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Static Digest

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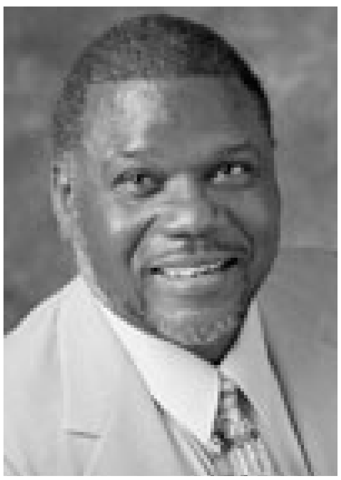
By Leo G. Henry Ph.D.,
ESD/TLP Consultants, LLC



Leo G. Henry

Move Underway to Change CBM to CBE (Charged Board Event)

In an attempt to bring awareness for the need to develop a universal procedure to test for component failures on printed circuits boards (PCBs), this article will review the existing publications but use as the base the white paper [1] published in 2005. The authors [1] reiterated then what earlier publications [2,3,4] stated: that only anecdotal evidence existed then for ESD failures of Integrated Circuits (ICs) that are mounted on PCBs. These failures had occurred after unprotected personnel handled the IC-populated PCBs during the many stages of manufacturing up to and including actual placement in the completed electronic equipment/system. In 1984 [4], it was reported that most components which reportedly failed for the ESD transients on the board, had failed functional testing (the board was inoperable). Failure Analysis (which included SEM analysis) of the ICs removed from the board, showed that the physical damage type was dielectric/silicon punch-through. When the boards were replaced in conjunction with implementing tighter ESD controls (training, handling and using protective packaging, for example), the yield improved over 1000 fold.

From 1985 [5], this PCB ESD discharging event was referred to as a Charged Board Model (CBM) ESD event, and CBM ESD testing was initiated. The magnitude of the transient ESD discharges from the PCBs into the ICs was shown by [4] to depend on three factors: (i) the potential on the PCB, (ii) the capacitance to ground of the PCB and (iii) any other circuit elements (for example, resistors) in the discharge path. The measured PCB capacitance (> 125pF) was always larger than that (25 pF) for IC devices being built at that time. The charged board failure thresholds were, however, much lower than the thresholds of the recognized charged device model (CDM) failures, and as the PCB-to-ground capacitance increased, the failure threshold of the board failures decreased. They also demonstrated that the ESD failure levels of the components mounted on PCBs were not correlatable to the failure levels of a component when tested to HBM or to CDM.

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In 1986, Enoch and Shaw [6], in their study of board-mounted ICs, used the field-induced method to charge the board (PCB), then grounded the PCB via one of the input connectors. They also ascribed the failures to induced voltage on the board, board capacitance and the resistance of the discharge path. They developed an equivalent circuit for the combined PCB and component and used the totally stored energy, Eb, in the PCB to get to the energy dissipated in the component, Ec. This can be represented by the function: Ec = f (Eb, Rc, Rt), where Rc is the dynamic resistance of the component during the transient and Rt is the resistance of the test circuit.

Figure 1: FICBM test method setup for a DSP board. After Olney [9].

Koyler et al in 1987 [7] presented similar failure data after getting rid of the human handling by employing instead an automated machine for mounting components on PCBs. They regarded the PCB to be an extended device package, but with higher capacitance, then they suggested two modes by which the board-mounted IC can fail: (i) during the insertion of the device into the board, and (ii) when the PCB discharges into the device, an external to internal mechanism.

Paasi 2003 [8] stressed Printed Wiring Boards (PWB) after they were charged by transportation on conveyor belts. They also did spice simulations and used different multilayer boards to point to the importance of capacitance. They pointed to the fact that populated PWBs vary depending on the amount of other devices on the board like capacitors, which can store charge and add to the overall total board dielectric discharge.

Olney et al [9] in 2003 used a regular CDM tester used to perform the field-induced stress testing of the components on the board. In one setup, he placed the device in a socket and mounted it on the board, and in the second setup, he placed the actually populated board on the tester table for stress testing. The PCB was centered on the charging plate as shown in Figure 1. The PCB is separated from the metal charging plate by a thin dielectric layer to prevent shorting to the charging plate. This addition can change the capacitance of the whole system, so it must be accounted for. Both polarities are stressed. The PCB is electrically tested between stress levels, and the stress levels are increased until the PCB electrically fails. He showed that the board stress was more severe than HBM and CDM, and used physical failure analysis to confirm the failures.

CBM: An Extension of CDM

Conceptually, the Charged Board Model (CBM) is similar to the Charged Device Model (CDM). During a CDM event, the charge stored by a packaged IC discharges (typically < 100picoseconds) just before contact is made with a conductive object at or near ground potential. During a CBM event, the charge stored by an entire PCB discharges (100s of picoseconds) just before contact is made with a conductive object

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at or near ground potential. Thus, the Charged Board Model can be thought of as an extension of the Charged Device Model where the PCB is the "device" that stores the charge. It is suggested that CBM be renamed CBE (Charged Board Event) because CBE does not really represent a new model, it is just a more severe CDM event – so severe that the failure can be mistaken for electrical overstress (EOS) damage.

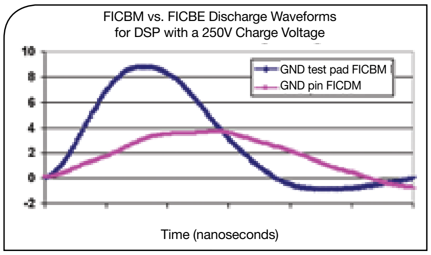

Figure 2: Comparison of FICBM vs. FICBE discharge waveforms. Olney et al. [9]

Figure 2 compares the Field Induced CDM (FICDM) discharge waveform for a component IC to the FICBE waveform for the same device mounted to the PCB shown in Figure 1. As is seen, for a given charge voltage, the FICBE discharge has much higher peak current and faster rise time, so the device on the board is more susceptible to ESD damage at the board level. Such ESD damage can look like EOS damage, but it is not EOS and should be referred to as Board ESD much like we have HBM ESD and CBM ESD.

Need for Standard Practice Document

The move is to change the CBM to Charged Board Event (CBE). CBE is not as well known as other ESD models but it represents a major real-world ESD threat. Even if all the individual components used for a given PCB have high device/component-level ESD robustness, one or more of these components could be very susceptible to ESD damage after mounting to a PCB since a PCB in general has much higher capacitance than an individual device [10-19]. CBE damage can be much more severe than CDM damage. Therefore, before attributing an IC failure on a PCB to EOS, the possibility of CBE ESD damage should be explored.

No industry standard currently exists for CBE testing, but a Standard Practice (SP) document is being considered by the Device Testing Working Group members. An SP document contains a procedure for performing one or more operations or functions that may or may not yield a test result. Note, if a test result is obtained, it is not reproducible. Standardizing CBE stress testing procedure will be challenging because PCB designs and layouts vary significantly and each PCB may have hundreds or even thousands of potential discharge points, so specifying specific discharge points in a standardized test method is not easy, but a Standard Practice document, which is just the best practices that are being used, can be developed.

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About the author:

Leo G. Henry, Ph.D., an independent ESD/TLP consulting engineer, is the overall chair for the ESD Association's ESD Standards Working Group for Device Testing. He is the elected junior vice president of the ESD Association and serves on the ESD Program Manager and Device Design Certification council as well as other committees. He has worked in the electronics industry for many years for such companies as Advanced Micro Devices, Barth Electronics, and ORYX Instruments. He has authored many technical papers, given many presentations at conferences and seminars, and taught at San Jose State University. He holds master's and doctoral degrees in materials science and engineering from the University of California at Berkeley and a master's degree in physics from the University of the West Indies. Phone: 510-708-5252 or 510-657-5252; leogesd@pacbell.net or leogesd@ieee.org

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By Vladimir Kraz

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Vladimir Kraz

Tech Corner: Human Body vs. Charged Device Models

Electrostatic discharges (otherwise called ESD events) have different characteristics, and these characteristics determine the effect these discharges have on ESD-sensitive devices, such as semiconductors and magnetic heads.

The ESD Association (www.esda.org) has defined three basic models of discharge: Human Body Model (HBM), Charged Device Model (CDM) and Machine Model (MM). Each model is meant to emulate particular discharge properties, such as the rise and fall times of the discharge current waveform. HBM, for example, emulates a discharge from a charged human body, which, electrically, is a combination of the capacitance of a human body and resistance of skin touching the component. An operator handling a device with tweezers does not fall under HBM. Even more interesting, discharge simulators for HBM use metal contacts. While making the discharge repeatable, this removes the validity of correlation between the model and real-life situation events. CDM emulates a discharge from a small charged device, such as an integrated circuit that is suspended on a vacuum pick and then placed on a metal surface, such as copper pads on the circuit board during assembly.

In reality, there are many more types of discharges reflecting different situations. In real-life situations, one needs to keep in mind that in every instance the actual properties of discharge would differ from the specified models.

In the past, the dominant discharge model affecting devices in production was HBM. Electronics assembly was predominately a manual operation, and the operators handled the devices by hand. A poorly grounded operator would develop a static charge, and during contact with the part, the charge would discharge, damaging the component in the process. Today, the manual operation is an endangered species – the ratio of manual vs. automated operations is constantly shifting in favor of the latter. In an automated process, the only time the operator would normally touch the device is when the device is defective and needs to be removed from the process.

The most relevant discharge model in today's automated production is CDM. Whenever a device is lifted from a tray or other transport, it is most likely charged (this happens whether the transport is antistatic or not). When such a charged device is placed on a PC board or any conductive surface inside the tool, a CDM-type event may occur. Even when an operator is involved using a vacuum pick to handle the device, the discharge is still largely of the CDM type.

Of course, there are occasions where the Machine Model or other more exotic models would apply, but statistically, CDM is the most frequently applied model in production. Roger Pierce of ESD Technical Services states that "… 99.9 percent of all real world ESD failures are due to the CDM" (Evaluation Engineering, Nov. 2002).

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Why It Matters

What importance does it have on establishing and maintaining a safe ESD environment in production? Different models affect devices in a different way. HBM is a relatively slow discharge – its rise time is limited by the high resistance of human skin and in real life is in an approximate range of 10 to 30 nanoseconds (metal-contact HBM simulators offer 2 to 10 nS range).

CDM is a very fast discharge – its rise time is defined by extremely low impedance of metal-to-metal contact, almost no inductance of contacts to speak of, and low self-capacitance of the device. The rise time of a CDM event is in the sub-nanosecond range and is thought to be as short as 65 picoseconds. When energy from a relatively slow discharge enters the device, this energy has time to dissipate throughout the lead frame and the substrate of the device. However, when a fast discharge occurs, its energy does not have sufficient time to dissipate before the immediate area of the device adjacent to the pin rapidly overheats and explodes, producing the all-too-familiar craters and blown-up traces.

In relative terms, the CDM-type damage threshold is often 10 to 20 times lower than the one for an HBM-type discharge. If an HBM-type discharge causes damage at 2000V, it is not uncommon to have the same component damaged by a 100 to 150V CDM event.

Why then are many standards and specifications still focused on HBM rather than on the much-more relevant CDM model? Inertia. It takes years to push any standard through the system, and there is always a reluctance to change established practices.

What to Do About It

First, analyze your production process and determine which model is most relevant for you. It may be that in some areas of your manufacturing CDM is prevalent, and in some others, HBM. Analyze the actual contact with the parts – even if the parts are being handled by an operator: Are they handled directly by hand or by a hand tool such as tweezers or a vacuum pick? A tool that can help with your analysis is the 3M™ ESD Pro Event Detector, which has a special mode to identify CDM-type events and filter out other types of EMI and ESD events.

Second, set your requirements for static voltage in the environment and for the strength of discharges based on the most sensitive part in your production, keeping in mind the applicable discharge models.

Third, understand your factory's growth. Today the assembly may be manual, but tomorrow it may be replaced by machines.

Above all, manage your ESD environment based on solid facts that are relevant to actual ESD exposure to your ESD-sensitive devices.

About the author:

Vladimir Kraz, instrumentation leader for 3M Electronic Solutions Division, holds 16 patents in communications and instrumentation. He holds master's degrees in electrical and mechanical engineering from universities in the former U.S.S.R. In 1993, he founded Credence Technologies Inc., of Santa Cruz, Calif., which was acquired by 3M in 2006. He frequently presents papers at global electronics gatherings, including SEMICON Japan and the ESD Association's symposiums, and serves on standards committees, currently co-chairing the SEMI 3.33 standard task force. Contact him at vkraz@3M.com

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By Brent Beamer

Global Market Manager,
Static Control Packaging

Right and Wrong Ways to Close a Static Bag

Closing a static bag keeps parts in and static out. There are several proper techniques for closing static bags, and a few methods that should be avoided.

Proper Ways to Close Static Shielding Bags

Static shielding bags protect parts from damage due to ESD and field exposure. Here are five good closing options.

Adhesive Labels

Adhesive Labels. 3M provides two types of adhesive labels, destructible and reusable. 3M™ Destructible Labels are good for part storage or outgoing shipment and provide a secure closure that is tamper evident when opened. 3M™ Reusable Labels are easily opened and reclosed, offering access during production. Labels also provide a warning that bag contents are to be handled with static precautions.

Zip Top Recloseable. 3M™ Zip Top Reclosable Static Shielding Bags can be opened and closed throughout the manufacturing process. These bags also provide an easy way to remove a few parts at a time from the bag.

Zipper Recloseable

Tape Recloseable. Self-sealing tape closure bags are resealable for multiple uses. 3M™ TapeTop Adhesive Closure Bags are easy to open and do not require a heat sealer to close. To close the bag, simply peel off the cover strip and fold the flap closed. Open the bag by lifting the flap.

Antistatic Tape. 3M™ Antistatic Utility Tape can be used to close bags. The tape is low charging both when removed from the roll and when removed from the bag.

Heat Sealing. Heat sealing a shielding bag provides a secure, airtight closure. The closure is permanent. A tear notch can be supplied to open the bag, or the bag can be cut open.

Proper Ways to Close Moisture Barrier Bags

Moisture barrier bags protect parts from damage due to moisture, ESD, and field exposure. Here are two good closing options.

Tape Recloseable

Heat sealing. For barrier bags to provide full moisture protection, the bags must be heat sealed closed. The closure is permanent. A tear notch can be supplied to open the bag, or the bag can be cut open. IPC/JEDEC J-STD-033 provides guidance for dry packaging.

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RipTop Recloseable. 3M™ RipTop Bags are made with the bottom open and the bag closed (fold) above the zipper. A product is loaded from the bottom and is kept inside the bag by heat sealing across the opening. To access the product, the customer rips the top off the bag above the zipper. The zipper allows the customer to use the bag again. RipTop bags are tamper evident.


Heat sealing

Keep the Stapler in the Office…

Some closing methods should not be used.

Staples. Staples are unacceptable for closing static bags. The staple punctures the shielding layers of the bag and may allow ESD to bypass the shield, damaging the parts inside the bag.

Glue. Glue may not adhere well to static bags. Using glue creates an opportunity for the glue to contact the product.

Adhesive tape. Standard tapes, while effective for closing the bag can generate static when the tape is removed from either the roll or the bag. Antistatic tape specifically designed for this purpose should be used instead.


Rip Top Reclosable

Renovating Your Plant?

Start with an ESD Survey

Any factory renovation or reconfiguration needs to start with a fresh look at static control. Invite a 3M representative to conduct an ESD survey of your entire operation, not just the assembly line but also receiving, inventory, and shipping. It will consider the sensitivity of items you manufacture, your current static control program, your procedures manual and worker training.

For more information about an ESD survey in the United States, contact:

Don Reynolds at 512-984-5430 or djreynolds@3M.com

Bill Pellegrin at 512-984-5447 or wepellegrin1@3M.com

Jim Novak at 866-760-1444 or jimnovak2@3M.com

R.J. Sturgeon at 408-251-9080 or rjsturgeon@3M.com

Go online to see the new catalog of 3M static control products. The catalog contains all the 3M legacy products as well as those of 3M Sanford (formerly SCC Products, Inc.) and 3M Santa Cruz (formerly Credence Technologies). Download it at www.3M.com/static.

Mount your wrist strap/footwear tester to the new 3M™ Pedestal Stand 749 and move it anywhere you need it on the factory floor or on field service calls.

Where to Mount Wrist Strap/Footwear Tester?

Anywhere – with 3M's New Stand

If you can't mount your wrist strap/footwear tester to a wall, or if you want to move the tester around, 3M offers an option that allows you to take it almost anywhere.

Simply mount the tester on the 3M™ Pedestal Stand 749 and set it up at the entrance to the manufacturing area, near the workbench or elsewhere in the factory, or take it with you on field service calls or to other remote locations.

The pedestal stand can be used with the 3M™ Wrist Strap and Footwear Tester 747 as well as two 3M wrist strap testers –the 746 and 740—all of which ordinarily are wall-mounted.

The mounting plate on the stand is large enough to accommodate certain models of barcode, magnetic and proximity (laser) readers that accept data from employee identification badges and feed it into the automatic data logging system available with the 747 tester.

Base Can Double as Footwear Tester for 740

With the 740 wrist strap tester, the stand's base plate not only keeps the stand upright but also can serve as a footwear tester. Personnel simply stand on the base plate and connect to the 740 tester to check on the operation of ESD heel straps or shoes.

Before the introduction of the 749 stand, an optional shoe electrode (Model 741) could be used with the 740 tester for checking footwear as well as wrist straps.

Expect Accurate Testing

Special insulated washers separate the column from the base, which keeps the operator from bypassing the grounding wire. This feature helps guard against a false result by creating a second path for the circuit.

The 40.5-inch stand is portable, weighing only 9 pounds, and is easy to assemble and dismantle. It's made of stainless steel for durability and won't tip over unless moved beyond 45 degrees from its upright position.

Calibration questions?

If you have a question about calibrating 3M equipment, call 3M Static Control Customer Service.

800-426-8688, Option 2

By Brent Beamer

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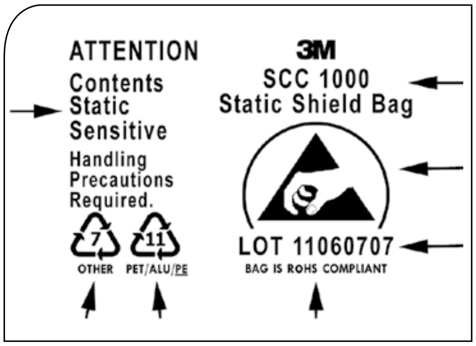

The symbols on 3M static shielding and moisture barrier bags are intended to convey critical information to users.

What Do Those Bag Markings Mean?

No, they're not advertising or decoration. The symbols on 3M static shielding and moisture barrier bags are intended to convey critical information to users.

Clockwise from right, here are the marks and what they mean:

Supplier Identification. The company name and product designation confirm the source of the bag in accordance with ANS/ESD S541.

ESD Protective Symbol. This symbol, a reaching hand within a triangle under a protective arc, means that the bag protects the contents from electrostatic discharge, in accordance with ANSI/ESD S8.1.

Traceability. The lot number ensures traceability to production and quality records, in accordance with ANS/ESD S541.

Europe RoHS. This text confirms that 3M has test data for the RoHS substances. "RoHS Compliant 2002/95/EC" means that the product or part ("Product") does not contain any of the substances in excess of the maximum concentration values in EU Directive 2002/95/EC, as amended by Commission Decision 2005/618/EC, unless the substance is in an application that is exempt under EU RoHS.

China RoHS. This symbol is from the People's Republic of China Packaging Labeling Standard GB 18455-2001, generally regarded as the packaging component of "China RoHS." China packaging standards require the packaging material code and recycling symbols to be placed on the package. The number 11 is China's code for packaging material, including ESD bags, made from a composite. The letters underneath indicate the composite's major components.

SPI Recycling Symbol. The Society of the Plastics Industry (SPI) developed the "chasing arrows" symbol and a coding system of numbers and letters to identify the resins used in manufacturing the product. The number 7, in this case, indicates multiple types of resins.

Caution and Handling Warning. ESD Association, European, and military specifications require that packaging containing ESD-sensitive items bear warnings to prevent the package from being opened outside an ESD Protected Area (EPA).

Charles Taylor

Get Connected with 3M Staff

Charles Taylor is the new static control business manager for 3M workstation and flooring products.

He has worked at SCC Products Inc. in Sanford, N.C., in various roles for 13 years. SCC was acquired by 3M in 2006.

Originally from Snow Hill, N.C., Taylor graduated from Campbell University in Blue Creek, N.C. in 1991 with a degree in mass communications.

He has long been active in civic and community activities. Most recently, in November 2007, he was elected to the Sanford City Council for a four-year term.

Austin offers running weather year-round, as these runners will attest. They're running in the 2007 3M Half Marathon, which typically takes place in January. That's the University of Texas tower in the background.

ESD Manager Training

Escape November Chill in Sunny Austin

Exchange your heavy coat for running shorts when you come to 3M's ESD Manager Workshop Nov. 11-12 in Austin.

Spend the day at 3M Austin's Innovation Center as training manager Bill Pellegrin leads you through sessions on ESD basics, grounding principles, testing and measuring, industry standards and cost-effective static control methods.

Unwind with a short run through tree-covered hills or along one of Austin's many hike-and-bike trails. Or play a round of golf, swim in Barton Springs, or go kayaking on Ladybird Lake.

Relax in the evening by dining at the Oasis, a lakeside restaurant with a panoramic view of the sun setting over Lake Travis, or venture downtown to the Sixth Street entertainment district to see why Austin calls itself the "Live Music Capital of the World."

For more information about Austin attractions, see the Visitors Bureau Web site, http://www.austintexas.org/visitors/about_austin/.

The 3M workshop offers a beginning to intermediate approach to ESD for those responsible for a company's static control program or those who want to ensure that proper controls are in place. You can expect to review protective flooring, personnel grounding, surfacing materials, packaging and ionization and ANSI/ESD S20.20 as part of a quality management system.

ESD Manager Training

When: Nov. 11-12, 2008

Where: 3M Austin Center, Austin, Texas

Advance registration required, class size is limited.
Registration cost is $899 US (Note new price).
Hotel, transportation and recreation are the responsibility of the attendee.

Or contact Bill Pellegrin at 512-984-5447,
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