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Broadband Interference Issues in Fabs

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Application Summary

Nearly every semiconductor fab has now, or has had in the recent past, production tools which exhibit process interruptions due to unknown causes. Often, the search for the causes of these problems is a time-consuming process of investigation by fab engineers and technicians in conjunction with the tool providers own technical staff. Depending upon the severity of the problem, the final cost of meetings, software and hardware revisions, and the loss of product or yield reduction, this can be very expensive – and still not solve the problem.

Modern semiconductor production equipment manufacturers have made great strides in hardening tools against electromagnetic interference (EMI) at the same time as they have met compliance standards for emissions. After all, the production environment is a crowded environment with many different processes and tools in close proximity. With processors reaching ever-higher clock speeds and the number of secondary processors in tools climbing as machine intelligence is distributed throughout the tools, the opportunity for interruptions due to interference has also become greater.

Broadband Interference Issues

The most common radiated interference, both pulse-field and continuous wave (CW), usually falls within the low kilohertz (kHz) to 3 Gigahertz (GHz) range. This encompasses an enormous region of communication, processor and general equipment operating frequencies.

In addition, ESD (electrostatic discharge) events put out multi-frequency broadband energy across this region in the form of fast rise-time pulse fields, often of surprising amplitudes (e.g., 50 V/m = 6.6 W/m2). This type of event, caused by an electrostatic discharge (ESD) in close proximity to production tools, can cause energy coupling to improperly grounded tool surfaces or can enter interior tool spaces through vents, ports or other unprotected openings. When it does so, it can interrupt tool operation through direct coupling to unshielded data or analog signal lines, or interrupt processors based upon the wide-band frequency component present in many ESD events. This type of scenario can be caused by nothing more complicated than an operator bumping an ungrounded cart into a tool or other nearby object. Even doors into critical areas have been known to create large ESD/EMI events.

Tools that are not designed to safely conduct this radiated interference to ground risk lockup, data corruption or mysterious soft errors which so annoy operators. Identifying what is actually causing the interference can be difficult or impossible, depending upon the method employed.

Equipment and Technique

The good news is that this interference region can be readily diagnosed using specialized antennas, probes, scopes (oscilloscopes and spectrum analyzers) and techniques. The equipment needs to be very mobile, of small footprint, and capable of performing broadband sweeps both inside and outside of confined tool spaces without disrupting the surrounding production process. Often a combination of radiated antenna and probe can be used in tandem to capture both the radiated source and the conductive path that noise takes through a tool. When actual locations of interruptive events (as in the case of ESD) need to be found and eliminated, multiple antennas can be used as phased arrays to allow time-domain analysis of these pulse fields.

It goes without saying that interference investigations on live tools in semiconductor fabs need to be undertaken with great care. Diagnosing external interference often requires dealing with various signal acquisition issues (reflection, diffraction, deflection, etc.) which can be challenging in a crowded production environment. However, inserting and attaching probes and antennas inside a live production tool introduces the additional hazard of inadvertent tool damage (as in taking a tool down until a replacement component can be brought in). This type of operation is often necessary for a successful investigation, but requires experience to avoid a production disaster (not to mention possible injury to the engineer using the equipment). With careful application, not only can the source of the interfering energy be found, but it can be traced through the tool to those components which are exhibiting vulnerability. At this point, remediation measures can be implemented to reduce or eliminate the problem. This is especially critical in those cases where the external source of the interference may for some reason not be removable.

Frequent Tool Errors

One successfully solved case involved a wafer processing tool which was prone to stage errors. On an average of 2-5 times per week, the tool would fault, requiring a particularly tedious restart. The tool software indicated that there was stage movement (read via optical laser) when there shouldn't have been. Much time (months) was spent looking for hardware problems associated with the stage control, followed by a software bug hunt when the hardware investigation turned up nothing.

In this case, a brief ESD/EMI investigation indicated not only the source and amplitude of the interruptive event (personnel moving ungrounded equipment), but also the path the interference took into the tool electronics cabinet. During this process, several critically ungrounded tool panels were discovered which acted as antennas in their own right. This re-radiated the external ESD event energy throughout the unprotected circuitry inside, leading to an eventual fault.

Stocker Problems

In another case, the primary interference path was much more obvious. A large wafer stocker was evaluated for frequent lockup, which caused problems with automated wafer boat delivery throughout the photolithography area. An ESD/EMI investigation focused on the fab area directly adjacent to the stocker. Large ESD events were found to be occurring due to the movement of inadequately grounded WIP carts, worktables and production staff.

In this case, the large open portals in the stocker front provided an unobstructed path for the interference to penetrate into the tool interior. Once again, the electronics in the interior were not purposefully shielded and disruptive energy was applied directly to unprotected ribbon cables controlling the robotics. A second interference path was found to be ESD energy coupling directly to the OHV (over head vehicle) track wiring in the aisle, which was also not shielded.

In the first case mentioned, the solution proved to be re-grounding of the surface panels for the tool. This conducted the ESD energy safely to ground, bypassing critical electronics areas. Efforts were also made to reduce ESD events through proper fab environment control of electrostatic charges.

In the second case, tool redesign or retrofit to defeat the interference was not practical. In addition, since the level of interference was severe and related to an environmental condition, the OEM was not inclined to alleviate a condition which shouldn't have been there in the first place. The remediation which addressed the problem took the form of careful re-grounding of all surrounding equipment (including adding conductive wheels to carts), which reduced the ESD levels around the stocker substantially.

Conclusion

Broadband interference of different types can be prevalent and undetected in even the most modern semiconductor fabs. Whether as continuous wave radiation of significant amplitude and frequency or as pulse-ESD/EMI events of short duration and high peak amplitudes, they can cause costly tool downtime or even wafer loss (or rework) through interrupted processes. Fortunately, there are in-fab methods and techniques available to detect and characterize this form of interference, as well as time-proven ways to end the problem.

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