

Electrostatic Discharge Awareness

AFRL SatFab, Jan 2010

Definitions

- **STATIC ELECTRICITY**
 - A stationary electrical charge that resides on the surface of an object.
- **ELECTROSTATIC DISCHARGE (ESD)**
 - The rapid discharge of a static charge to ground (or to a lower potential). Both objects involved must be conductive.
 - During a discharge lasting a few nanoseconds, current levels can exceed several amps.
 - The combination of a voltage high enough to break down internal insulation followed by the sudden surge of current through a very small area causes most ESD damage.
- **ELECTROSTATIC DISCHARGE SENSITIVE (ESDS)**
 - A classification given to parts and devices that can be damaged or destroyed by common levels of static charge.

How is Static Electricity Generated?

- Two ways to generate:
 - Triboelectric – generated by friction/separation of materials.
 - Inductive- generated by electric fields (No physical contact required)
- Three factors determine how much charge generated by friction/separation:
 - Material
 - Some materials generate more than others. Insulators generate the most, conductors generate the least.
 - Intimacy of contact
 - The closer the two objects, the more charge is generated.
 - Speed of Separation
 - The faster they are pulled apart, the greater the charge generated.

Common Static Charge Sources

- Work surfaces Plastic or wood bench tops.
- Floors Carpets, tile, painted or sealed concrete.
- Clothes All common fabrics, cotton generates the least, wool and synthetics the most.
- Chairs Synthetic fabric upholstery, plastics.
- Packing Material Styrofoam, plastic bags, foam cushions, cardboard and paper.
- Tools Soldering irons, heat guns, plastic cases

Single Biggest ESD Hazard

People

- Always conductive
- Normally isolated
- Mobile
- Touch everything
- Impossible to eliminate
- Resistant to training and habituation
- Prone to rationalize improper behavior

Common Electrostatic Voltages

Action	10-30% Humidity	30-70% Humidity	70-90% Humidity
Walking on carpet	35,000V	7,500V	1,500V
Walking on vinyl floor	12,000V	3,000V	250V
Working at bench	6,000V	400V	100V
Removing paper from vinyl sleeve	7,000V	1,500V	600V
Picking up poly bag from benchtop	20,000V	6,500V	1,200v
Using polyurethane padded chair	18,000V	5,000V	1,500V

How much static does it take to damage hardware?

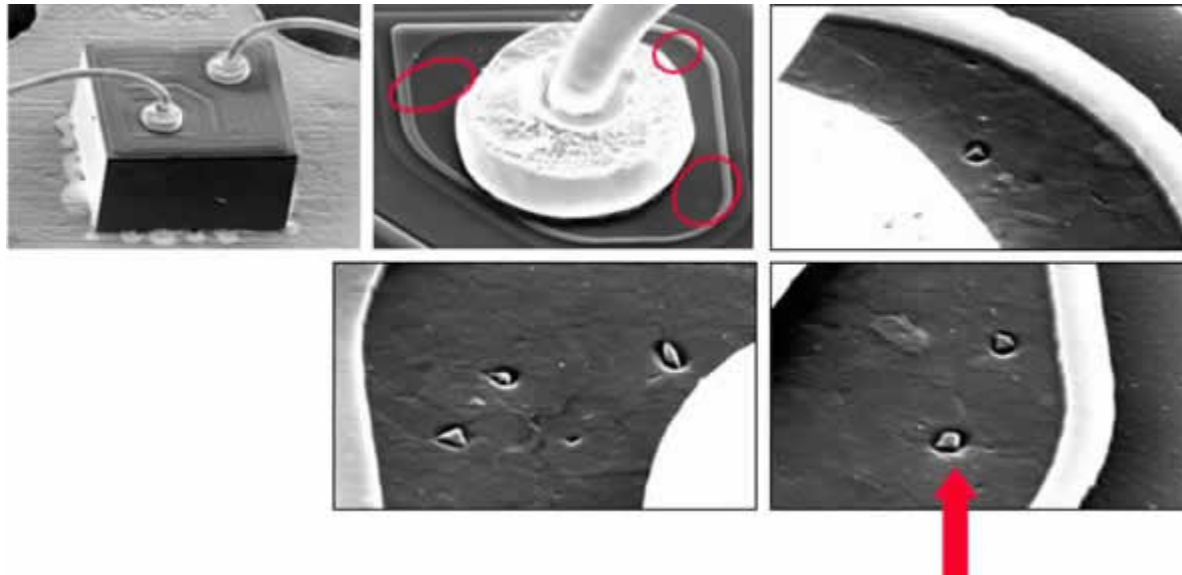
Device	Range of minimum ESD susceptibility
MOSFET	30 To 1,800 volts
EPROM	100 volts
Op Amp	190 to 2,500 volts
CMOS	250 to 3,000 volts
Film resistors	300 to 3,000 volts

Types of ESD Damage

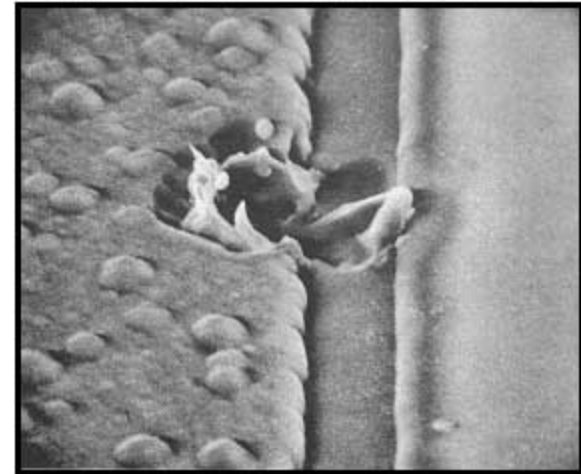
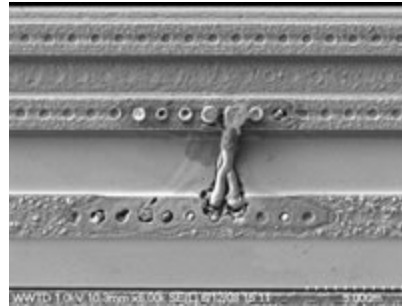
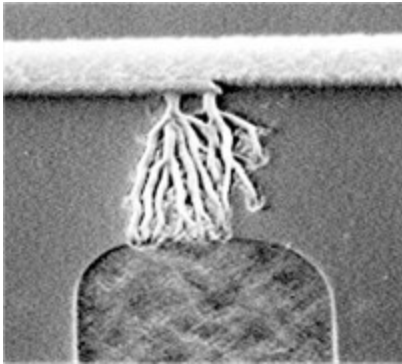
- Immediate Failure
 - ESD damages the part and renders it useless immediately.
 - Identifying the failed part can be difficult and time consuming.
- Latent Failure
 - ESD damage is not severe enough to cause immediate failure.
 - May cause a small increase in current draw, usually not detectable.
 - Part degrades over time (metal migration, etc) until failure occurs.
- Circuit Upset
 - Pulse from ESD event is erroneously detected as a normal circuit function with unintended and undesirable results.
 - Usually impossible to duplicate, can result in large amounts of time being spent examining hardware and software in an attempt to determine cause of problem.

Some Examples

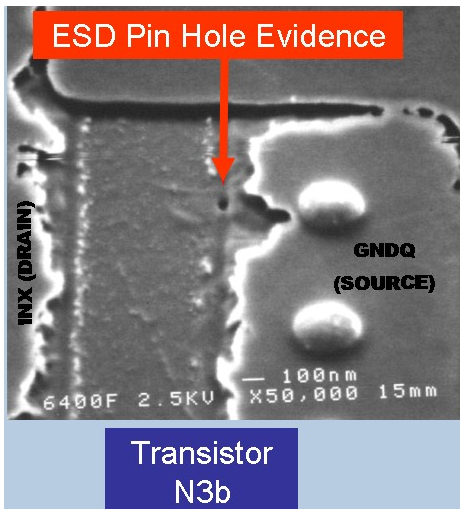
Bipolar transistor, discharge through underlying silicon



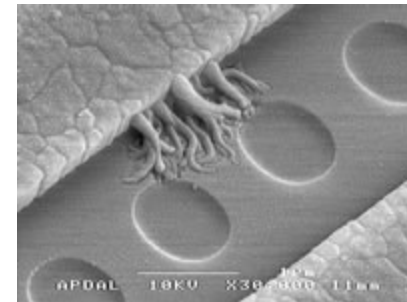
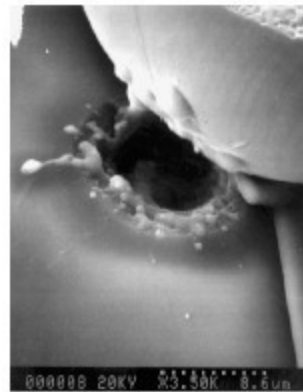
Some Examples



Surface damage at 4300X



Transistor N3b



ESD At Large

- Cell phone manufacturers estimate that 1/3 of all phone failures caused by ESD.
- PC and peripheral manufacturers consider ESD as the cause of between 50% and 66% of home and office computer failures.
- Most fueling fires that occur at gas stations are caused by ESD.
 - Don't get back in the car while fueling!

How do we protect ESD Hardware?

- Humidity Keep humidity above 30%
- Training Teach all personnel how to minimize static buildup and how to safely dissipate static
- ESD Areas Identify areas where ESD sensitive items
- ESD Work Stations Provide workstations with dissipative surfaces, common point ground.
- Proper packaging Use shielding bags, secondary packaging, ESD warning labels.

Personal ESD Protection

- Wrist Strap
 - Must fit snugly, metal portion must be in contact with skin at all times.
 - Must be connected to approved grounding point before you touch hardware.
 - Must be tested before use.
- ESD Lab Coat
 - Check for conductive grid, collar label should indicate ESD safe.
 - Must be in contact with your skin to work.
 - If you're wearing a long sleeve sweater, the lab coat is likely not doing anything.
- Habits
 - Test your wrist strap, wear your wrist strap, connect your wrist strap.
 - Wear your lab coat. Button up your lab coat.
 - Move slowly. Fast movement builds up more charge.

ESD Workstations

- Standard ESD Controlled Workstation
 - Common point ground
 - Static dissipative mat or benchtop
 - Wrist strap ground point
 - Placard and evidence of inspection
 - Absence of plastics, papers, other charge building materials.
- Large Object ESD Controlled Workstation (clean tents)
 - Must be in an ESD controlled area
 - Large object must be grounded
 - Scaffolds or supports must be grounded
 - Wrist strap ground points must be provided

Handling Precautions

- Connect your wrist strap to approved ground before handling ESD sensitive items.
- Wear your ESD safe lab coat in ESD controlled areas.
- Only handle sensitive items in ESD controlled areas.
- Keep ESD sensitive items in closed shielding bags for storage or movement.
- Only place ESD items on dissipative surfaces.
- Avoid touching exposed circuitry, pins, or contacts, handle boards by their edges.
- Keep large sensitive items in ESD controlled areas and keep them grounded at all times.
- Ground large shipping containers before opening.
- Use nitrile gloves when gloves are required.

Contamination Control & Clean Room Practices

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Definitions

- **CONTAMINATION**

- **Particulate Contamination**

- Material with an observable length, width, and thickness. Examples include fibers, hair, dust, lint, etc.

- **Molecular Contamination**

- Foreign material that lacks readily defined dimensions. Examples include residues, finger prints, etc.

- **CLEANROOM**

- A room designed to reduce ambient particulate contamination to a specific level

- SOURCES OF CONTAMINATION

- Environment:
 - Dust, fumes, vapor, fungi, bacteria, pollen, etc.
- People:
 - Skin flakes, dandruff, hair, fingerprints, spit, etc.
- Activities:
 - Machining, cleaning, packaging, soldering, testing, etc.

Basic Clean Room Design

- Efficient air filtration –HEPA (High Efficiency Particulate Air) Filters
- Positive Pressure- Keeps unfiltered air out
- Laminar air flow- Minimizes turbulence, purges contamination from room
- Materials- Walls, floors, furniture, & fixtures designed not to generate or shed particles
- Layout- Anteroom for gowning, storage
- Classes- # designation indicates the number of .4 micron or larger particles per cu. ft.

Clean Room Practices

- **Goals:**
 - The goal of clean rooms is to minimize gross particulate contamination and prevent accumulation of residues.
- **Specifics:**
 - Clean rooms practices vary by classes.
 - The 204 room is class 100. Accordingly, we need to wear the full coveralls (“bunny suits”), leggings, and shoe covers. As MOSES is an optical payload, it needs to be kept covered when not in use.

Practices Cont'd

- If you know you will be working in the clean room regularly:
 - It's best to shower at night rather than the morning before work.
 - Avoid cosmetics (Especially you, Tom)
 - Avoid heavy use of aerosols, perfumes and cologne
- Before entering:
 - Make sure you have all the tools you will need
 - Pre-clean tools and equipment with alcohol
 - Remove outer packaging before bringing delivered items into the room
 - Use the sticky mat in the anteroom

Practices cont'd

- Preparing to enter the clean room:
 - Clean shoes on tacky mat
 - Leave personal items in anteroom
 - Make sure you have a clean bunny suit, hair net, face cover, and powder free gloves
- While in the clean room:
 - Avoid fast motions (it generates particle movement)
 - Avoid leaning over hardware
 - No gum
 - Do not remove items from under the suit
 - Do not touch your face
- Packaging
 - Cut packaging open (don't tear)
 - Promptly discard or stow packaging

Practices Cont'd

- If you must:
 - Move hardware into and out of the clean room, use a fresh suit when you re-enter the clean room
 - Unpackage an item of questionable cleanliness in the clean room, do it as far from flight hardware as possible, remove the packaging immediately and wipe down the item.

Open Area Contamination Control

- When moving flight hardware to test areas outside the clean room:
 - Wear at minimum a clean room smock, hair net, mask and gloves
 - Install protective covers on hardware and if possible, completely cover hardware
 - If using a crane for heavy loads, a drip shield is recommended to protect from possible oil leakage