ESD/EOS 6

6.1 ESD

6.1.1 Electrostatic Discharge (ESD)

Electrostatic discharge (ESD) costs the electronics industry millions of dollars each year in damaged components, non-functional circuit boards and scrambled or missing information. ESD can occur in the manufacturing, shipping, receiving, and field handling of integrated circuits or computer boards with no visible signs of damage. A malfunction in these components or boards can occur immediately or the apparatus may perform for weeks, months, or even years before an unpredictable and premature breakdown causes a field failure.

6.1.2 Why Should I Care About Electrostatic Discharge?

When you incorporate electronic components or boards into your products, ESD damage can have a direct impact on your company’s reputation and profits. That is because electrostatic damage directly affects the quality and reliability of your products. However, for a small investment in time, manpower, and equipment, you can virtually eliminate ESD-caused problems. The tangible benefits to you include:

- Higher manufacturing yields
- Less rework and inventory
- Reduced overall costs
- Fewer field failures and warranty calls
- Increased product reliability
- More repeat business resulting in greater profits

6.1.3 Intel’s Commitment to Eliminate ESD Damage

Intel manufactures and uses electronic components, and has implemented a comprehensive ESD prevention program to ensure that its products are delivered to customers with the highest possible reliability. Our experts would like to share with our suppliers and customers what they have learned about ESD control. Using this information, you can implement similar preventive practices in your factories and warehouses. As a result, component failures can be minimized.

6.1.4 What is ESD?

ESD is the transfer of electrical charge between two bodies at different potentials, either through direct contact or through an induced electrical field. It is the phenomenon that gives you a mild shock when you walk across a carpeted floor and then touch a doorknob. While this discharge gives a harmless shock to humans, it is lethal to sensitive electronics. For example, the simple act of walking across a vinyl floor can generate up to 12,000 V of static electricity. That is many times the charge needed to ruin a standard Shottky TTL component.

Several technical failure mechanisms associated with ESD cause damage to microelectronic devices, including gate oxide breakdown, junction spiking, and latch-up.

- Gate oxide failure is a breakdown of the dielectric between the transistor gate and channel resulting in excessive leakage or a functional failure.
- Junction spiking failure is a migration of the metallization through the source/drain junction of MOS transistors causing leakage or a functional failure.
- Latch-up failure can be triggered by ESD, causing an internal feedback mechanism that gives rise to temporary or permanent loss of circuit function.

6.1.5 Common Causes of ESD

Electrostatic generation arising from friction between two materials is called triboelectric charging. It occurs when two materials are separated or rubbed together. Examples include:

- Opening a common plastic bag.
- Removing adhesive tape from a roll or container.
- Walking across a floor.
- Transporting computer boards or components around in their trays on carts.
- Sliding circuit boards on a work bench.

When handling parts or their containers, ungrounded personnel can transfer high static charges. Unless these static charges are slowly dissipated, ESD event can inflict damage to the devices.

Electrical fields can penetrate electrical devices. An ungrounded person handling a component or computer board in a non-static shielding container can inadvertently transfer an electrical charge through the container into the sensitive electronic device.

6.1.6 ESD Occurs at All Levels of Integration

Electrostatic discharge is not selective when affecting your products. It can strike components directly or indirectly by passing to the component via connectors and cables. Components mounted on circuit boards are also susceptible.

In-line film resistors between inputs and off-board connectors provide only marginal ESD protection and are often damaged themselves.

6.1.7 What Can I Do To Prevent ESD?

Fortunately, preventing ESD can be relatively easy and inexpensive. Two areas of focus are:

- Eliminating static charges from the workplace.
- Properly shielding components and assemblies from static fields.

Eliminating static electricity in the workplace is accomplished by grounding operators, equipment, and devices (components and computer boards). Grounding prevents static charge buildup and electrostatic potential differences. Electrical field damage is averted by transporting products in special electrostatic shielding packages.

Many vendors of ESD-protective equipment are willing to audit your facilities, recommend appropriate procedures and materials, and assist in their implementation. You may choose to consult with such a firm to determine your exact requirements; in the meantime, review this chapter to gain an understanding of the basic components of a sound ESD prevention program.

6.1.8 Outfitting An Effective Workplace

An effective workplace should be outfitted with the following items:

ESD protective clothing/smocks. Street clothing must not come in contact with components or computer boards since the various materials in clothing can generate high static charges. ESD protective smocks, manufactured with conductive fibers, are recommended.

Electrostatic shielding containers or totes. These containers (bags, boxes, etc.) are made of specially formulated materials which protect sensitive devices during transport and storage.

Antistatic or dissipative carriers. These provide ESD protection during component movement in the manufacturing process. It must be noted that antistatic materials alone will not provide complete protection. They must be used in conjunction with other methods such as totes or electrostatic shielding bags.

Dissipative table mat. The mat should provide a controlled discharge of static voltages and must be grounded. The surface resistance is designed such that sliding a computer board or component across its surface will not generate more than 100 V.

Personal grounding. A wrist strap or ESD cuff is kept in constant contact with bare skin and has a cable for attaching it to the ESD ground. The purpose of the wrist strap is to drain off the operator’s static charge. The wrist strap cord has a current-limiting resistor for personnel safety. Wrist straps must be tested frequently to ensure that they are undamaged and operating correctly. When a wrist strap is impractical, special heel straps or shoes can be used. These items are effective only when used in conjunction with a dissipative floor.

ESD protective floor or mat. The mat must be grounded through a current-limiting resistor. The floor or mat dissipates the static charge of personnel approaching the work bench. Special conductive tile or floor treatment can be used when mats are not practical or cause a safety hazard. Chairs should be conductive or grounded with a drag chain to the flooring.

6.1.9 Summary

Intel uses a full range of electrostatic discharge prevention techniques. We invest in proper employee training, purchase appropriate ESD protection equipment and supplies and adapt our handling and manufacturing procedures for ESD prevention requirements. The same attention to detail is required of all our suppliers, factories, repair centers, and field service staff.

Intel is committed to helping its partners — both suppliers and customers — to manage the ESD problem. If we can be of further assistance in your efforts to eliminate electrostatic discharge damage, please contact the Intel Components Quality Question Line: In the USA 1-800-628-8686 or 1-916-356-7599, or contact your local Intel Sales Office.

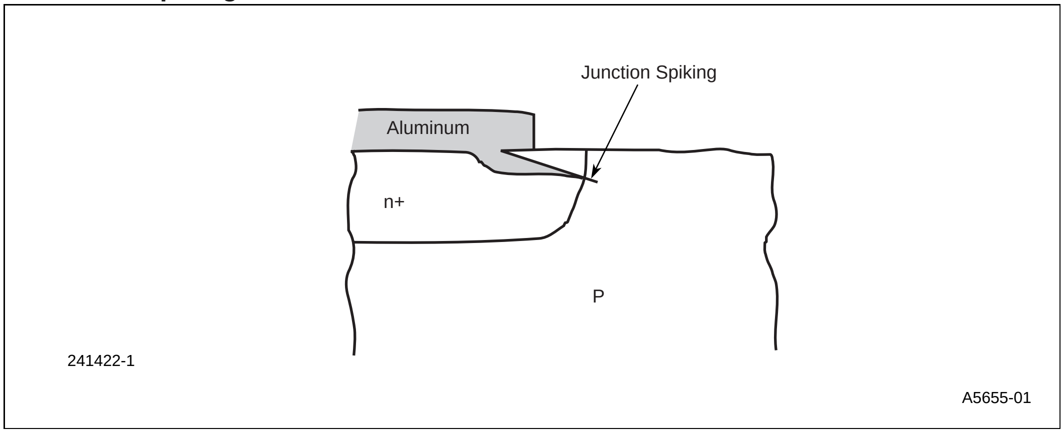
6.2 EOS - Electrical Overstress

EOS is the number one cause of damage to IC components. This section describes EOS and how to prevent it.

6.2.1 How EOS Damages a Component

Damage is caused by thermal overstress to a component's circuitry. The amount of damage caused by EOS depends on the magnitude and duration of electrical transient pulse widths. We can broadly classify the duration of pulse widths into long (>100 µs) and short (<100 µs) types, and magnitude into exceeding an individual component's EOS threshold. For short pulse widths the most common failure mode is junction spiking.

Figure 6-1. Junction Spiking Failure



For long electrical pulse widths the most common failure modes are melted metallization and open bond wires.

Figure 6-2. Melted Metallization Failure

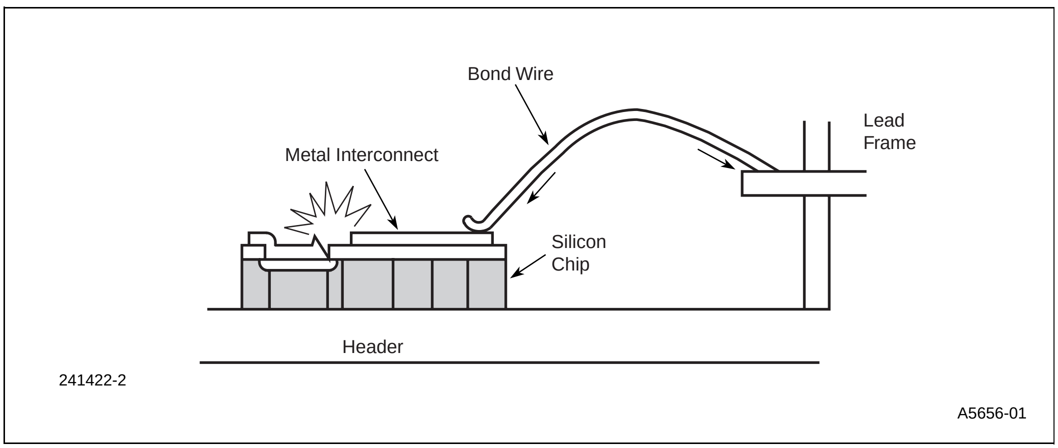
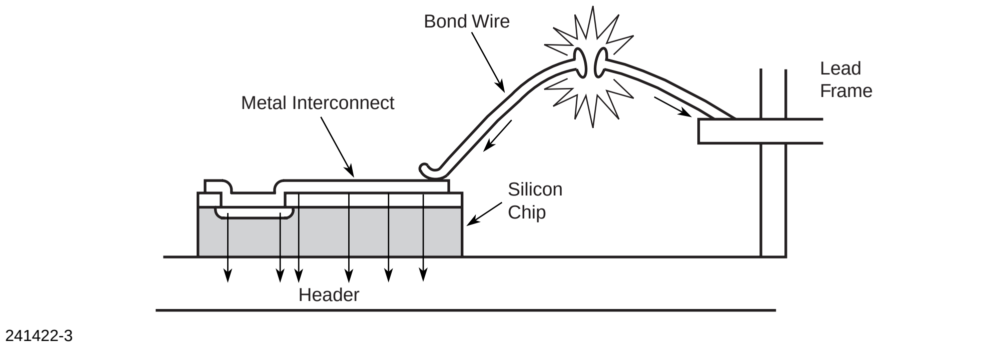


Figure 6-3. Open Bond Wire Failure



6.2.2 Common Causes of EOS

Inadequate work procedures:

- Lack of standard work procedures
- Incorrect device orientation
- Insertion/removal of components with power applied
- Boards/units not well connected, then power applied

Noisy Production Environments:

- Lack of power line conditioners
- Lack of AC line filters

Improper testing at device or board level can create EOS:

- Hot switching effect
- Incorrect test sequence such as application of signals to Device Under Test (DUT) before powering up chip
- Application of excessive voltages to chip beyond spec limits
- Poorly designed electrical stress tests such as burn-in which overstresses sensitive chips

Use of low quality power supplies:

- Poor design considerations can lead to noise sources especially in switching power supplies
- Lack of power supply overvoltage protection circuits
- Insufficient line filtering and/or transient suppression at the input stage of power supplies
- Incorrect selection of fuse providing inadequate protection

Lack of Proper Equipment and Line Monitoring:

- Equipment not grounded
- Loose connections causing intermittent events

- Poor wire maintenance
- AC supply lines not monitored for voltage transients or noise

6.2.3 Prevention of EOS

Establish and follow proper work procedures.

Conduct regular AC supply line monitoring and, if necessary, install EOS line control equipment such as incoming line filtering and transient suppression circuits.

Ensure proper testing of components and boards:

- Check test programs for hot switching and incorrect test sequence.
- Solicit maximum specification ratings from manufacturers to ensure devices are not over-stressed.
- Ensure reliability stress tests are properly designed, especially during burn-in.
- Check for excessive noise levels.
- Use “transzorbs” to clamp voltage spikes.

Use quality power supplies with the following features:

- Overvoltage protection
- Proper heat dissipation
- Use of fuses at critical locations

Adhere to a strict equipment maintenance program to ensure:

- Equipment is properly grounded
- There are no loose connections

6.3 Reference

[1] Edward S. Yang, “Microelectronic Devices”, McGraw-Hill, 1988.

[2] Kohlhass, Phil, “Controlling Potential Static Charge Problems”, 3MNuclear Products Dept., St.Paul, MN.

[3] “Electrical Overstress/Electrostatic Discharge Symposium Proceedings”, The EOS/ESD Association and ITT Research Institute, 1985 and 1986.

[4] DOD-HNBK-263,Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment”, 2 May, 1980.

[5] McFarland, W.Y., “The electronic benefits of an effective electrostatic discharge awareness and control program—an empirical analysis”. 1981 Electrical Overstress/Electrostatic Discharge Symposium Proceedings.

For more information regarding PGA insertion, request a copy of item # 8130 by calling the Intel FAXBACK line U.S. 1-800-628-2283 or 1-916-356-3105 Europe 44-793-4960646

6.4 Revision Summary

- Renamed chapter
- Removed Mechanical Assembly Damage Section