ENABLING ESD-SAFE ELECTRONICS PRODUCTION THROUGH ADDITIVE MANUFACTURING

Take Charge of Your Factory Floor With the Essentium HSE 3D Printing Platform and Z Collection of ESD-Safe Materials

ESSENTIUM™

Executive Summary

Electrostatic discharge (ESD) is the sudden transfer of electric charge from one object to another. If the voltage potential between the two objects exceeds the dielectric breakdown strength of the ambient air, the transfer of charge results in a visible and sometimes audible spark. In an electronics manufacturing setting, these events can cause catastrophic damage to sensitive electronic devices and integrated circuits, even at lower potentials where a spark isn't generated.

ESD events are the Achille's heel of electronics manufacturing. Multiple steps and safety precautions are implemented on the factory floor to mitigate the effects of ESD. ESD-safe materials minimize static charge buildup and allow static electricity to flow harmlessly into the ground instead of into products, making them essential when assembling, testing, or inspecting electronic components. Without them, immediate and/or latent damage to parts, tools, and products can cause premature failures and problems for manufacturers, ranging from recalls to lost production time.

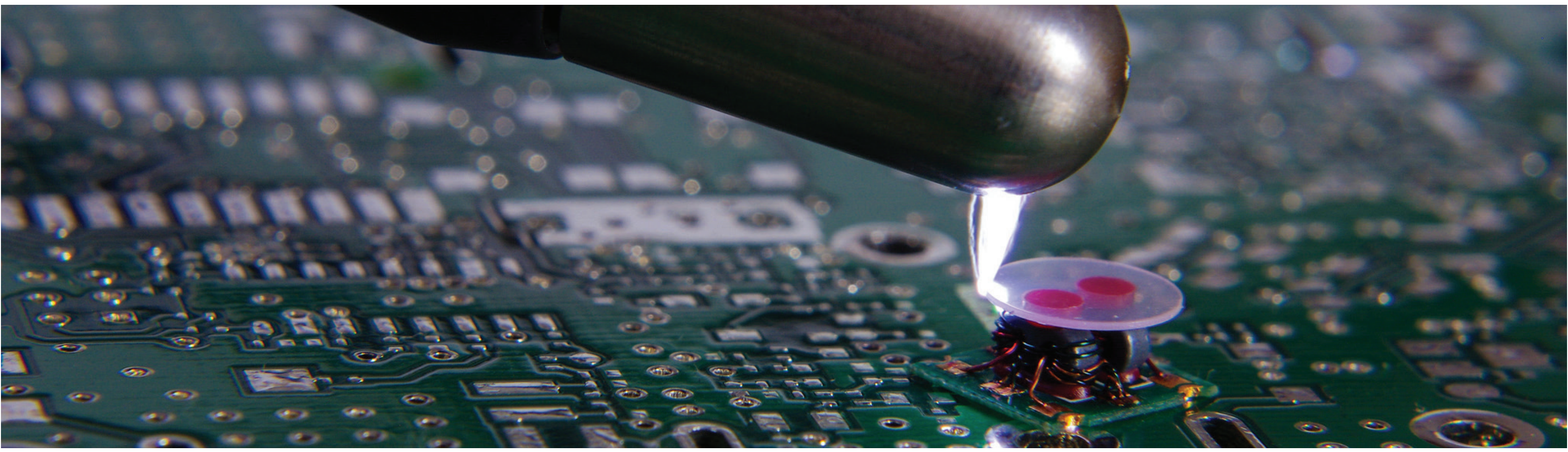
ESD-safe tools, such as jigs and fixtures, scrapers, part trays, and tweezers are traditionally made using injection molding or subtractive processes, which machine stock material into form. These tools are made from expensive polymers, usually require outside suppliers to design and manufacture, and have long lead times to deliver. To provide the necessary electrical properties, many of these materials contain high percentages of carbon, making them prone to marking and marring the products they are supposed to protect.

This white paper examines how additive manufacturing (AM) can be used to more quickly and affordably produce the ESD-safe tools needed on the factory floor, and how Essentium's unique Z Collection of ESD-safe filaments delivers the required protection while offering the non-marking and non-marring qualities that manufacturers need.

ESD-SAFE ENVIRONMENTS: CRITICAL TO ELECTRONICS MANUFACTURING

Electronics manufacturing encompasses the production of parts that use electricity, sensors, and chips that control the flow of electricity, as well as any product that has electronic components integrated into it. Examples range from the smallest semiconductor wafers and electrical switches to planes, trains, and automobiles. These days it is difficult to list even a few examples of products or industries that do not incorporate some type of electronic mechanism into the manufacturing process or the product itself.

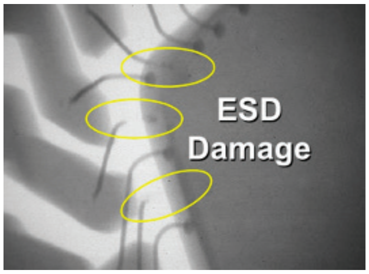
Whether the product is a semiconductor chip with transistors 1/1,000th the width of a human hair, an LCD screen, a refrigerator, or a truck, there is an extra element of safety and compartmentalization that must be applied in factory floor environments when manufacturing or assembling anything that uses electricity. The reason: electrostatic discharge, or ESD.



What is ESD?

ESD is the sudden transfer of electric charge from one object to another. If the voltage potential between the two objects exceeds the dielectric breakdown strength of the ambient air, the transfer of charge results in a visible and sometimes audible spark. In an electronics manufacturing setting, these events can cause catastrophic damage to sensitive electronic devices and integrated circuits, even at lower potentials where a spark isn't generated.

We're all familiar with ESD events whether we realize it or not. They are the tiny shocks we get throughout the day when we touch a metal door handle after walking on carpet, peel clothes apart from the dryer, or shake hands with another person on a dry day. There is not a lot of current in these shocks, so the discharge of static buildup from these events does not result in any harm to people; they're just, well, a little shocking. However, the same static discharge that is only slightly discomforting or even imperceptible to humans—sometimes as little as 30 volts—can be very damaging to electronic components. Microchips, CPUs, and solid-state memory drives are especially vulnerable to ESD given their fragile nature and microscopic connections. The smallest discharge could fry a transistor, rendering an entire printed circuit board (PCB) useless. Given their growing role in life-saving medical equipment and applications like autonomous vehicles, a premature failure in a PCB could have life-changing consequences. For these and other safety-related reasons, all manufacturing environments must take necessary precautions to protect their people, equipment, tools, and products from ESD events.



There are primarily two types of damage caused by ESD that are of concern to electronics manufacturers:[1]

- **Catastrophic damage:** The electronic device or component is rendered inoperable immediately after the ESD event. For example, the ESD event may have caused a metal melt, junction breakdown, or oxide failure. Catastrophic failures are usually noticed right away during testing, and the part is discarded and replaced.

- **Latent damage:** The electronic part appears to be working fine following the ESD event; there is no noticeable damage. However, sensitive circuitry not visible to the human eye has been degraded and will cause the part to fail prematurely or affect the long-term viability of the product or system, which may not be discovered until the device is in use. This is a far more injurious outcome for the manufacturer, as it could result in recalls, expensive repairs, lost production time, and decreased consumer confidence in the brand going forward.

Controlling and Preventing ESD

Care must be taken at every step of the manufacturing and assembly process to prevent the buildup of static electricity and the potential for ESD. Everything must be grounded, allowing electricity stored in employees' bodies, workstations, and tools to flow through and dissipate harmlessly into the ground instead of into the product being worked on. Toward that end, electronics manufacturers adopt strict rules and procedures for factory floor safety:[1,2,3,4,5]

- Assembly workers must attach grounding straps to their shoes and/ or wrists and stand on ESD-safe mats or sit at ESD-safe workbenches while using grounded tools. Some wear anti-static smocks and gloves as well.

- Factories install anti-static floor tiles embedded with electrically conducting fibers to mitigate static electricity created by simply walking.

- Robots and machines equipped with ESD-safe grippers and handles prevent charge transfer at the point of contact with a part.

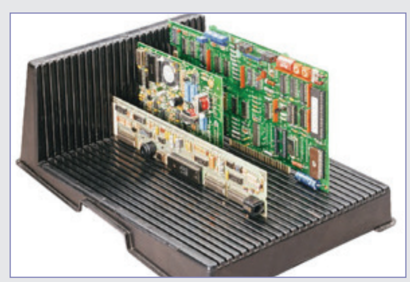
- Parts to be bathed or exposed to chemicals must be carried in ESD-safe racks and trays.

- Jigs and fixtures used during the assembly process must have an electrical surface resistance in a range sufficient to either mitigate charge buildup or enable the safe flow of charge to Earth ground.

- When a device or component is finished, packaged, or ready to move on to the next phase of assembly, there are ESD-safe tapes, sleeves, envelopes, and anti-static bags lined with conductive coatings to ensure safe transport.

ESD wrist strap

Anti-static floor tiles



ESD-safe racks

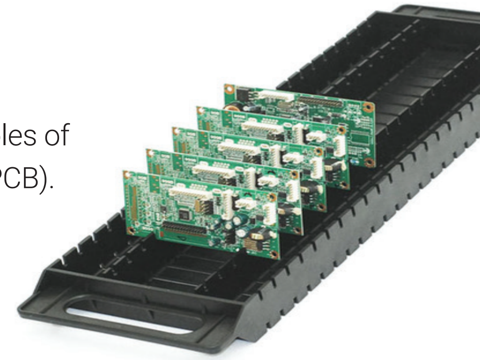
ESD-safe bag

Further, all aspects of the environment are tightly controlled. Static electricity is a natural force; it cannot be eliminated entirely, but it can be managed. For example, relative humidity on the factory floor is usually kept above 40%, as dry environments are more conducive to ESD events.[2] Humid conditions help prevent electrostatic buildup as moisture dissipates electric charges. The goal is to limit charge buildup so that it stays below a threshold that will damage devices. Increasing humidity levels generally aids in this goal. Some factories use air ionizers to neutralize electrostatic charges around workstations.

Nothing is left to chance because if something does go wrong, it can be expensive to correct. That's why many electronics manufacturers have turned to additive manufacturing (AM) to achieve greater control over the tools, timeframes, and costs that prevent the occurrence of ESD events.

ESD-Safe Electronics Applications

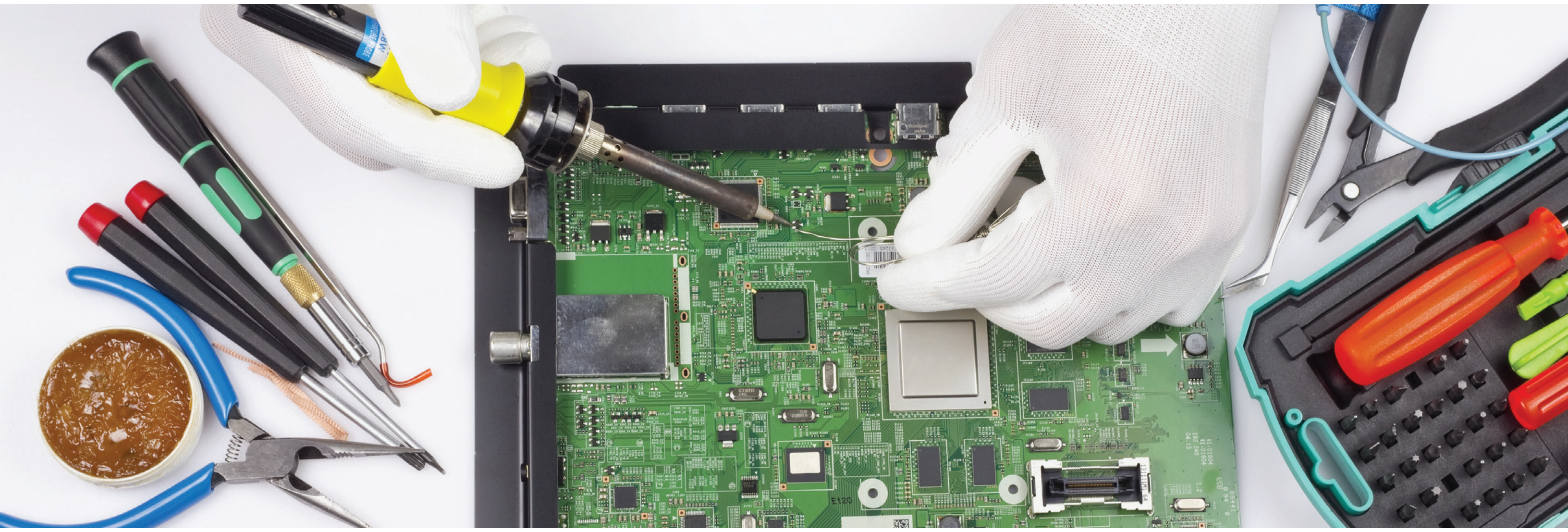
There are multiple uses for ESD-safe plastics, but one of the most well-known examples of ESD-sensitive applications in electronics manufacturing is the printed circuit board (PCB). PCBs are subjected to all kinds of processes, such as etching, paste printing, wave soldering, lead trimming, washing, and conformal coating. To protect chips, semi-conductors, and certain portions of the board from exposure during manufacturing, workers mask sensitive areas of the PCB and seat them in trays. To ensure these parts do not suffer latent damage from ESD, the trays as well as the boots that cover sensitive components must be made of ESD-safe material.



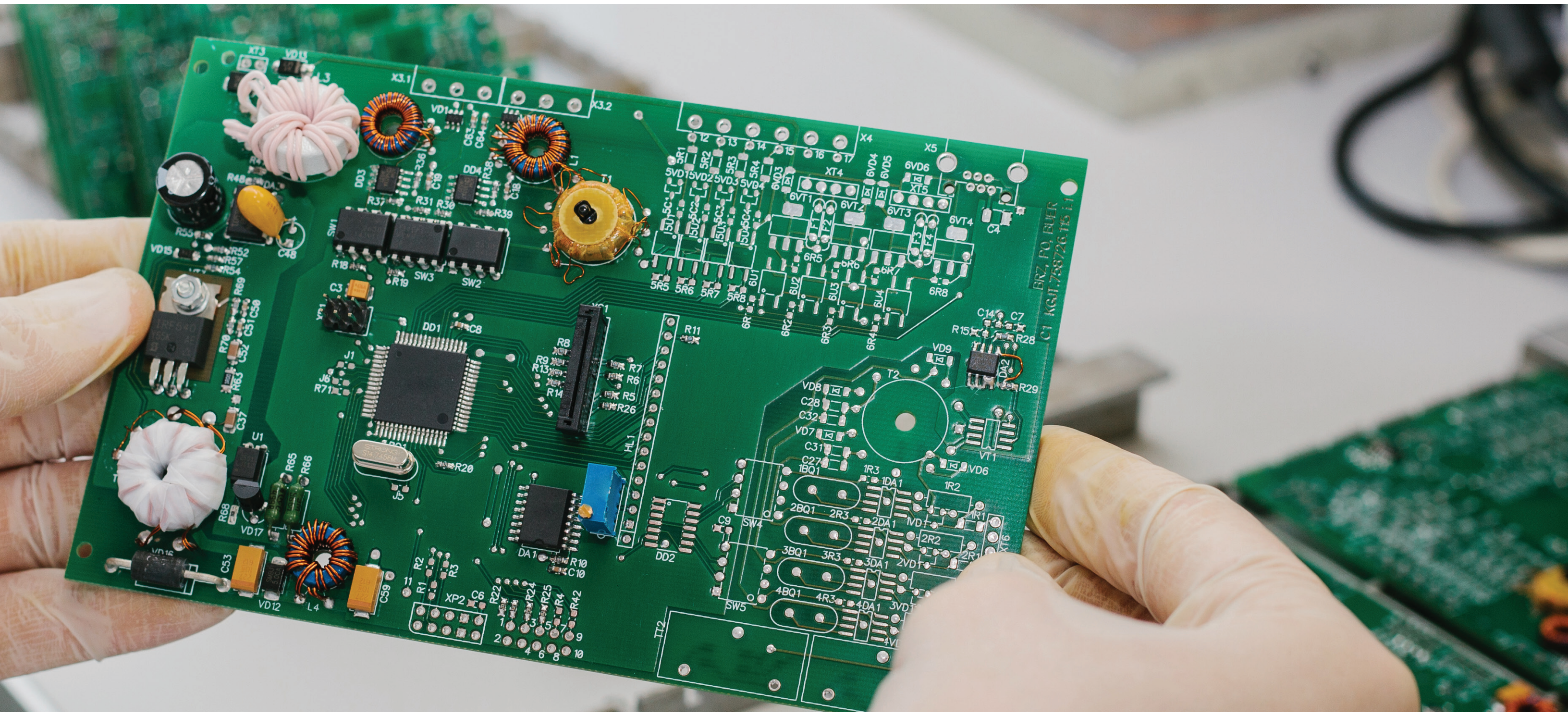
A PCB carrying tray made from ESD-safe material.

Beyond PCB trays and racks, there are all types of ESD-safe applications on the typical factory floor when any electronic product is manufactured, including:

- ✔ Anti-static trays to hold small parts
- ✔ Anti-static tweezers to pick up delicate components
- ✔ Anti-static screwdrivers, spudgers, and wrenches for product assembly
- ✔ Anti-static brushes and air guns to clean or dry parts after machining
- ✔ Anti-static dust caps to protect product attachment points during shipping
- ✔ Anti-static jigs and fixtures for product assembly, alignment, testing, and inspection
- ✔ Anti-static robotic grippers, snap-fit connectors, and vibration dampening parts



Traditionally, these and other tools have been made with injection molding equipment or subtractive methods to mill blocks of ESD-safe materials into the desired shape. Several plastics can be modified with additives and fillers to offer the desired surface resistance properties, such as ESD-safe ABS, nylon, and Delrin®. Some of them, like DuraStone™, are very expensive. Further, fixtures machined from solid pieces of material are sometimes less than ideal due to the limitations of milling and routing.

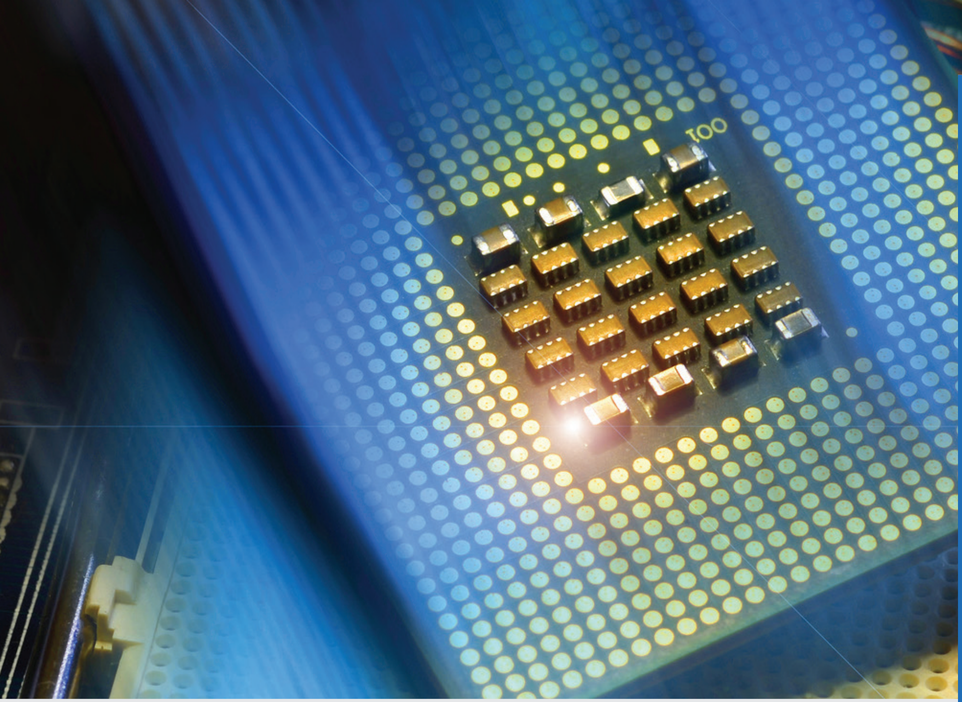


The issue for most electronics manufacturers is that most jigs and fixtures used in the assembly of a finished product are vendor-supplied and made in small quantities. It can be cost-prohibitive to injection mold just a few pieces or to make tools on a per-part basis using subtractive methods. This forces factories to use outdated or less than optimal tools or delay the development of next-generation toolsets until production can be fully cost-justified. There may be hundreds of tools needed to assemble a product or multiple sizes of the same tool required for different processes. This results in long lead times and very expensive tooling charges that get passed on to the customer as non-reoccurring engineering expenses (NRE).[7] This puts manufacturers at the mercy of suppliers, with minimal leverage over time and cost to part. Yet, most manufacturers are not capable of creating all the jigs and fixtures needed to build their own products. It is not cost-efficient for them to purchase expensive injection molding equipment or CNC milling machines, staff and train the personnel to operate it, then design the part, identify, and source the materials to produce it in-house. So, electronics manufacturers turn to outside suppliers that are skilled at jig and fixture production for ESD-safe applications.

What is Surface Resistance? [6]

Electrical resistance is a measure of a material's opposition to the flow of electric current when an electric field is applied. Materials with high resistance are insulators, while materials with low resistance are conductors, allowing current to flow more freely through objects. Surface resistance is measured in ohms (Ω).

With regard to ESD protection, a specific surface resistance range is desired. Materials with a rating of 1×10^4 ohms to 1×10^{11} ohms are dissipative and generally considered safe for use in electronics manufacturing.



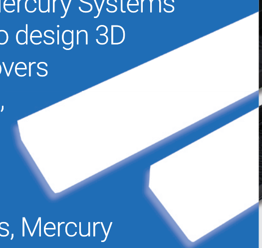
Additive Manufacturing: Game-Changing ROI for Electronics Manufacturers

Rather than spending hundreds of thousands of dollars to bring injection molding equipment and expertise in-house or waiting on third-party vendors to supply the jigs and fixtures needed for mass production, AM is an excellent alternative for making many ESD-safe tools in-house. Engineers can quickly make iterations to an original design, print a prototype, test it for fit, and make further modifications to achieve final design in a fraction of the time and cost of traditional manufacturing. Having access to an industrial-grade 3D printer with ESD-safe filaments on-site brings several advantages to the factory floor:

- **Fast turnaround.** Printing a replacement part or tool in just a few hours can be the difference between keeping an assembly line moving or shutting it down for extended periods.
- **Reduced costs.** Once a jig or fixture is designed, it can be reprinted for just the cost of filament. No need to remake molds or pay rush charges to replace tools.
- **No minimums.** Electronics manufacturers can eliminate worries of cost justification or having to purchase and inventory more parts than needed. Jigs and fixtures can be printed on-demand, in any quantity, making it easy and cost-effective to replace even a single tool if it is lost, broken, or just worn out.

Mercury Systems Slashes Cost by 95% Using Essentium Solutions

Printed circuit board (PCB) manufacturers like Mercury Systems, a leading aerospace electronics manufacturer, are well aware of the challenges of conformal coating. To protect parts, technicians must manually mask sensitive areas (a cost-effective yet time-consuming process), or affix injection-molded boots (a more efficient option, but one with unsustainable lead times and costs) to prevent the conformal coating from getting into PCB connectors.



To solve this challenge, Mercury Systems teamed with Essentium to design 3D printed PCB connector covers using ESD-safe materials, and the results were staggering. Rather than having to wait 12 weeks for injection-molded boots, Mercury was able to design, iterate, and print enough boots for production use in one day with the Essentium HSE and TPU-74D-Z ESD-safe filament. Instead of spending $9,000 on tooling and parts for one single product order, Mercury estimates they spent $500 on 3D printed equivalents. Based on these numbers, Mercury estimates partnering with Essentium helped reduce costs by 95% and decrease lead time by nearly 85%.

In addition to cost and lead time savings, the lifespan of these 3D-printed boots is much longer than their injection-molded counterparts. Essentium TPU 74D-Z is resistant to heat and aggressive chemicals, allowing the boots to endure cycle after cycle, unlike the injection-molded boots that would degrade in under 10 cycles and would have to be thrown away and replaced.

These impressive results have opened new opportunities for 3D printing elsewhere on Mercury Systems' factory floor. Get the whole story by downloading the **Essentium Mercury Systems Case Study**.

mercury

DOWNLOAD CASE STUDY

TTM Technologies Uses Essentium ESD-Safe Materials to Reduce Time-to-Market

TTM Technologies, Inc. is a top-five global printed circuit board manufacturer. The company name is an abbreviation for "time-to-market," which accurately describes its core mission to reduce development and production time for customers with its one-stop-shop manufacturing approach.

TTM uses groundbreaking technologies to create the best possible solutions, including AM. Like all electronics manufacturers, TTM goes to great lengths to ensure its factory floor is protected against ESD events, and uses only ESD-safe filaments for the production of 3D printed stands, trays, caps, and spacers needed to create customized electronic components.

The issue for TTM is that most ESD-safe filaments have a high percentage of carbon or graphite. This provides the necessary surface resistance properties but has a marring defect. Materials made with carbon can scratch, streak, or otherwise damage the same parts that TTM is trying to protect.

TTM set out to find a substitute and discovered Essentium's Z Collection of electrostatically dissipative materials. This open ecosystem of materials contains a variety of filaments including PCTG-Z and TPU 95A-Z, which are specifically formulated to be ESD-safe and non-marring.

Using Essentium materials allows TTM to quickly print ESD-safe jigs and fixtures in the sizes and shapes needed for every job. The custom fixtures allow engineers and technicians to handle, transport, and work on assemblies without damage, saving TTM thousands of dollars while delivering on the promise of the company name. Learn more by downloading the **Essentium TTM Case Study**.

TTM Technologies
Time-To-Market Interconnect Solutions

DOWNLOAD CASE STUDY

- **Customized tool design.** Designing next year's model with only a slight change to ergonomics? Quickly 3D print updated tools to accommodate changes for assembling the new version. For example, when making boots for short runs of specialized PCBs, there may be slight changes in design or chip position from board to board. Rather than absorb the time and cost to create injection molded boots for each version, they can be quickly 3D printed in the exact shapes and quantities needed. AM also excels in over molding or encapsulation applications, providing an alter native to injection molding to quickly produce ESD-safe parts using two materials; a core of functional filament encapsulated by an outer layer of conductive material to provide anti-static capabilities
- **Minimal waste**. Machining away chunks of material to carve a final product is a messy process. Besides creating waste and dust, materials like ESD-safe Delrin and Durastone are expensive, meaning manufacturers pay for raw materials that are never used.
- **Easier to design parts with complex geometries**. AM excels in printing thin-walled parts as slim as 0.4 mm and tools with complex shapes in one piece, tasks that are difficult to execute with traditional machining. It takes more time to remove material using a subtractive process, and the accuracy of 3D printing yields a more consistent product with sharper angles and precise positions and dimensions of connectors and voids than those machined by hand.

Whatever the product, adopting AM in concert with ESD-safe materials allows electronics manufacturers to design jigs and fixtures to be 3D printed with advanced engineering-grade materials that prevent the occurrence of ESD events. Lead times can be reduced from weeks to hours, multi-component assemblies can be simplified into a single 3D printed part, and the cost savings in materials and man-hours typically exceeds 90 percent over subtractive methods. The key to all of this is proper materials that can survive the demanding processing steps associated with electronics manufacturing.[7] As a materials-first company Essentium knows that real innovation only happens when advanced technology meets high-quality materials.

ESD-SAFE MATERIALS
What Makes a Filament ESD-Safe?

3D printer filaments modified for ESD-safe applications typically are infused with carbon particles. This provides the necessary electrical properties when jigs and fixtures come in contact with electronic components. The material itself can be flexible for printing PCB boots, or rigid for printing PCB component trays, depending upon the durometer or stiffness of the base polymer to which the carbon is added.

The problem with many ESD-safe filaments is that they contain relatively high percentages of carbon in the form of carbon black, graphite, or agglomerated carbon nanotubes, usually between 15% and 25%. While this achieves the desired electrostatic dissipative effect, the addition of that amount of conductive filler substantially changes the characteristics of the polymer in ways that can compromise performance, resulting in lower toughness, impact resistance, and elongation at break. To counteract this, manufacturers will add plasticizers to restore some of the ductility to the composite. This in turn leads to more compromises in the mechanical properties of the material, reducing its overall performance when force or pressure is applied during product assembly. Also, note that traditional ESD-safe materials were designed with injection molding or machining in mind. Most of the 3D printable ESD-safe materials currently on the market are based on formulations designed for injection molding and are not optimized for an additive manufacturing process. Further, materials with high carbon content suffer from a severe marking or sloughing issue, with material easily transferring from the rack, jig, or fixture to the part being assembled or supported (*pictured, right*). This can also result in air-borne contamination of filament particles that could find their way into a solder joint or another location that could affect the performance and reliability of the product. In fact, many "ESD-safe" filaments available today fail to meet the demanding standards for materials used in clean electronics manufacturing environments.[7]

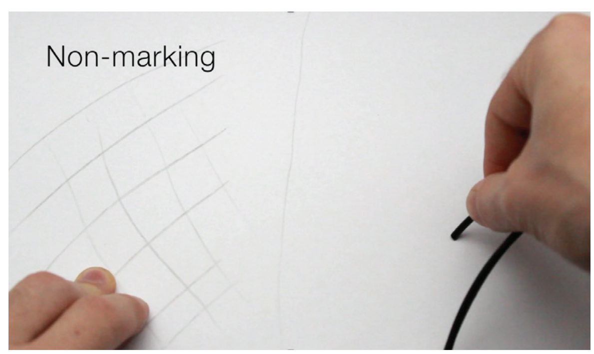
Non-marring versus Non-marking.

One of the most desired properties of ESD-safe materials, besides the proper surface resistance range, is that they be non-marring and non-marking.

Non-marring means the jig or fixture will not damage the surface of parts on which it is used.

Non-marking means the filament will not leave a mark on other parts.

Essentium ESD-safe materials are designed to be both.



ESD-safe materials with a high percentage of carbon will write like a pencil, marking parts.

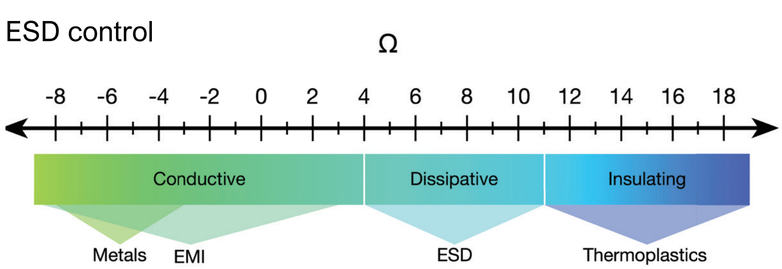
Essentium ESD-Safe Solutions

To address the needs of non-marking and non-marring ESD-safe electronics manufacturing applications, Essentium offers a portfolio of ESD-safe materials. These best-in-class materials are easy to print and finish and are available in multiple spool sizes and diameters. The Essentium Z Collection of ESD-safe materials are engineered to provide the necessary surface resistance properties without compromising the performance of the filament. The Essentium Z Collection of filaments use much less carbon, as little as 0.01% in the overall filament, by using multilayer filament and dispersed carbon nanotube technology.

A PCB carrying tray made from Essentium ESD-safe material.

Dispersed Carbon Nanotube Technology

Carbon nanotubes are a cutting-edge class of nanomaterials that solve many of the challenges associated with other conductive fillers. Carbon nanotubes can create an electrically conductive network in a polymer matrix at very low loading levels because of their incredibly high aspect ratio of length to diameter. Carbon nanotubes are also incredible conductors of electricity, which allows for a very wide range of nanotube-polymer conductivity values and applications. At one end of the spectrum are highly electrically conductive nanotubes and at the other are electrically insulating thermoplastic materials with no nanotube loading. In the middle are nanotube values with ESD-safe static dissipative properties. Engineers can select the desired material properties by precisely tuning the loading level and percolation behavior of nanotubes in the polymer. Carbon nanotubes also tend to reinforce the polymer matrix making it slightly stronger and more wear-resistant. With Essentium's proprietary dispersion technology, nanotubes are completely bound to the polymer matrix, meaning Essentium ESD-safe filaments have superior non-marking and non-marring qualities and do not rub off onto sensitive devices or cosmetic surfaces.[7] Further, with Multi-Process Mode on Essentium's new independent dual extrusion (IDEX) HSE 280i HT 3D Printer, printing a single part with multiple materials is now possible for ESD-safe applications that could not be done with traditional injection molding equipment. For example, when printing structures designed to reduce electromagnetic interference, it makes sense to print the entire part with an ESD-safe material. However, if that enclosure will house a Bluetooth antenna that needs to transmit and receive wireless signals, the ESD-safe material could interfere. To solve this issue, the body of the enclosure could be printed with the HSE 280i HT 3D Printer using an ESD-safe material to isolate electrical noise, and the area in proximity to the antenna can be printed with Essentium PCTG to ensure good transmission—in the same print.

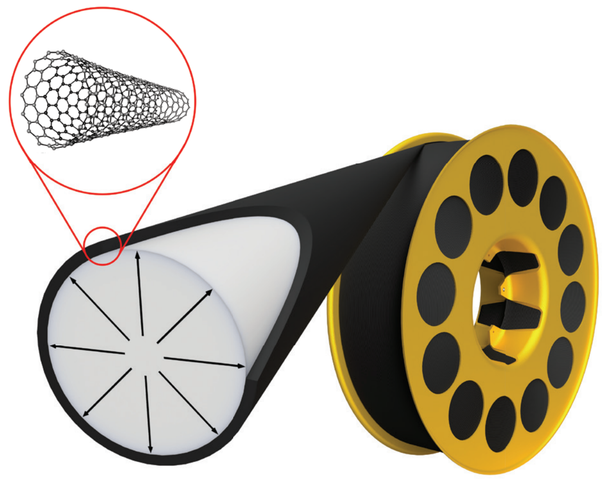


The Essentium Z Collection of ESD-Safe Filaments

Essentium currently offers a family of five ESD-safe materials in the Z Collection, each optimized for different electronics manufacturing applications.

Essentium uses only high-purity carbon nanotubes combined with a proprietary extrusion process to extrude a multilayer 3D printer filament that concentrates the nanotubes onto the surface of the filament rather than throughout the entire volume of the material. As a result, Essentium's Z Collection eliminates the compromises of other materials. Because the bulk of the filament in the core of the piece is the base polymer, all of the desired mechanical and thermal properties of the material are retained. The conductive outer layer of the filament is on the order of a few microns thick (fractions of the width of a human hair) and does not appreciably alter the physical properties, it simply embeds an ESD-safe layer throughout the entire printed part.[7]

Most high-performance conductive fillers on the market are expensive and can affect the base price of the polymer resin significantly. With Essentium's Z Collection, only a small fraction of the filament mass is composed of the nanotube compound, minimizing cost. Finally, Essentium's open ecosystem approach means these materials can be used with Essentium HSE 3D Printers or any open-source 3D printer.



ESD-Safe Filament	Description	Key Features	Applications
TPU 74D-Z  Colors: Black Diameters: 1.75 mm Target Surface Resistance: 10^4 to 10^9 Ohms	TPU 74D-Z is a high durometer filament in Essentium's electrostatically dissipative portfolio. No-warp drop-in replacement for ABS when extreme toughness is required. A very hygroscopic thermoplastic, TPU 74D-Z rapidly absorbs moisture from humid air. Keep the material in vacuum-sealed packaging until needed.	• Semi-rigid • Best-in-class tear resistance • Excellent tensile strength • Excellent abrasion and wear resistance • High impact • Low-temperature flexibility • Excellent chemical, solvent, oil, and ozone resistance	• Electronics manufacturing ESD-safe jigs and fixtures • Abrasion-resistant covers • Robot grippers • Snap-fit connectors • Heavy load vibration isolation • Impact-rated structural components

ESD-Safe Filament	Description	Key Features	Applications
TPU 80A-Z  Colors: Black Diameters: 2.85 mm Target Surface Resistance: 10^4 to 10^9 Ohms	TPU 80A-Z is the lowest durometer (softest, most flexible) filament in Essentium's electro-statically dissipative portfolio. Excellent elongation at break and impact strength. Low-friction surface allows for easier feeding while printing.	• Soft-touch • Ultra-flexible • Best-in-class elongation at break • Excellent abrasion and wear resistance • Excellent vibration damping • Low-temperature flexibility • Excellent chemical, solvent, oil, and ozone resistance	• Electronics manufacturing ESD-safe jigs and fixtures • Non-marring grippers • Print-in-place soft springs • Bumpers, vibration absorbers, isolation mounts • Seals, gaskets, suction cups, boots, plugs • Parts catchers, shoe straps

ESD-Safe Filament	Description	Key Features	Applications
TPU 95A-Z  Colors: Black Diameters: 1.75 mm 2.85 mm Target Surface Resistance: 10^4 to 10^9 Ohms	TPU 95A-Z is a medium durometer filament in Essentium's electrostatically dissipative portfolio. TPU 95A-Z balances high-elongation with impressive impact resistance and tensile strength. This filament has a low friction surface that allows for easier feeding while printing.	• Flexible • Best-in-class tensile strength • Exceptional elongation at break • Excellent abrasion, tear, and wear resistance • High impact • Excellent vibration damping • Low-temperature flexibility • Excellent chemical, solvent, oil, and ozone resistance	• Electronics manufacturing ESD-safe jigs and fixtures • Vibration damping feet • Grommets • Bushings • Protective case inserts • Automotive vibration isolation • Overmolded soft grips • Flexible hose and ducting

ESD-Safe Filament	Description	Key Features	Applications
PCTG-Z  Colors: Black Diameters: 1.75 mm Target Surface Resistance: 10^4 to 10^9 Ohms	PCTG-Z is specially formulated to be ESD-safe with all-around mechanical properties. It is an easy-to-print material with significantly increased impact strength when compared to PETG.	• All-purpose material for ESD-safe jigs and fixtures • Low cost • Easy to print, machine, and finish • Excellent surface finish • Prints in open air • Unaffected by humidity • Strong enough for lightly loaded fixtures • Non-marring	• Handheld tools • Semiconductor jigs and fixtures for electronics • Internal machine calibrations • Robotics and automation components • Parts for explosion-proof environments • ESD-safe part trays

ESD-Safe Filament	Description	Key Features	Applications
HTN-Z  Colors: Black Diameters: 1.75 mm 2.85 mm Target Surface Resistance: 10^4 to 10^9 Ohms	HTN-Z (high-temperature nylon) is the ESD-safe version in Essentium's HTN line of materials. Designed for use in medium-duty electronics manufacturing, HTN-Z has improved mechanical and thermal properties compared to standard nylons. HTN-Z does not contain carbon, but rather an anti-static filler that serves to insulate it from ESD events. Drop-in replacement for ESD-safe Acetal (Delrin®) with best-in-class slow moisture absorption.	• Solvent resistance • Excellent temperature resistance • Easy-to-print, low-warp material that boasts high-toughness and wear resistance • Higher strength than PCTG, ABS, and Nylons	• Assembly aids for electronics • Low-temperature reflow ovens and soldering processes for PCB placement fixtures • Nozzle alignment jigs • ESD-safe fixtures • Electrical housings • Part trays for electronics manufacturing

Trust Essentium for ESD-Safe Performance

Essentium's Z Collection of industrial-grade filaments offers superior performance across a wide range of electronics manufacturing applications that require protection from ESD events. When combined with the Essentium HSE 3D Printing Platform, customers benefit from the speed, strength, and scale of high speed extrusion technology while reducing costs, increasing quality control, and ensuring products are free from marking and marring.

Contact us to learn more about how Essentium ESD-safe materials can help you take charge of your factory floor.

Sources & Acknowledgements

[1] The Prevention and Control of Electrostatic Discharge (ESD), AN-40-005 Rev.: A M150261 (04/14/15) File: AN40005.ppt, Mini-Circuits

[2] The Importance of ESD and creating a safe work environment, Direct2Younetowrk, www.direct2u.co.uk, 2017

[3] ANSI/ESD S20.20-2007, Protection Of Electrical And Electronic Parts, Assemblies And Equipment (Excluding Electrically Initiated Explosive Devices)

[4] ANSI/ESD S541-2018, Packaging Materials For The Protection Of Electrostatic Discharge Susceptible Items

[5] ANSI/ESD STM11.11-2015 Surface Resistance Measurements of Static Dissipative Planar Materials, Ted Dangelmayer and Matt Strickland, March 30, 2018

[6] International Standard IEC 61340-5-1, Edition 2.0 2016-05 Redline Version, Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements

[7] Electrostatic Discharge (ESD) Safe Materials for 3D Printing, Q&A with Brandon Sweeney, Head of R&D for Materials and Co-founder at Essentium, Inc., ManufacturingTomorrow.com, July 23, 2019

Appendix: ESD Standards

For more information on standards and methods for ESD control, please refer to the following resources:

Standard	Description
ANSI/ESD S20.20	Protection of Electrical and Electronic Parts, Assemblies and Equipment
IEC 61340-X-X	Electrostatics Parts 1- 6
ANSI/ESD S541	Packaging Materials for ESD Sensitive Items
ANSI/ESD STM11.11	Surface Resistance Measurements of Static Dissipative Planar Materials
ESD TR17.0-01:2015	Best Practices Used in Industry
ESD SP10.1:2016	Automated Handling Equipment (AHE)
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