Real-Time Vibration Monitoring Optimizes 200 mm Equipment Productivity

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Abstract

Increased equipment productivity is key for 200 mm fabs to realize profitability goals. This is true especially because some products won't be transitioned to 300 mm production; therefore, equipment at these 200 mm fabs will need to keep running at optimum levels to reduce wafer scrap and achieve maximum yields. It is becoming increasingly imperative that process and equipment engineers be armed with a new set of solutions for monitoring equipment vibration and acceleration that provides a better feedback loop for controlling equipment conditions in order to accelerate yield improvements, and to reduce machine downtime.

As the semiconductor industry gears up to support the exploding demands in automotive, consumer and cell phone applications, it is becoming increasingly imperative that tool and process reproducibility be controlled to tolerances never previously required in order to achieve greater yields. These tighter tolerances have driven the need to scrutinize legacy methods for monitoring equipment and to investigate new methods for ensuring tool matching and greater productivity in 200 mm fabs. Among the key areas being investigated are process equipment vibration and acceleration.

A fab's critical process tools must meet very strict tolerances. They are also highly sensitive to vibration; therefore, continual monitoring to confirm their precision is needed. However, semiconductor process and equipment engineers have not routinely monitored wafer process equipment vibration and the speed and accuracy of wafer handoffs as part of an ongoing predictive maintenance program.

During vibration analysis, readings are compared with past levels, with significant changes indicative of developing machinery problems. Thus the objectives of vibration and acceleration monitoring are fourfold: 1) to set baselines for optimum performance; 2) ensuring that equipment is running smoothly at optimum speed and uniformity across the wafer production process; 3) providing valuable lead-time for maintenance planning; and

4) addressing problem areas as quickly as possible to realize more productive tool time.

Where robots and stages are used to move silicon wafers, the force used to accelerate these can vibrate equipment and cause a shift in the payload, particle contamination, and damage to the wafers. Even small vibrations from traffic, workers or nearby machinery can have serious consequences that include:

- Wafer damage
- Particle contamination
- Increased equipment downtime
- Increased maintenance burden
- Process nonconformity
- Increased defects and reduced yield

Equipment that causes wafer damage or fails particle qualifications due to excess vibration must be taken off line and re-qualified, slowing down the manufacturing process. This makes equipment vibration and acceleration a key performance factor in the semiconductor fab. As a result, there is a critical need for new metrology tools that deliver precise and objective measurements to pinpoint vibration problem areas in real time.

Wireless Metrology Devices Speed Equipment Monitoring and Calibration

Until now, monitoring was done by manual, time-consuming processes. Balancing tasks took several hours to complete, and relied almost entirely on the practical experience of the maintenance staff. Moreover, manual monitoring provided no feedback or means for the data to be stored and saved for future in-depth analyses.

Recently, innovative new wafer-like sensor systems, such as the WaferSense™ Auto

Figure 1. WaferSense™ Automatic Vibration System – 300mm Sensor/200mm System

Vibration Systems (see Figure 1) developed by CyberOptics Semiconductor, have become available and are being adopted by 200 mm fabs (as well as 300 mm fabs) to enable engineers to troubleshoot wafer-handling equipment and robot issues before wafers even enter the systems. These wireless metrology devices offer substantial improvements over current methods of equipment vibration and acceleration monitoring by giving fab engineers the ability to quickly and accurately qualify and recalibrate tools. Moreover, they provide the ability to document the data in real time.

These vibration devices can help control parameters affecting yields that previously went unmonitored. They pinpoint problem areas that could cause potential wafer damage, and enable fabs engineers to set precise baseline standards for equipment as well as predict maintenance issues before they occur. These vibration-sensing systems take equipment monitoring and analysis to the next level of performance, both by identifying problems sooner and by slashing the time it takes fab engineers to make adjustments.

Wireless, wafer-like systems are designed to move through semiconductor process equipment and automation material-handling systems like a 200 mm or 300 mm wafer. As these tools follow the path a semiconductor wafer would take as it moves through the processing flow, their built-in sensors monitor three-axis accelerations and excess vibrations, capturing and relaying data in areas where slides, slips and bumps can damage wafers.

The vibration system's built-in software allows data to be reported in real-time via Bluetooth™ to a computer or laptop where the GUI collects and displays this data in a form similar to an oscilloscope's (see Figure 2). Once the location or absence of damage-causing or contamination sources has been identified, equipment speed or

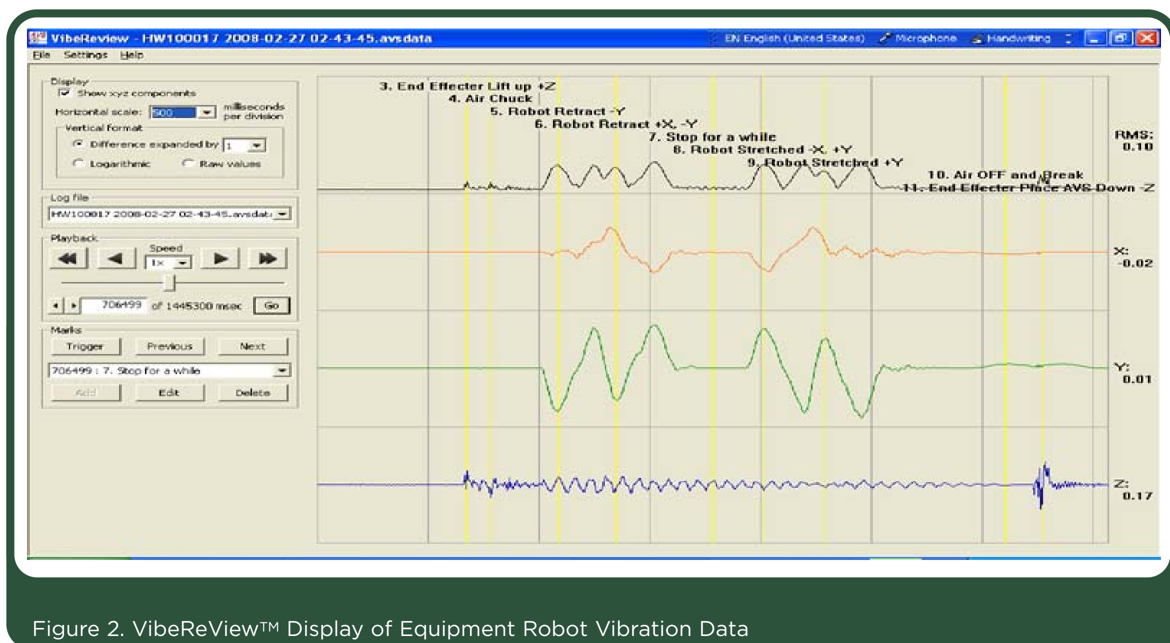

Figure 2. VibeReView™ Display of Equipment Robot Vibration Data

alignment can be adjusted and motion parameters optimized. Fab engineers can use this data to set baseline performance, save it to the computer for analysis and periodically monitor and compare data for changes.

The benefits of such a wireless vibration-monitoring system are numerous. The monitoring device can observe conditions inside the tool to identify potential problem areas much sooner than has been possible with wired or manual measurement devices. It allows fab engineers to seamlessly monitor process equipment on an ongoing basis, see the effect of adjustments in real time and speed equipment alignment and setup by hours. With the ability to save, file and compare vibration and acceleration data, maintenance engineers can compare current readings not only to historical data, but can compare one tool to another to determine the optimum performance parameters.

Characterizing PM Frequencies

Fab engineers charged with ensuring that wafer-processing equipment runs ever-more smoothly and productively will find that these vibration-monitoring systems provide objective, measurable data that will help them predict maintenance issues before they occur. This can potentially extend PM frequencies or show that they need to be shortened for improved yield considerations.

Moreover, fab operators will find that these devices are cost-effective, often paying for themselves within one or two uses by quickly identifying wafer-damaging vibration sources, saving time, reducing test wafer costs and eliminating the need for extra tests. Such wireless vibration-sensing devices offer fab engineers the means to achieve maximum equipment acceleration *and* minimum vibration, in order to optimize equipment productivity and significantly improve yield. They are quickly becoming an invaluable part of a fab's maintenance arsenal.

About the Author

Dennis Bonciolini is CTO/director of engineering at CyberOptics Semiconductor (www.cyberopticssemi.com). He has more than 25 years of experience in semiconductor device manufacturing and R&D for both IDMs and OEMs.