

Image Sensor Handling and Best Practices



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APPLICATION NOTE

Application Note Abstract

This application note describes minimal methods for customers to incorporate in their handling, storing, and cleaning processes for image sensors.

INTRODUCTION

Integrated circuits, including image sensor products are sensitive to Electrostatic Discharge (ESD).

ESD events can cause immediate damage to a device so that it is no longer functional. The effect may also not be noticed until a considerable time has passed, with the unit operating to specifications for some time. ESD events also show up as shifts in device characteristics.

ESD events occur by improper handling of the image sensor. Improper handling includes any operation that creates an electrostatic discharge; for example, handling the device without a wrist strap. Environmental conditions also contribute to the likelihood of an ESD event.

The cost of an appropriate ESD control program is well offset by the savings achieved in avoiding damaged devices (see References [1] and [2]).

This application note discusses minimum required procedures to minimize the occurrence of an ESD event when handling image sensors. Requirements listed in this application note are based on IPC/JEDEC JESD625[3]. Image sensor customers should incorporate requirements of this Application Note along with IPC/JEDEC JESD625[3] and J-STD-001 into their ESD control systems.

Disclaimer

ON Semiconductor is not responsible for damage caused by improper handling or cleaning of the device after it is received by the customer.

Rating

ON Semiconductor CMOS image sensors, unless stated otherwise in the applicable device datasheet, are rated as follows for ESD sensitivity according to the ANSI/ESDA/JEDEC classification method.:

- Human Body Model: JS-001 Class_2
- Charged Device Model: JS-002 Class C2A

NOTE: For CCD devices, unless a class rating is specified, consider the product to meet Class 0A for HBM, and Class C0A for CDM.

Glossary of Terms and Definitions

For the purpose of this application note, the following definitions apply:

- *Air Ionizer*: A source of charged air molecules (ions).
- *Antistatic Material*: Refers to the property of material that inhibits tribo-electric charging.
- *Conductive Material*: A material that has a surface resistivity less than $10^5 \Omega$ per square or a volume resistivity less than $10^4 \Omega$ centimeter.
- *Electrostatic Discharge (ESD)*: The transfer of electrostatic charge between bodies or surfaces that are at different electrostatic potentials.
- *Electrostatic Discharge Susceptibility [sensitivity] (ESDS)*: The lowest level of ESD that produces changes in device characteristics such that the device fails to meet its specified characteristics.
- *ESD-Protective Packaging*: A packaging system that provides electrostatic protection and limits tribo-electric charging to levels that do not result in device damage.
- *ESD-Protective Work-Surface*: A table top or other surface on which to work that has a resistance to ground of less than $10^9 \Omega$.
- *Insulation Material*: A material having a surface resistivity of at least $10^{12} \Omega$ per square or volume resistivity of at least $10^{11} \Omega$ centimeter.
- *Static Dissipative Material*: A material having a surface resistance between $10^5 \Omega$ and $10^8 \Omega$ or a volume resistivity between $10^5 \Omega$ centimeters and $10^8 \Omega$ centimeters.
- *Static Electricity*: Electrical charge at rest. The electrical charge is due to the transfer of electrons within a body (polarization) or from one body to another.

MINIMUM REQUIREMENTS FOR ESD PROTECTED AREAS, WORKSTATIONS, AND TOOLS

The following are the minimum requirements when handling image sensors.

ESD Protective Work Surface

When unprotected ESD sensitive (ESDS) devices are handled, a grounded static protective work surface with a resistance to ground of less than $10^7 \Omega$ should be used.

ESD Protective Flooring or Floor Mats

Grounded flooring or floor mats are only required when personnel or mobile ESD protective workstations use floor grounding methods.

Personnel Grounding

Each person handling or within 12 inches of unprotected ESDS devices, must be grounded using either of these:

- Wrist straps:
 - ◆ Provide a continuous electrical path directly from the user to ESD ground.
 - ◆ Have an integral resistance at the wrist band end that limits current to less than 0.5 mA at the highest voltage level that an ESD may be encountered.
 - ◆ Be worn by operators handling unprotected ESDS devices when seated.
- ESD protective footwear (heel straps, toe straps, or shoes). These should:
 - ◆ Provide a direct continuous electrical path from the user to the ESD protective flooring or floor mat.
 - ◆ Be worn on both feet.
 - ◆ Limit current to less than 0.5 mA through the specific path to ground at the highest power supply voltage that may be encountered.
 - ◆ Not be relied upon for grounding of seated personnel.

ESD PRECAUTIONS FOR DEVICE HANDLING

Methods to Minimize Static Charging

Static charge preventive actions should be used at ESD protected areas and workstations where electrostatic potentials greater than ± 1000 volts are measured and unprotected ESDS devices are within 12 inches of the charged sources.

Charge prevention and neutralization methods include, but are not limited to, antistatic solution treatments, relative humidity control, air ionizers, sleeve protectors, and ESD protective clothing.

● *Antistatic Solution:*

Antistatic chemicals (solutions) can be used to prevent static charge generation on static generating or charging materials in the work or storage areas. During application of any antistatic chemical, consider the following:

- ◆ Choose the antistatic solutions to avoid contamination of ESDS devices.

- Static generating sources and charged surfaces.
 - ◆ Non-essential and personal items should not be placed on ESD protective work surfaces that are in use.
 - ◆ No item with an electrostatic potential greater than ± 1000 volts should be closer than 12 inches from unprotected ESDS devices.
 - ◆ Operations, equipment, or clothing generating electrostatic potential greater than ± 1000 volts within 12 inches of unprotected ESDS devices should be neutralized or reduced to less than $\pm 1,000$ volts.
 - ◆ Charged items must not contact ESDS devices.

Note that the above personnel grounding recommendations are intended to protect ESDS devices and not the personnel handling them. Safety of personnel is outside the scope of this document and is not the responsibility of ON Semiconductor.

ESD Protective Smocks

When ESD protective smocks are worn, they should cover all personal garments above the waist, except at the neck area.

Air Ionizers

As part of customers' image sensor ESD control systems, ionizers must be used at least as defined in this Application Note.

ESD Protected Area and Workstation Identification

ESD caution signs must be posted at each ESD protected workstation or at the entrances of defined ESD protected areas.

- ◆ Avoid any contact of the solution with the sensor glass lid.
- ◆ Do not apply antistatic spray or solutions in any form to energized electrical parts, assemblies, panels, or equipment.
- ◆ Do not apply antistatic solutions when devices and packages are directly exposed to spray mists.
- ◆ The need for initial application and frequency of reapplication can only be established through routine electrostatic field measurements during normal operations using an electrostatic field meter.
- *Relative Humidity Control:*
Relative humidity has a significant impact on the generation of static electricity and its control is required, where image sensor devices are stored or handled using manual or automated means. At a minimum, customers are expected to follow humidity control requirements as defined in J-STD-001.

- *Air Ionizers* should conform to the following:
 - ◆ Table ionizers should be positioned so that the devices at the ESD-protected workstations are within the ionizer manufacturer's specified coverage area. The ionizer should be aimed at the devices and operator's hands rather than at the operator.
 - ◆ Ceiling ionizers should be oriented in relation to the work surfaces in keeping with the ionizer manufacturer's instructions.
 - ◆ Devices should not be brought closer to the ionizer than specified by the ionizer manufacturer.
 - ◆ There should be an unrestricted, straight line air flow between the ionizers and the unprotected devices.
 - ◆ Ionizer balance (positive and negative ions) should be verified according to IPC/JEDEC JESD625[3].
- ◆ Ionizer charge decay performance should be verified using the method described in EOS/ESD-S3.1 according to IPC/JEDEC JESD625[3].
- *ESD Protective Smocks:*
When worn, ESD protective smocks must accomplish the following:
 - ◆ The ESD protective smocks must be buttoned (except for the collar) whenever the wearer is at an ESD protected workstation or in a designated ESD protected area.
 - ◆ The ESD protective smock manufacturer's cleaning instructions should be followed to gain maximum effectiveness and utility from the smocks.
- *Gloves:*
Only static dissipative Nitrile gloves must be used when handling ESDS devices.

DEVICE HANDLING

This is a general guideline. Imaging sensors must be handled in an ESD safe area. A ground strap is required when handling the sensors in a non-ESD safe area. ESD safe gloves must be used.

While handling imaging sensors:

- Wear mouth protection (face mask) to minimize the risk of contaminating the glass lid through saliva or other particles.
- Wear gloves that are ESD safe. The gloves must be clean. Contaminated or dirty gloves need to be changed or cleaned.

- Finger tips of the gloves should be tight to reduce the risk of contaminating the glass lid.
- Always handle image sensors at the package; never touch the glass lids.
- Handle the pin grid package (PGA package) carefully to avoid bending the pins.

Static charge can be generated during any assembly or test process step. Ionizers should be used at each assembly or test process step requiring manual or automated handling of image sensors to avoid any artifacts or damage resulting from static charge.

COVER GLASS CLEANING

Purpose of Cleaning the Cover Glass

The packaging of image sensors requires high levels of cleanliness. High quality glass windows are used instead of typical ceramic or plastic encapsulation methods. In some sensors, special coating is placed on the glass to control spectral properties.

Special handling precautions are required to prevent scratching, chipping, particulate or other contamination of the glass and/or coatings.

In particular, electronic module assembly processes involving image sensors can expose the sensor cover glass to particles or contaminants. ON Semiconductor recommends that all handling and assembly processes be audited and modified to reduce the risk of exposure to particles or contaminants. In the event that such exposure cannot be completely eliminated, it may be necessary to clean the cover glass. The following are ON Semiconductor's recommendations for proper cleaning of the glass.

Procedure for Cleaning the Cover Glass

Perform the cleaning in an ESD safe protected workstation including use of ionizers as described in the

section of this document titled "ESD PROTECTION FOR DEVICE HANDLING". Always wear an ESD wrist strap. Do not touch the cover glass with fingers or anything other than a cleaning paper as required in this section. Finger grease can etch optical coatings and cause permanent damage. The gloves should be static and powder free. Gloves should be static dissipative Nitrile gloves.

Materials:

- Clean compressed nitrogen
- Ultra-clean DI water (4–6 megaohms/centimeters deionized water that has been filtered)
- High-grade IPA (solvent grade/100% pure lab purity grade)
- ESD protective Wipe:
 - ◆ For CCD sensors: Berkshire DurX 670
 - ◆ For CMOS sensors: Puritech Puritech S1091PRT or RTMKC002
- ESD protective gloves for example: Nitrile Glove, required Ansell 93–401/402 or NiProTect CC529

Method A: Blow Off

This method is applicable for loose particle contamination. This is the only method that guarantees no residues such as drying spots.

- Remove particles from the glass by blowing with an ionized-N₂ gun.
- Do not blow towards the other parts. If you work under a flow box, try to blow out of the box.

Method B: High-Grade IPA Clean or Ultra-Clean DI Water

- Apply cleaning solvent using a separate lab-ware quality polypropylene squeeze bottle (Nalgene trade name), not the original bottle
- Use a lint free wipe in one direction, with even pressure across the glass surface.
- Never wipe the cover glass with a dry cloth. The cleaning solvent should be applied directly to the cleaning wipe and never directly on the cover glass.
- The ESD protective wipe should not be saturated, only dampened with the cleaning agent.
- After each wipe, either start with a fresh wipe or fold the wipe to provide a fresh surface for glass cleaning

Note: High grade IPA or ultra-clean DI water are acceptable for cleaning both plain glass and AR coated glass.

Note: Method A and B are acceptable methods to clean the CCD image sensor cover glass with the following exception. DI Water or IPA is not recommended for cleaning the CCD image sensor cover glass. Instead, 100%

ethanol is required as the cleaning agent for CCD image sensor cover glass.

Caution on Cleaning Agents

- Use high-grade IPA only to clean the image sensor lid glass. Other solvents can contaminate the glass, attack the resin and sealant, and degrade reliability of the package.
- Do not use acetone because it attacks the resin that glues the cover glass to the package.
- Do not use methanol due to its toxicity and low quality cleaning properties.
- Do not use sodium hydroxide (NaOH) because it degrades the AR coating on the glass.
- Do not use highly alkaline (pH > 8) cleaning chemistries.
- Do not use any solvents commonly used in paint strippers: toluene, benzene, methyl-ethyl ketones, ester solvents, acetone or methyl chloride, freons, terpens, anionic surfactants and multi-hydroxyl ethers.

If the surface is not clean, repeat these procedures. If the contaminant is not removed in two or three wipes, it is possible that the cover glass is permanently damaged. Inspect the device in optical microscope for permanent damage.

CAUTION: ON Semiconductor recommends customers evaluate cleaning process to ensure that no damage to the image sensor component occurs.

SENSOR MOUNTING AND SOLDERING CONSIDERATIONS

Mounting for SMD

- Image sensors require special considerations when soldering to printed circuit boards. Image sensors with color filter arrays (CFA) and micro-lens are especially sensitive to high temperatures. Prolonged heating at elevated temperatures may result in deterioration of the performance of the sensor.
- The cover glass, with or without coatings, is sensitive to contamination. Avoid spilling solder flux on the cover glass and particularly glass with coatings. Avoid mechanical or particulate damage to the cover glass.

Pin Grid Array – PGA

Hand Soldering

When a soldering iron is used to solder devices to a through-hole board, the following conditions should be followed:

- Use a soldering iron with temperature controlled tip (30–80 W).
- The soldering iron tip temperature should not exceed 350°C.

- The soldering period for each pin should be less than three seconds.

Wave Soldering

Preferably, place image sensors in a PGA package in a socket, where the socket, and not the image sensor, is subjected to the mounting reflow procedures such as IR, convection, or wave soldering.

CAUTION:

- Do not place the image sensor in the socket during the reflow process.
- Do not mount PGA packages using IR or convection solder reflow. Wave soldering is preferable for mounting PGA packages, if a socket is not used.

CSP (BGA) Handling

For Chip Scale Packaging assembly process, follow J-STD 020 [6] and JEDEC/IPC J-STD-033 [7] to prevent failure. For more information about mounting and soldering, refer to ON Semiconductor's number [9].

Solder Paste and Flux

Solder Paste should be compatible with the BGA's solder. For details refer to applicable device datasheet. The flux type should be no-clean and Halide-free (no corrosive residue is allowed).

Reflow Profile

In general, reflow profile considerations rely upon PCB material, solder paste manufacturer recommendations and

the other electronic components on the same board. The package thickness and volume can affect the reflow profile requirement. Refer to the package dimensions on the product datasheet and the JEDEC Standard J-STD-020-01[6].

Image Sensors parts may be moisture sensitive; use proper handling and baking techniques according to the moisture sensitivity classification IPC/JEDEC J-STD-033[7].

GLASS PROTECTIVE FILM

ON Semiconductor assembles and tests image sensors in a clean room environment. Customer manufacturing processes can generate contamination and are often not performed in a clean room environment. Glass contamination or damage compromises the quality and functionality of the image sensors. For added cover glass protection, ON Semiconductor offers an optional protective film on select image sensor devices.

Currently, ON Semiconductor uses two different protective films for this purpose. The first, used on devices with part numbers beginning with "A", "M", or "N", can withstand standard surface mount technology (SMT) reflow at a maximum temperature of 260°C. They are qualified according to JEDEC J-STD-020-01[6] reflow standards with 3× reflow test with no adverse material issues. The second, used on part numbers beginning with "K", cannot withstand high temperatures and is not intended for soldering using a reflow process. Neither of these protective films are qualified for any aqueous or chemical wash steps.

In all cases, the protective film at a minimum covers the glass directly above the active array of packaged image

sensors. The actual size and shape of the protective film varies by device and package type. Refer to the applicable device datasheet for configuration details by product.

Required Removal Procedure

For all devices, the protective film should be removed prior to testing of the final product, as the film may impact optical test results if present. Removal of the protective film must be performed using standard ESD precautions in a controlled humidity environment. Use of ionization fans focused on the device during tape removal is required to avoid creating a charge that could impair the performance of the sensor. It is required to peel the protective film with tweezers in a smooth steady motion, in a parallel direction to its placement on the glass, with no twisting, and with the ionized air aimed directly at the newly exposed tape/glass interface, as shown below.

Since the protective film could potentially adhere to other surfaces, it should be disposed of immediately after removal. Protective film should not be reapplied to the sensor.

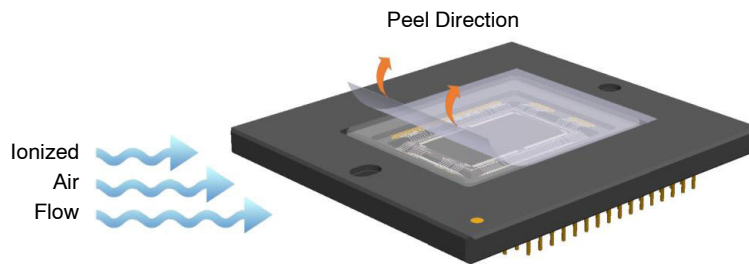


Figure 1. Glass Protective Film

ON Semiconductor does not guarantee that the protective film adhesive will not leave a residue on the glass after removal. In the event that some residue remains, the glass

can be cleaned per the required process described in the section "Cover Glass Cleaning".

STORING UNMOUNTED IMAGE SENSORS

Short-Term Storage

Unsealed devices should always be stored under the long-term conditions. Assembled devices with sealed cover glass should always be stored in their 1st-level packaging which is a moisture proof, vacuum-sealed, anti-static bag (Moisture Barrier Bag – MBB). The sensors in their 1st-level packaging should be stored indoors, in a dust-free, enclosed environment with the following conditions:

| Description | Condition |
|-------------------|--------------|
| Time Limit | < 1 Year |
| Temperature | 20°C to 40°C |
| Relative Humidity | < 60% |

CAUTION: Avoid storage locations with the following characteristics:

| Description | Condition |
|------------------------|---|
| Direct Sunlight | Carriers (tubes, trays, or single unit carriers) may deform or color filter arrays may fade. |
| Corrosive Gases | Leads/pins may oxidize or corrode. |
| Excessive Loads | Devices may be damaged if heavy objects are stacked on packing boxes. |
| Radiation | Imaging defects may be induced. |
| Electromagnetic Fields | Imaging defects may be induced. |
| Static Electricity | Device may suffer catastrophic damage. If devices are stored in open trays, full ESD protection must be used to avoid damage when handling the devices. |

Long-Term Storage

Assembled devices stored for longer than one year are considered to be in long-term storage. When long-term storage is anticipated, the devices in carriers should be placed into moisture proof, vacuum-sealed, anti-static bags or in an electrostatically safe, moisture proof enclosure to prevent device degradation of the electrical characteristics and/or deterioration of the leads/pins. Ideally, this would include a dry nitrogen flow. The moisture proof package/enclosure should be stored indoors, in a dust-free, enclosed environment with the following conditions:

| Description | Condition |
|-------------------|--------------|
| Time Limit | 1 to 5 Years |
| Temperature | 20°C to 40°C |
| Relative Humidity | < 60% |

The storage avoidance characteristics noted above under Short-Term Storage also apply to Long-Term Storage.

Long-term storage, if done improperly, may cause the leads/pins to oxidize or corrode, which may affect the lead/pin solderability. When devices are stored for time periods in excess of one year, the lead/pin solderability should be confirmed prior to use. Additionally, the electrical characteristics should be confirmed, as necessary, prior to use.

Dry Pack Description

Dry pack consists of a desiccant and a Humidity Indicator Card (HIC), sealed inside a Moisture Barrier Bag (MBB) and a barcode label. The MBB provides ESD protection and has the required mechanical strength and flexibility, is puncture-resistant and heat-sealable. The desiccant packed in each bag will keep the internal relative humidity level below 10% at 25°C. The Humidity Indicator Card provides the customer with a simple and efficient means to verify the internal humidity.

Storage Requirements and Time Limits out of Dry Pack

The MSL at which each product is classified determines the appropriate packaging storage and handling requirements when the product is out of dry pack. Refer to JEDEC standard IPC/JEDEC J-STD-033[7], IPC-610[8] for the packaging, storage conditions and floor life before the assembly process. Non-SMD packages, such as PGA, JLCC, are not recommended for reflow and hence non-SMD products do not have an assigned MSL level. Nevertheless, storage requirements as are applicable for these packages and the recommended floor life is 168 hrs. If the floor life is exceeded, the affected product must undergo bake prior to any reflow process.

CAUTION: During the ramp down of the bake out process, it is required that the ramp down rate is gradual to prevent condensation on the underside of the glass lid.

SAFE STORAGE REQUIREMENTS

Moisture Absorption

If the customer cannot mount the product within the specified time limit, or factory conditions exceed the specified maximum temperature and/or humidity level, then the customer can abate moisture absorption by following any of the safe storage methods to maintain the floor life:

Dry Pack: The calculated shelf life for dry packed SMD packages while in a MBB, when stored in an environment maintained at $< 40^{\circ}\text{C}/ 90\% \text{RH}$ is a minimum of 12 months.

Dry Cabinet at 10% RH: Integrated circuits not sealed in a MBB may be placed in a dry atmosphere cabinet maintained at $\leq 10\% \text{RH}$ up to a maximum time specified in IPC/JEDEC J-STD-033[7]. If the time limit is exceeded, bake is required to restore the floor life.

Dry Cabinet at 5% RH: Integrated circuits not sealed in a MBB may be placed in a dry atmosphere cabinet maintained at $\leq 5\% \text{RH}$ for an unlimited shelf life equivalent to storage in a MBB.

CAUTION: Image sensors (surface mounted or otherwise) with a cavity will gather water vapor if placed in a high water vapor pressure environment. The environment can be a high relative humidity and/or temperature for an extended period. Baking the image sensor for an extended period may remove the previously gathered water vapor from the cavity. ON Semiconductor recommends preventing the ingress of water vapor by storing the image sensor in one of the three methods mentioned above.

Solderability Degradation

If the customer cannot mount the product within 24 months after the assembly date, ON Semiconductor recommends performing a solderability test in order to check for lead condition (discoloration, etc.) prior to mounting the product.

The customer can abate solderability degradation by storing the product in a nitrogen environment.


DRYING PROCEDURES AND REQUIREMENTS

Product that are not handled or stored within required conditions must undergo bake for drying prior to reflow to reset floor life. Re-sealing in an MBB with a desiccant is required if product is not used after bake.

Refer to JEDEC standard IPC/JEDEC J-STD-033[7], IPC-610[8] for the bake conditions.

REFERENCES

- [1] Enhancing Profits With Effective ESD Control by Stephen Halperin, in collaboration with Ron Gibson Dec 1, 2004, Conformity http://www.conformity.com/artman/publish/printer_107.shtml
- [2] White paper: *A Case for Lowering Component Level HBM/MM ESD Specifications and Requirements.*
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- [4] IPC/JEDEC Standard No. 22-C101.01.
- [5] IPC-7095L: Chapter 6: Printed Circuit assembly design considerations and Chapter 7: Assembly of BGA on printed circuit boards.
- [6] Reference: JSTD020-01 Jedec Standard for Moisture/Reflow Classification.
- [7] IPC/JEDEC J-STD-033 Handling, packing, Shipping, and Use of Moisture/Reflow Sensitive Surface Mount Devices.
- [8] IPC-610: Acceptability of electrical assemblies.
- [9] SOLDERM/D: ON Semiconductor's Soldering and Mounting Techniques Reference Manual.

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