Optical Defect Investigation and Drill Down Automation

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Abstract

Determining the cause of defects can be elusive and many go unidentified. By combining tool data collection and advanced analytics, the source of defects can be identified and intervention controls added to prevent their re-occurrence. An advanced analytical package able to identify yield loss patterns and assign a score similarity gives results more quickly than an engineer manually examining data. This APC process is a relational data base.

INTRODUCTION

Fab tools have greatly increased the amount of data collected during processing. This has given rise to guardbanding tool settings to prevent loss due to excursions. Default or common sense limits are typically applied to prevent the tool from running atypically. However, yield loss may occur from smaller tool variations and with no correlation identified there is no justification to further tighten tool guardbands. Correlating yield loss to a processing parameter is difficult when there could be hundreds of reported parameters at each processing step. An engineer may investigate several key tool settings, but is unable to exhaustively eliminate all settings at each processing step.

Variations in the processes do occur and determining which variations effect yield can be difficult. This is where the tool trace database and advanced analytics join to identify correlations between tool data and yield data. Use of process monitors and advanced analytics provides the engineering tools to rapidly detect yield influencing anomalies and help find solutions to improve tool repeatability. Our goal is to rapidly identify the process variation that correlates to yield loss and to decrease the amount of time required to identify a defect cause. In these cases the tool trace DB was interfaced with BISTel eDataLyzer (eDL) analytical package to perform the analysis.

Figure 1 is one example of a yield loss pattern. For the most part, an engineer can see this pattern and it resembles a familiar chuck pattern on several toolsets. Its cause went undetermined as it intermittently appeared and subsided.

Fig. 1. The pattern is an OI yield loss pattern identified by eDL.

Figure 2 is an example of a yield loss event that occurs within lot. It therefore is not a tool to tool variation and is likely a tool excursion type issue.

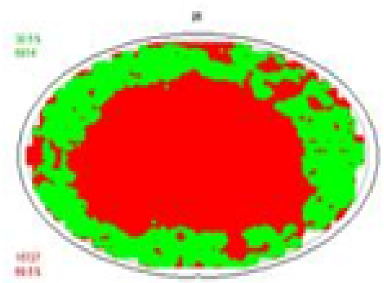

Fig. 2. Yield loss pattern appearing on a few wafers in a lot.

Figure 3 is an example of an electrical response outlier. Again, it is a within lot issue categorizing it as a tool excursion issue.

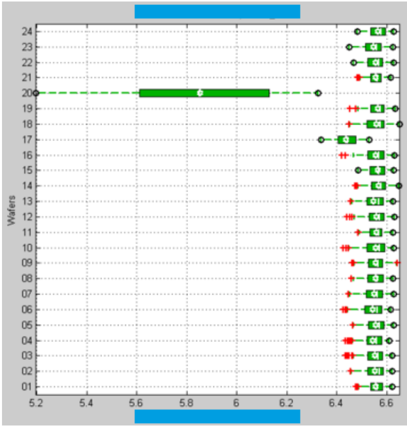

Fig. 3. An electrical outlier wafer.

BACKGROUND

For some problems, defect appearance in the line and the type of problem will indicate where to look and narrow the number of possible causes. This is the most common way of beginning to determine the root cause of processing problems. These methods do not always work or the problem can't always be narrowed down to a limited part of the line. In these cases, the search can encompass thousands of tool parameters and hundreds of processing operations. This is a circumstance where integrated trace data and advanced analytical tools can narrow the field of possible defective steps quickly.

These systems still require engineering knowledge to know what to filter out and what to consider when examining correlation results, but can eliminate a significant portion of the collected data as not statistically significant. BISTel EES is the tool trace collection software and BISTel eDataLyzer (eDL) is the analytical software used.

FDC ANALYSIS

Tool data traces integrated with eDL software analysis was the primary data and analysis methods used to investigate the defect issues shown above. The eDL tool has built in data acquisition and analysis packages. A manual importing of data was also used to interface with eDL for analysis.

CASE 1

The first case was an automated importation of optical inspection (OI) defects from the eDL interface with the database. During routine yield loss analysis, a pattern of loss was identified in several wafers (Figure 4).

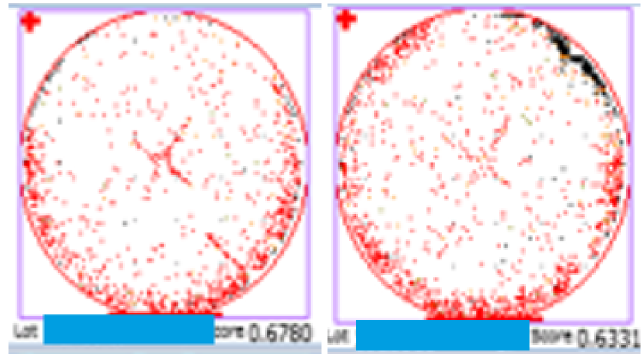

Fig. 4. The pattern is an OI yield loss pattern identified by eDL.

The 'X' pattern at the center of the wafer looks similar to several chucks in the fab. The pattern appears as a discoloration and in an area that encompasses many processing layers. The software statistical algorithm returns results that are scored and ranked to how similar the pattern is between wafers. The pattern was identified by eDL software and wafers were given a similarity score for analysis purposes. That yield loss pattern is then defined as an input parameter for further drill down. When this OI pattern was compared to the trace data many possible correlations were returned. The advantage of using this analysis was that the entire lines processing data was examined and the top probabilities were returned in 30 minutes rather than an entire day or multiple days of manual searching. As stated previously, many results were dismissed by engineering as unlikely or not related, however, many were worth investigating. In this example, the chart (Figure 5) that lead to the root problem was the 211th rank. Even this level of ranking required only a few minutes of review to highlight as a potential candidate.

Fig. 5. A correlation results chart in eDL software. This shows a time correlation turn on between wafers that have a high OI correlation score and lower scores.

This led to the investigation of the etch tool and the discovery that a throttle angle change over the tools maintenance cycle influences the OI patterns appearance. It also prompted a modeling of the throttle valve angle and including it in maintenance guidelines.

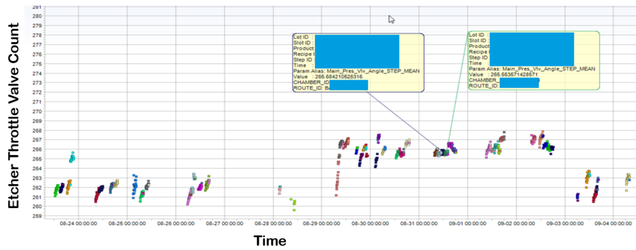

Fig. 6. A graph of ether throttle angle vs time.

CASE 2

The next two tests utilized the manual importation of data for analysis. The software allows for the manual importation of different data types. For this analysis a simple good bad flag was used to find single wafer outliers. The advantage is that a single lot can be investigated very quickly to find a tool excursion in the middle of a single lot. The first example is an investigation into yield loss within lot. The variation across lot is very low throughout the line. When individual wafers become yield outliers it is indicative of mishandling, tool excursions, and pilots. So the 3 wafer yield loss shown in Figure 7 was a good candidate for this sort of test. A csv file was created where all good wafers were tagged as good and bad wafers were tagged as bad. This file was imported into the eDL software and trace data collected by the software for analysis.

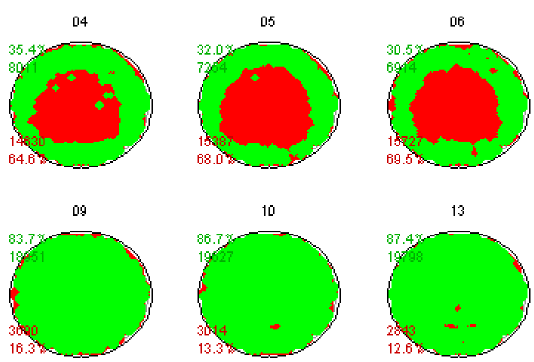

Fig. 7. Three outlier wafers flagged for investigation. They are shown adjacent to typical yielding wafers.

The analysis in eDL gave several probable results and several of them were investigated. The 12th ranking result showed a large separation in tool response vs good and bad wafers. The results are shown in Figure 8 below.

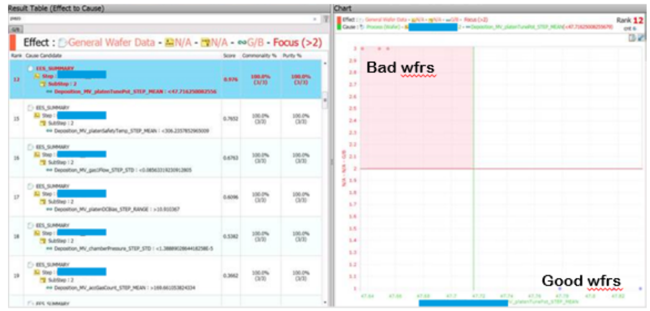

Fig. 8. eDL results showing 3 wafers far out of normal distribution for tool parameter.

The tool parameter chart was investigated and a drop occurred just prior to the processing of the 3 wafers in question. Additionally, a small drop was seen later in the lot and although those wafers were not under investigation they also had an electrical response and smaller yield drop. Equipment engineering was shown the response and began an investigation into the erratic behavior.

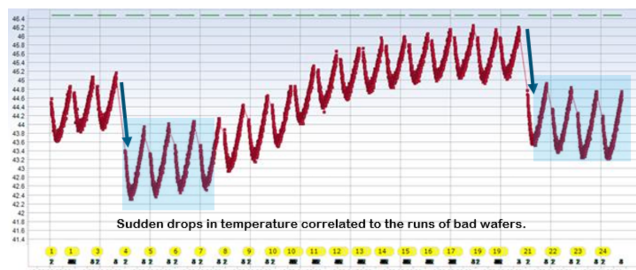

Fig. 9. Graph of the tool parameter and a sudden drop occurring two times within the lot.

CASE 3

The final example is similar to the second example. In this case another manual importation of data was used and a single wafer highlighted for analysis. In choosing a single lot the analysis is exceptionally fast and will not be influenced by lot to lot variations.

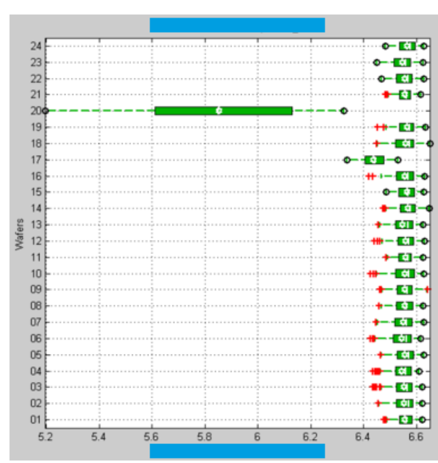

Fig. 10. Strong electrical response in a single wafer.

The results of this analysis gave very few statistically significant responses and the 2nd response (Figure 11) showed a large separation in the tool parameter.

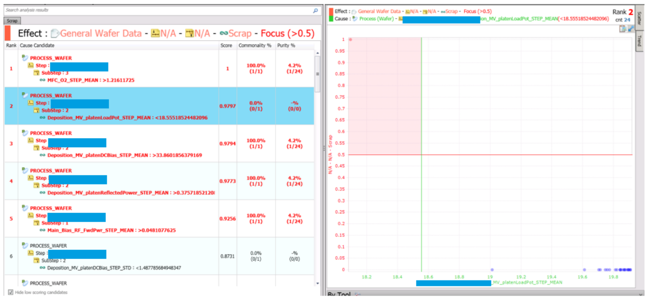

Fig. 11. eDL results showing that wafer far out of normal distribution for tool parameter. Drilling down to the tool parameter traces there was a large drop in the electrical parameter when a large delay time between processing caused a drop in temperature. This interruption was correlated back to the tool operation and rules were added to processing habits to prevent future excursions like this one.

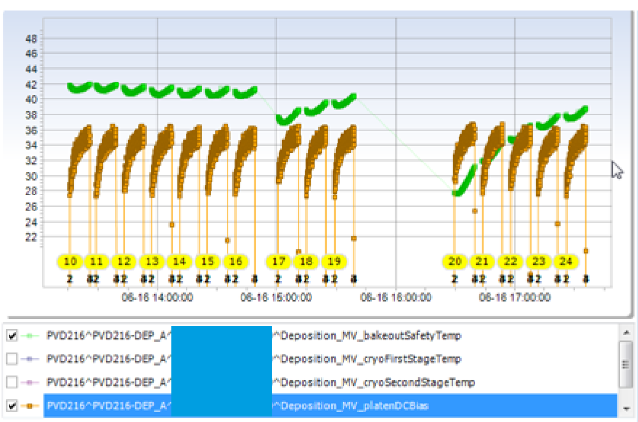

Fig. 12. Graph of the tool parameter and a sudden drop occurring two times within the lot.

CONCLUSION

In this work we showed that by using eDL analyses with tool trace collection we could investigate yield more easily and drill down to root cause loss more quickly. The first case analysis took about 30 minutes to identify and the last two cases were identified in 10 minutes each.

In all three cases the results lead to tool variations or excursions that would have been difficult or time consuming to identify and lead to new tool limits and tool improvements to prevent future excursions.

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ACRONYMS

FDC: Fault Detection and Classification
BAW: Bulk Acoustic Wave
APC: Advanced Process Control