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APPLICATION NOTE

Tool Interference Issues

ESD/EMI/RFI

Modern semiconductor production equipment manufacturers have made great strides in hardening tools against electromagnetic interference (EMI) and radio frequency interference (RFI), 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 tools, the opportunity for interruptions due to interference has also become greater.

The Production Environment

Unfortunately, really no one in the production facility is sweeping for interference. Not only is the equipment to search for interference sources in a working production environment (without disrupting production) expensive and specialized, but the techniques used are somewhat different from the EMC certification process. Add to this that the interference can affect tools both externally and internally, and the difficulties in determining causes and vulnerabilities rapidly increase. In fact, deploying a broad-band antenna in a working fab is an interesting experience. Not only can the clock frequencies of processors in tools and computers be readily seen, but also a myriad of other signals related to special processes as well. The relative energy level of these signals varies and, in general, the interference potential is low unless certain tools are specifically susceptible to signal frequency interruption.

Much attention has been placed by modern facility and process owners in providing robust and effective grounding for tool sets. High-frequency grids, carefully put in place during initial construction, usually drain conducted interference effectively away from critical equipment components. This doesn't mean that conducted interference can't sometimes propagate through ground into tools causing those annoying intermittent problems.

Broadband Issues

The most common radiated interference 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). Tools that are not designed to conduct this radiated interference to ground safely 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 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 introduce 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.

Some Problems Solved

- Stepper/scanners exhibiting lockup due to unsecured top panels which no one noticed.
- Door gasket problems which either created ESD events on closing or allowed external events inside the tool space.
- Load-stage ESD events from charged product carriers coupling to unshielded internal cabling.
- Front-end handlers dropping or miss-indexing wafers due to interference coupling to control boards and circuits.
- Wafer and reticle stockers experiencing periodic lockup or handling errors due to interference coupling to internal electronics through open ports and over-head track wire paths.
- OHVs (over-head vehicle) performance issues due to unshielded control nodes susceptible to ESD pulse fields.
- ESD and RFI coupling to laser interferometer signal lines controlling wafer positioning.
- Out-of-range transducer values caused by ESD pulse coupling to unshielded analog signal lines.
- Reference data corruption in wafer testers due to ESD coupling to unprotected ribbon cables.
- High-frequency ground cross-section analysis to determine if noise is being effectively conducted out of the tool electronics cabinet.
- Elimination of inadvertent ground loops introduced during tool installation or reset.
- Evaluation of EMI filter performance on installed tools.

Additional Elements

Investigating and solving interference problems from EMI and RFI uses adaptations of standard EMC techniques. ESD-related problems require an additional element of analysis if the interference problem is to be addressed effectively.

ESD events can be produced in a surprising number of ways in modern production environments. Over 90% of them are caused by humans going about their various duties (the other 10% being usually caused by conductors passing through electrostatic fields or other mechanical operations). This lends a seemingly random source of interference generation which is largely invisible. If ESD is suspected as either the major or a contributing interference element, the source of it needs to be discovered and brought to the attention of those who control that part of the process or facility.

OEM companies are usually reluctant to spend their resources solving the problems of the general production environment over which they have no control. They normally take the reasonable position that the environment should be interference-free for their tool. When this isn't the case, what is desired is a focused investigation which demonstrates the origin of the problem and its solution in the most cost-effective manner – which translates as the least cost to the tool vendor. To that end, standard ESD auditing techniques can be employed in the area directly surrounding the tool to determine the source and severity of interfering events. At that point, the solution responsibility usually transfers to the facility or process owner for the remediation of the problem which shouldn't be there in the first place. Hopefully, the investigator has the tact to communicate this in a manner which does not promote antagonism between any of the parties involved.

How Involved Is This Process?

Surprisingly, interference investigations for tools have traditionally been very rapid affairs. The normal time budget is on the order of two (2) days, or 16 hours. The reasons for this are several. First, the techniques and equipment have been optimized for performance in production environments to present the least amount of interruption necessary (which means they also deploy rapidly). Second, the investigation has natural boundaries which lend themselves to rapid results, helped by the fact that radiated interference at least decreases calculably with the distance from the source. Third, the tool needs to be in at least ready mode for the investigation and does not need special preparation.

Conclusion

Despite the efforts of OEM tool vendors in making their equipment ever more robust, there are interference problems at large in production facilities today that can cause significant disruption. Ideally, investigations into problems should address all of the critical possibilities if a successful outcome is to be achieved. Moreover, this investigation process should be carefully optimized for cost-effectiveness, promote cooperation and goodwill between vendors and owners and provide valuable feedback to the tool design process.

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