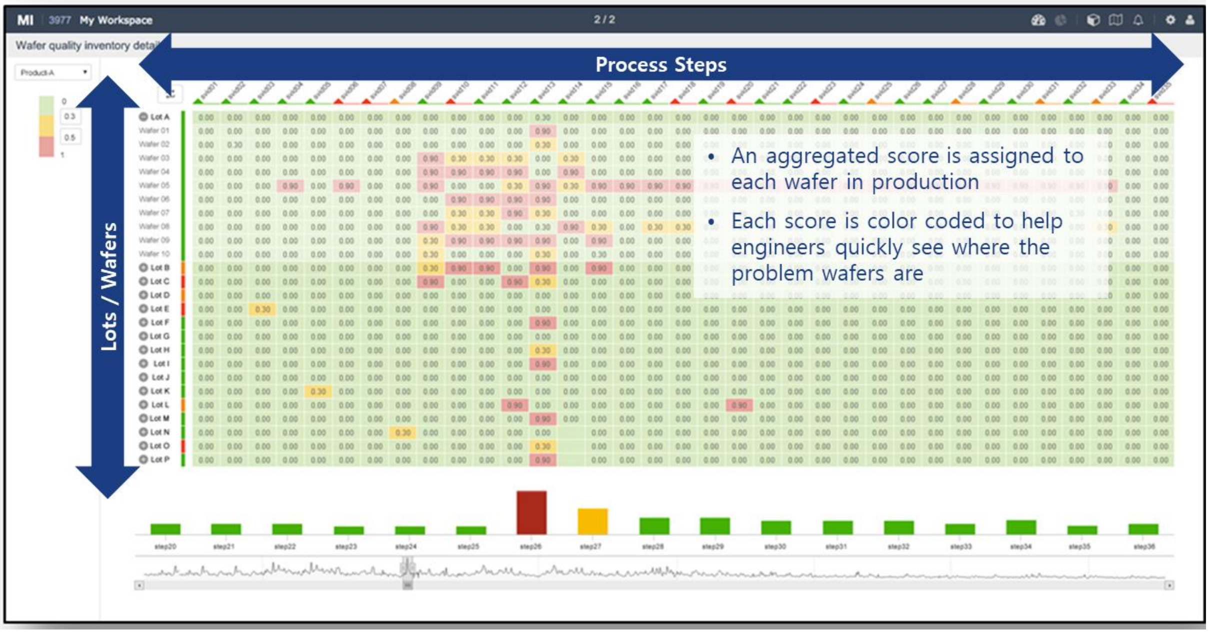

- An aggregated score is assigned to each wafer in production
- Each score is color coded to help engineers quickly see where the problem wafers are

Figure #2: Example screenshot of the proposed solution which provides visibility on real-time quality assessment information on the entire wafer inventory