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ESD Association Technical Report

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Electrostatic Guidelines and Considerations For Cleanrooms and Clean Manufacturing

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FOREWORD

The ESD Association Standards Committees have developed standards “for the protection of Electrostatic Discharge (ESD), susceptible items”. These standards are used to select and verify the performance of protection methods for ESD sensitive devices. ESD sensitive devices require protection during their manufacture and throughout their subsequent use. The primary focus of the standards and ESD control methods has been electronic devices in general and semiconductor devices in particular.

There is a well-established need for ESD and ESA (Electrostatic Attraction) control in cleanrooms and other clean manufacturing environments. While standards have been concerned with the effects of ESD on semiconductor devices, they have not considered the requirements for cleanroom and clean manufacturing of these devices or other items requiring clean processing.

ESD damage to electronic devices is well documented. Electrostatic charge and ESD are also known to interfere with the operation of production equipment and to increase levels of particle contamination on semiconductor wafer surfaces. Similar problems exist in other industries requiring cleanroom and clean manufacturing environments such as disk drive - (recording heads and disk media), medical, optical materials and devices, commercial/military aerospace technology, thin film/coating applications, and media manufacturing.

A number of relevant issues must be considered for electrostatic charge control methods to be used in cleanroom and clean manufacturing environments besides their ability to dissipate electrostatic charge. These may include but are not limited to, particle generation, chemical compatibility, outgassing and clean airflow restriction.

This document will identify considerations and provide guidelines for the selection and implementation of materials and processes for electrostatic control in cleanroom and clean manufacturing environments. Applicable industry standards are referenced to support this document. Requirements for static control in both the construction and operation of clean environments are addressed.

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1.0 PURPOSE, SCOPE, AND APPLICATION

1.1. Purpose

This document provides guidelines and considerations for the use of electrostatic discharge (ESD) and electrostatic attraction (ESA) control methods, equipment and materials in cleanrooms and clean manufacturing environments.

1.2 Scope

ESD and ESA control has become a necessity in cleanrooms and clean manufacturing environments. Static charge should be considered a contaminant that must be eliminated or controlled to enhance the manufacture of semiconductors, disk drives, flat panel displays, medical and optical devices, thin film media, and a variety of other products.

By controlling electrostatic charge it is possible to:

- a. Protect product from contamination due to Electrostatic Attraction (ESA), and Electrostatic Bonding (ESB) of particulate to critical product surfaces.
- b. Prevent ESD from directly damaging devices and products.
- c. Prevent malfunction of production equipment due to electromagnetic interference (EMI) generated by ESD.
- d. Prevent product handling and conveyance problems caused by electrostatic charging, Polarization, and attraction.

1.3 Applications

The contents of this document do not set standards or requirements for use of materials or equipment in a cleanroom or clean manufacturing environment. The user for each application should define the requirements. This document provides information and guidance when designing, facilitating, and implementing electrostatic control materials, equipment, and methods in critical cleanroom and clean manufacturing environments. Cleanroom and clean manufacturing environments may have additional requirements, which are beyond the scope of this document.

1.4 Limitations

This document is not intended to characterize cleanroom cleanliness levels that are product or process specific, nor does this document identify equipment or methods of particle contamination measurement. This document is not intended to apply to facilities using or producing flammable materials, ordnance, or other explosive materials

2.0 NORMATIVE REFERENCES

Unless otherwise specified, the following documents of the latest issue, revision, or amendment, form a part of this standard to the extent specified herein.

2.1 ESD Association

EOS/ESD ADV 1.0 ESD Association Glossary of Terms

ESD STM 1.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Wrist Straps

ESD TR 20.20 ESD Association Technical Report for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies and Equipment – Handbook

ESD STM2.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Garments

ANSI EOS/ESD S3.1 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items – Ionization

ESD ADV 3.2 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items – Selection and Acceptance of Air Ionizers

ESD STM4.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Worksurfaces – Resistive Characterization

ESD STM4.2 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Worksurfaces – Charge Dissipation Characteristics

ESD STM5.1 ESD Association Standard for Electrostatic Discharge (ESD) Sensitivity Testing - Human Body Model (HBM) Component Level

ESD S5.2 ESD Association Standard for Electrostatic Discharge (ESD) Sensitivity Testing - Machine Model (MM) Component Level

ESD DS5.3.1 ESD Association Standard for Electrostatic Discharge (ESD) Sensitivity Testing – Charge Device Model (CDM) Component Level

ANSI/EOS/ESD S6.1 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Grounding - Recommended Practice

ANSI/ESD S7.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Resistive Characterization of Materials - Floor Materials

EOS/ESD S8.1 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Symbols - ESD Awareness

ESD S9.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Footwear – Resistive Characterization

EOS/ESD S11.11 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Surface Resistance Measurement of Static Dissipative Planar Materials

ESD S11.12 ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Volume Resistance Measurement of Static Dissipative Planar Materials

ESD ADV11.2 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items– Triboelectric Charge Accumulation Testing

ESD S11.31 ESD Association Standard for Evaluating the Performance of Electrostatic Discharge Shielding Materials – Bags

ESD STM12.1 ESD Association Standard Test²⁹³ Method for the Protection of Electrostatic Discharge Susceptible Items - Seating - Resistive Characterization

ESD ADV53.1 ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items - ESD Protective Workstations

ESD STM 97.1 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Floor Materials and Footwear - Resistance Measurement in combination with a Person

ESD STM 97.2 ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items - Floor Materials and Footwear - Voltage Measurement on a Person

ANSI ESD S20.20 ESD Association Standard for the Development of an Electrostatic Discharge Control Program for the Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

2.2 Other Electrical References

UL - 779 Standard for Electrically Conductive Flooring

ASTM F150 Test Method for Electrical Resistance of Conductive Resilient Flooring

IEEE STD 142-1982 Recommended Practice for Grounding of Industrial and Commercial Power Systems

ANSI C2 National Electrical Safety Code

ANSI/NFPA 70 National Electrical Code

ANSI/NFPA 77 Static Electricity

ANSI C63.16 "American National Standard Guide for Electrostatic Discharge Test Methodologies and Criteria for Electronic Equipment"

IEC 61000-4-2, "Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment, Part 2; Electrostatic Discharge Requirements"

2.3 Contamination

Fed. Std. 209E Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

IES -RP-CC004.2 Evaluating Wiping Materials used in Cleanrooms and other Controlled Environments

IES-RP-CC005.2 Gloves and Finger Cots used in Cleanrooms and other Controlled Environments

IES-RP-CC006.2 Cleanroom Testing

IES-RP-CC018 Test Methods for Cleanliness of Worksurfaces

IES-RP-CC022.1 Electrostatic Charge in Cleanrooms and other Controlled Environments

ASTM 1249 Moisture Vapor Transmission Rate

NASA SP-5076 Contamination Handbook

ASM E595 – Mass Weight Loss of Non-Volatile Residues

Mil. Std. 1246C Standard for Product Cleanliness Levels and Contamination Control Program

SEMI-E33-94 Standard for Electromagnetic Compatibility of Semiconductor Production Equipment

ISO 14644 Cleanrooms and Associated Controlled Environments

3.0 DEFINITIONS

3.1 Unless otherwise defined in this document, the terms used in the body of this document are in accordance with the definitions found in the EOS/ESD Association Glossary of Terms, EOS/ESD ADV 1.

3.2 Electrostatic Attraction (ESA) -The coulomb force that results from the opposite charge on two bodies. This Force may result in movement of either or both of the bodies involved (e.g. particle attraction to surfaces or movement of small parts)

3.3 Mini-environment- the actual localized controlled space limited by a defined enclosure that separates or isolates the inside from the outside environment, such that the transfer of potential contamination from one side to the other is minimized or completely eliminated depending on the design. (ISO 14644)

4.0 CONTAMINATION CONTROL CONSIDERATIONS

4.1 Cleanrooms

Cleanrooms exist because particles on critical product surfaces cause defects. In general this occurs whenever a manufacturing process involves thin film deposition on substrates. Examples include oxide coatings on semiconductor wafers, as well as paint applications on car bodies. Particle defects may require the product to be reprocessed or reworked adding unanticipated cost, or may cause damage resulting in yield loss.

4.2 Particle Contamination

Lowering airborne particle counts with high quality air filtration and laminar airflow systems are common methods used in cleanrooms and clean manufacturing environments to reduce surface contamination. Modern filtration efficiency can be quite good. Few damaging particles propagate through the air filtration systems. Once constructed, cleanroom contamination levels are certified according to the requirements of Federal Standard 209E or ISO 14644.

Most particles are generated within the cleanroom and clean manufacturing environment by personnel, equipment, and production processes. These particle sources are often close to the product.

Eliminating charged surfaces can enhance the ability of the air filtration system to remove particles from the cleanroom and clean manufacturing environment. There is an established correlation between electrostatic surface charge, ESA, and electrostatic bonding of particles to surfaces. The neutralization of electrostatic charge on critical surfaces will reduce the ESA and bonding of particles to these surfaces and allow for more efficient removal of particles entrained in the laminar airflow by the air filtration system.

4.3 Contamination Control Requirements

Contamination control requirements may make some static control methods difficult to use in cleanrooms. Chemical or thermal characteristics necessary for some manufacturing processes may also limit the choice of static control methods. Many static control methods make use of static dissipative or conductive materials that involve additives to insulative base materials. As with any other object brought into a cleanroom, these materials must demonstrate cleanroom compatibility. This involves testing for particle shedding (particularly since many materials use carbon or metallic particles or fibers to achieve the desired conductivity) of both new materials and those that have undergone some period of cleanroom use. Refer to IEST RP-CC004 for a particle shedding test methodology. Static control materials must also pass the same outgassing and non-volatile residue testing as other cleanroom materials. Refer to IEST RP-CC016 for test methods for outgassing and for non-volatile residues. Air ionizers used in a cleanroom should not introduce contamination or other problems such as EMI, ozone, excessive air turbulence etc.

5.0 ELECTROSTATIC DISCHARGE (ESD) EFFECTS

5.1 ESD Problems

ESD is the uncontrolled transfer of charge between two objects at different electrostatic potential. The most common results of ESD are damage to static sensitive products and equipment malfunctions. Examples of this are common in the semiconductor and electronics industries, as well as in the manufacturing of medical or optical devices and recording media and film.

5.2 Industry Concerns About ESD

In semiconductor electronics production, smaller device geometry's have evolved from the need for miniaturization, increased performance, and greater operating speeds. This has resulted in higher densities of individual devices on semiconductor wafers. ESD events cause damage and failure of devices through various mechanisms such as melting, vaporization of metallization lines, and punch through of thin oxide layers. ESD events can also weaken devices, creating latent defects or "walking wounded". Devices pass production testing, but may fail prematurely.

Products in the medical, optical, and media/film industries, are also known to be sensitive to ESD events and electrostatic charge. Whenever thin films are deposited on substrates, they may be damaged by an ESD event.