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TECHNICAL NOTE

The Role of Ionization in E78 Compliant Tools

The SEMI E78 Guideline

In high technology processes associated with wafer manufacturing, problems resulting from static charge are a well-known issue. Yield losses are due to contamination from ESA, wafer handling issues due to ESA, ESD damage to reticles, and ESD-induced EMI, which causes process tool lockup.

In response to the growing need to control static charge effects in tool environments, SEMI developed the E78 guideline, which helps tool and fab owners assess and determine safe, allowable static charge levels for their processes. Formally, the guide is known as SEMI E78-1102: Guide to Assess and Control Electrostatic Discharge and Electrostatic Attraction for Equipment. The guideline provides the following information:

- A tutorial on how to assess the magnitude of static charge effects on a fab
- A guideline for determining the acceptable levels of static charge for various fab operation conditions
- A set of procedures for auditing and measuring static charge generation in a tool
- A table of static charge levels, divided into four categories of compliance for each of the three categories, ESD, ESA and EMI.
- Recommendations for controlling static charges in tools to attain more stringent levels of compliance.

Many semiconductor manufacturers have added SEMI E78 Compliance to their tool specifications in order to help insure their fab processes against devastating static charge effects. To attain specified levels of E78 compliance, some tool suppliers may have to implement changes to their tools in order to decrease the amount of generated static charge. These changes may include grounding of isolated conductors, exchanging insulative materials for static dissipative materials, and adding air ionization.

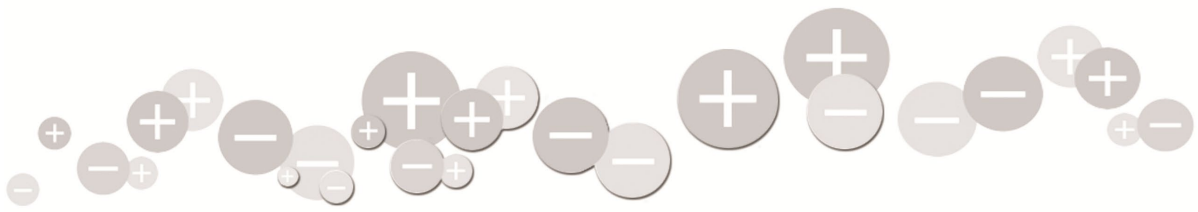
The Addition of Ionization

Since some insulative materials cannot be removed from a process or grounded, ionization is the most effective way and often the only way to eliminate static charge in a tool. Materials that cannot be changed or grounded include tool components, process materials, and the insulative surfaces of the wafer or reticle itself, which cannot be changed. While the E78 guideline addresses potential changes in tool design and materials, it does not completely address the issues in the instances of incoming charged wafers, reticle processes, and partially compliant process tools. These areas are discussed below.

Incoming Charged Wafers

The E78 guide details static charge measurement procedures that use a neutral wafer as the basis for the measurements. However, a wafer may come into an E78 compliant tool already charged from a previous process tool or handling. When this happens, the tool must be able to immediately neutralize the charge in order to ensure the wafer is processed or measured correctly and still exits the tool at compliant static charge levels. The tool design must incorporate the ability to dissipate incoming static charge in order to remain compliant.

Adding ionization to compliant tools ensures the tool will remove incoming static charge and continue to comply with the E78 guideline, not just in single tools but through all the processing steps. If no ionization is present in the tool, each tool may add only 1 nC of charge to an insulative wafer, but with no discharging capability or neutralization present, 50 process steps



would add a total of 50 nC of charge to each wafer, which is far outside safe static charge limits.

Reticle Processes

The E78 guideline outlines methods of protecting reticles against two types of damage: charged device model damage and machine model damage1.

There is also a third model1, field induced damage, to consider as well. Reticles experiencing an externally-applied electric field from a nearby charged object (for example, a plastic mini-environment wall) can be damaged. The electric field can drive a spark from one reticle chrome structure to an adjacent one. Typically, fields as low as 1 kV/inch can cause this effect in modern reticles but some metallization reticles with long bus structures can experience damage from fields of less than 500 V/inch.

Incorporating ionization in reticle processes will remove the potential damage of field-induced damage. All tools that process, measure, or store reticles should incorporate ionization as part of their reticle protection design plan. Ionization keeps the tool statically neutral, avoiding ESD events that have the potential for costly damage.

Partially Compliant Process Tools

Most 300 mm process tool manufacturers use EFEM (Equipment Front End Module) interfaces between the loadport and the process chamber. Many manufacturers mistakenly rely on only the E78 compliance of an EFEM to protect their tool, ignoring any static charge generation in the process or measurement chamber itself. Unfortunately, an E78-compliant EFEM does not mean the entire tool is E78 compliant, since any charges generated in the process must be neutralized before exiting the tool for the entire tool to be considered E78 compliant.

The only way to neutralize charged wafers coming from the process chamber is with ionization. In some cases, ionization may be installed in the process area itself to keep the charge from generating to a level that cannot be neutralized quickly in the EFEM. Once the wafer leaves the process chamber and is delivered to the EFEM, ionization should be present to finish the neutralization task.

Ionization is Part of E78 Compliance

The intent of E78 compliance is to prevent static charge issues from generating and moving from one fab tool to another. To address the situations that are not covered in the E78 guideline, it is necessary to incorporate discharge capability into every tool. Ionization, grounding, removing insulative materials, and employing dissipative materials are the four basic methods of safeguarding against ESD safety, but only ionization can neutralize existing charge in critical areas such as EFEMs, reticle processes, and on wafers. Ionization remains the best possible way to eliminate static charge effects in tools.

Specific ionization products for process tools are available, easy to install and maintain, and cost effective. The newest digital ionization products offer such features as EFEM-specific designs, multi-mode capabilities for any environmental need, and software controlled and monitored performance. These systems are proven investments with quick ROI over the product yield losses and lost production time resulting from static charge.

Including ionization and E78 compliance in every tool purchase specification will ensure the best static charge control in the tool and higher yields to the device manufacturer.

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References

1. SEMI Standard E78-1102 Electrostatic Compatibility: Guide to Assess and Control Electrostatic Discharge (ESD and Electrostatic Attraction (ESA) for Equipment, 2002, SEMI.
2. Montoya, J., Levit, L, Englisch, A. “A Study of the Mechanisms for ESD Damage to Reticles”, 2000 ESD Association Annual Conference Proceedings.

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