Customer Service Note

Electrostatic Discharge (ESD) Precautions for the Handling and Assembly of Semiconductor Die and Wafers

Introduction

Electrostatic discharge (ESD) is a continuing, industry-wide problem. ESD events can destroy product outright or greatly reduce product reliability—it can damage pixels and circuitry in image sensors, degrading the image quality, and it can cause excessive current increases in other semiconductors.

Identifying ESD failures can be difficult. Because fallout can be intermittent, low level, early, or field failures, they can appear initially to be some other type of failure, with different locations and appearances. The energy levels can vary with each discharge. ESD events can occur at more than one location in an assembly line.

Die and wafers must be protected against static electricity and ESD at all times. Procedures must be put in place and consistently followed for safe transport, handling, and assembly of these static-sensitive devices. Device-level ESD protection circuits placed around the bond pads do not protect die and wafers until the die is completely packaged. Controlling static electricity generators in the workplace is accomplished by rigorously grounding workstations, reducing high-static voltage areas to less than 1,000 volts (1kV), and using ionization techniques.

Precautions, Equipment, and Handling Procedures

Grounding Systems

A properly implemented grounding system will prevent conductors and people from charging up to dangerous levels (> 1kV) (JEDEC specification JESD625-A). It also provides (safe) discharge paths for charged objects or product.

The path to ground on surfaces that die and wafers can come in contact with (microscopes, tables, etc.) should be in the dissipative range (10^5–$10^9\Omega$), not a direct/fast ground ($<10^5\Omega$). This will reduce the chance for a destructive CDM-type discharge event by reducing any charge generated on the die or wafer in a controlled manner. Any charge generation more than 1kV should be discharged to a lower than 1kV potential, using techniques described in JESD625-A or ANSI/ESDA Specification S20.20.

When ESD events are suspected, several areas should be measured to verify that they are within the dissipative range.

- Check that static-dissipative clothing and wrist straps are being used and worn properly.
- Verify that static-dissipative floor and counter top mats are being used.
- Examine floors, ceilings, shelves, chairs, carts, and stainless steel table tops to ensure they are properly grounded per JESD625-A.
- Verify that machines and microscopes are properly grounded per JESD625-A.

See specification JESD625-A or S20.20 for details on the best methods used for measuring each area.

Environment

The workplace environment must be controlled. Measure static voltage buildup using a static field meter to verify that the measured voltage is <1kV within 12 inches of static-sensitive devices.

Remove charge sources:

- Materials like clear plastics (Plexiglas) will hold extremely high static charges, and readily charge up by triboelectrification.
- Do not use insulators near static-sensitive devices or as part of an assembly jig.
- Do not set static-sensitive devices near tables ends that have insulative side walls.
- Some television screens and monitors generate very high static fields. Make sure these are located far from static-sensitive devices or replace with safer models.

Maintain static-safe procedures:

- Replace static-dissipative bags as needed.
- Clear work areas of non-essential material that may create static.
- Use conductive or dissipative wafer cartridges (not shipping boxes) after incoming for assembly wafer transport.
- Routinely perform audits to measure electrostatic fields and ensure ESD precautions are in place and being applied. JESD625-A recommends monthly audits.
- Minimize human handling—human handling increases the chances for ESD events in numerous, random ways.
- Do not permit anyone to enter a static safe-guarded area without proper protective gear, not even for short periods of time.
- Verify that conductive, static-dissipative, or static-shielded bags are being used for storage and transport to act as a shield against charges.
- Verify that static-dissipative packing materials, tape, and labels indicating static sensitive devices are being used.
- Maintain appropriate humidity conditions. The recommended minimum humidity is 40% R.H., per JESD625-A.

Ionization

Beyond the standard grounding precautions, ionization is needed to control charge buildup on or near static-sensitive devices. Ionization is the only effective means of removing charge from insulators in a short time. Die and wafer act like insulators.

Room or ceiling ionizers should be used for maximum protection, especially for any area indicated as a high-static voltage area.

Table 11: Key Areas for Effective Use of Ionization

Area	Recommended Ionization
Incoming (as wafers are removed from shippers)	Area ionization
Visual inspection (especially while product is still on the wafer)	Area ionization
Wafer wash/post-wafer wash	In-machine ionization
Die attach and wire bond	In-machine ionization
Substrate lens assembly/heat stake	Area ionization

Follow the manufacturer's specifications for the use and maintenance of ionizers. They should to be checked periodically; clean the points and check the balance and decay rate.

Training

Personnel must be trained in the use of ESD-protective equipment and proper handling procedures. Everyone involved in the process should be able to help identify and prevent potential ESD problems.

Definitions of Materials and ESD Properties

Charge device model (CDM) is a type of ESD event that occurs when a device acquires charge through some triboelectric (frictional) or electrostatic induction processes and then abruptly discharges when it touches a grounded object or surface.

Conductive materials freely conduct electricity and will not generate an electrostatic charge. A material having a surface resistivity of less than $1 \times 10^5\Omega$ per square or volume resistivity of less than $1 \times 10^4\Omega$ centimeter (JESD625-A). They can be grounded to remove the charge and acts as an electrostatic shield that a charge will not pass through. Examples of conductive materials include copper, stainless steel, carbon impregnated plastics, and people.

Electrostatic discharge (ESD) is the transfer of charge between bodies at different electrical potentials.

Electrostatic field are lines of force surrounding an electrically charged object (JESD625-A).

Human body model (HBM) is the most common mechanism for characterizing an ESD event: The charged human body is modeled by a 100pF capacitor and a 1,500Ω discharging resistance (MIL-STD-883G). The discharge itself is a double exponential waveform with a rise time of 2–10ns and a pulse duration of approximately 150ns. (JESD625-A)

Insulative materials generate a charge that can only be removed through the use of an ionizer. Examples of insulative materials include plastics, teflon, styrofoam, and cardboard. A material having a surface resistivity of at least $1 \times 10^{12}\Omega$ per square or volume resistivity of at least $1 \times 10^{11}\Omega$ centimeter (JESD625-A). Die and wafers are insulative materials.

Machine model (MM) simulates a more rapid electrostatic discharge from a charged machine, fixture, or tool. The MM test circuit consists of a charged 200pF capacitor that is discharged directly into the device being tested with zero ohms of series resistance.

Static-dissipative materials are carbon impregnated or use a surfactant to eliminate generating a charge. A material having a surface resistivity between 1×10^{5} and $1 \times 10^{11}\Omega$ per square or volume resistivity of between 1×10^{5} and $1 \times 10^{11}\Omega$ centimeter (JESD625-A). Examples of static-dissipative materials include smocks, shoe covers, and gloves that contain carbon threads.

Triboelectrification is the generation of electrostatic charges when two pieces of material in intimate contact are separated (when one or both is an insulator). (JESD625-A).

Summary

Successful control of ESD throughout the transportation and assembly process requires continuous support and commitment, investment of time and resources, periodic assembly line audits to verify different components of the entire system, ongoing training, and monitoring of personnel ESD precautions.

The benefits of controlling ESD in the workplace include higher yields and improved quality and reliability, resulting in reduced manufacturing costs.

References

JEDEC Specification JESD625-A, December 1999

ANSI/ESDA Specification S20.20, August 1999

Department of Defense MIL-STD-883G, February 2006

Micron Quality and Reliability Handbook, September 2005

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