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Reports from the Fab

Diffusion Group Traces Reduced Yield to Vibration Sources and Wafer Leveling

The User

The vertical diffusion group at a 200 mm fab.

Wafer damage plagues high-volume process

Engineers in the vertical diffusion group at a 200 mm fab experienced reduced yield when their high-volume process led to wafer breakage, micro scratching and particle contamination.

The diffusion team suspected that the root causes of the reduced yield were misaligned wafers in crowded cassettes and tool vibration created by environmental forces, including fans, failing robotic components and carts moving along the aisle's perforated floor.

The team wanted to characterize the root causes, correct the production deficiencies and set new controls for the process.

The wafer boat that entered the diffusion furnace held 250 wafers in multiple cassettes. The wafers were vulnerable to damage during the high-volume handling at the load port, in the cassettes with narrow pitch and as they ascended a long Z axis and were exposed to the hot furnace, according to Allyn Jackson, customer support manager at CyberOptics Semiconductor.

"There were so many opportunities for wafers to be damaged in the process, and wafers weren't making it through," Jackson said. "But they knew the high rate of defects was preventable."

The engineers needed to ensure that wafers were level in the cassettes and handled with minimal vibration to improve yield.

Testing tool vibration and wafer alignment in cassettes

The diffusion team ran a series of tests over two days that compared the same tool movements at different locations in the process to characterize the root causes of the wafer damage.

Engineers placed a 200 mm form factor vibration sensor and a 200 mm form factor leveling sensor in the same test cassette. The vacuum-compatible sensors measured wafer vibration in x, y and z dimensions and wafer tilt in x, y dimensions.

“The two-day test gave the team a great deal of data on wafer leveling and tool vibration,” Jackson said. “The sampling of data here offers insight into ways the sensors uncovered serious tool maintenance and setup issues.”

The team moved the cassette throughout wafer-handling stations in the diffusion process: from the load port to the CZ stage, from storage rack to transfer rack and into the cooled furnace. The engineers also measured the tilt and vibration of wafers in a storage rack with the fan on and off and as engineers ran carts at various speeds and weights in the aisle next to storage and transfer racks.

The team reviewed the sensors’ real-time metrology measurements with companion software that displayed the data on a GUI.

The two-day test indicted that the vast majority of stations in the process failed to meet established go, no-go leveling parameters set for the y axis. The wafer in the test cassette was often tilted forward during the process and likely to walk off.

“When the wafer isn’t level, any slight vibration can cause a wafer-transfer robot to miss the handoff,” Jackson said.

The test indicated that the diffusion boat was level throughout its ascent into the furnace.

“To capture the alignment of the boat at the bottom, middle and top of its ascent would be very difficult and time consuming,” Jackson said. “The team was able to do it in about 10 minutes during the test movements.”

Jackson added that the diffusion team’s test of environmental forces during wafer handling confirmed that each of them increased the vibration of wafers in the cassette: With the fan on, the wafer’s z-axis vibrations measured up to 0.25 G with high frequency in a storage rack. When carts traveled by a storage rack, the wafer’s vibration measured up to 0.25 G. When two transfer racks were tested side by side, one caused significantly more x-axis vibration, indicating a failing robotic component such as a ball bearing.

Re-characterizing the diffusion process, setting controls

The diffusion team at the 200 mm fab used vibration and leveling sensors in tandem to characterize the various root causes of wafer damage that occurred during their high-volume processing of 250 wafers in a boat.

“They proved to themselves that the sensors were invaluable in uncovering problems that impacted their yield,” Jackson said.

The real-time data from the wireless sensors on tool vibration and leveling allowed engineers to make immediate adjustments and re-characterize the diffusion process.

The team has established co-planarity among wafer-handling stations to ensure proper wafer tilt in cassettes and prevent wafer damage throughout the process.

Engineers have also established a link between tool vibration and various environmental forces, including fans, failing robotic components and carts moving along the aisle's perforated floor.

The diffusion team's log-file data on tool vibration and wafer leveling throughout the process will allow them to establish new preventative maintenance (PM) requirements and process controls for both tools and engineers.

"The team's two-day test and ongoing use of the sensors have re-characterized the entire process moving forward," Jackson said.

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