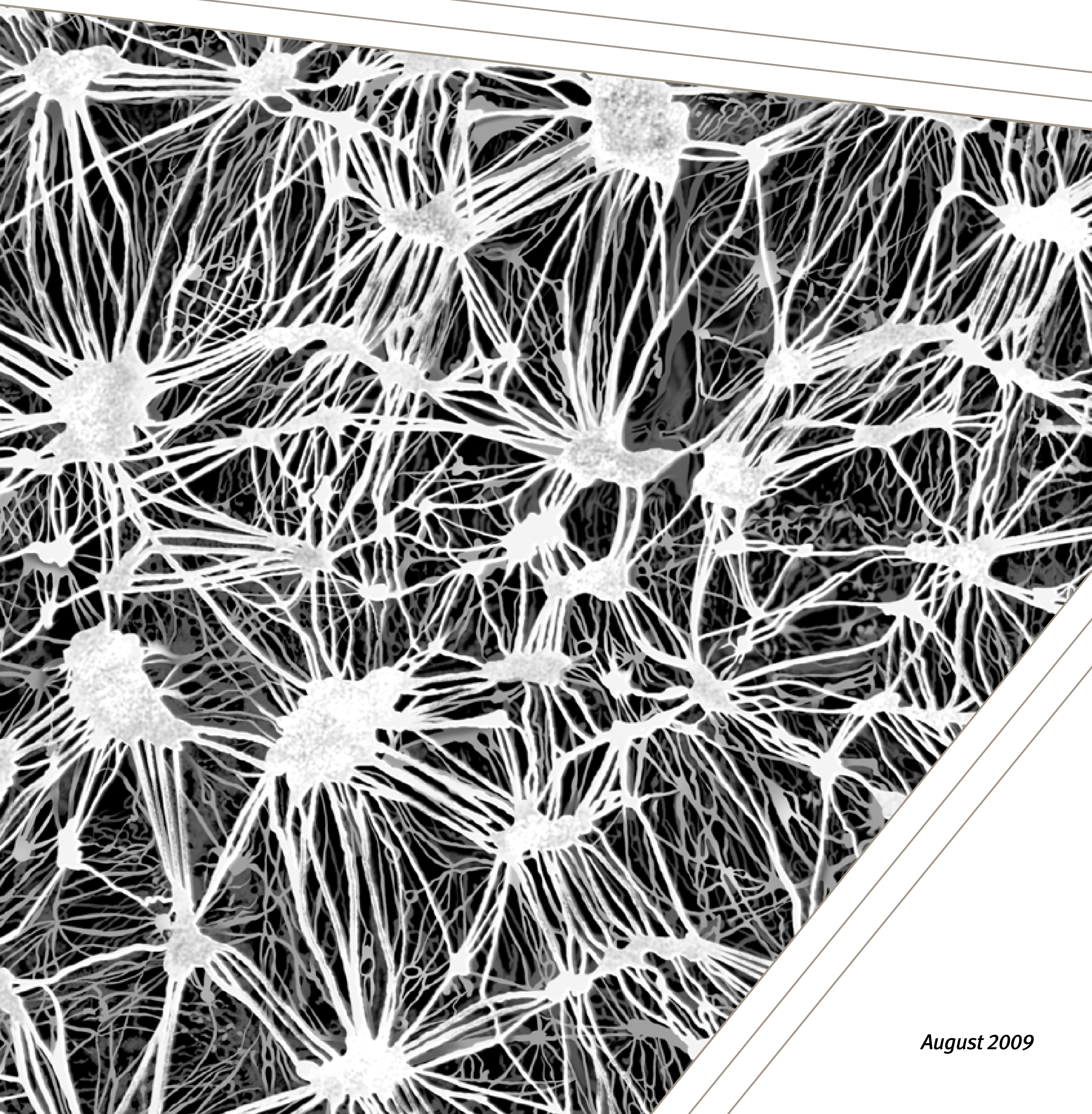
Electronic Packaging EMI Material-Based Solutions

White Paper



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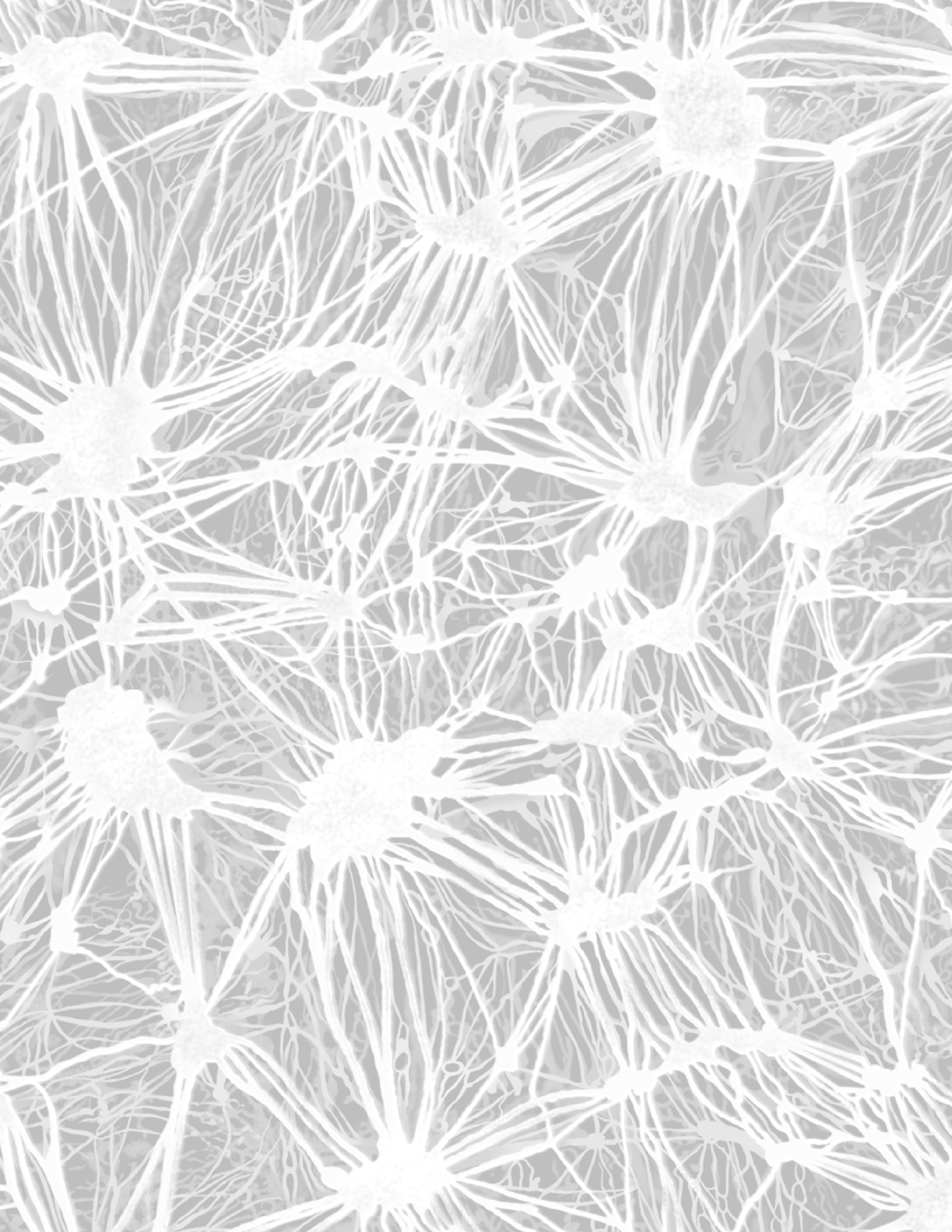

Electronic Packaging–EMI Material-Based Solutions

David Garagnani, Applications Engineer

Contents

Page Number	Topic
4	Introduction
5	Material Selection
7	Product Performance
8	Product Volume and Installation
9	Environmental Factors
10	Conclusion

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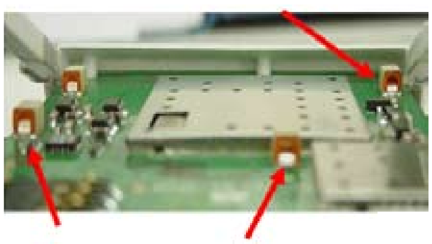
Introduction

Electronics packaging solutions are developed on many levels, from the board architecture all the way to the mechanical enclosure. The individual elements that compose these solutions work together so that the device can pass compliance tests. While printed circuit boards for new electronic devices are being designed, it is important to consider electromagnetic interference (EMI) shielding solutions early. As a packaging engineer, one of the main issues you encounter is that the individual components may pass EMI testing, but as the components are combined into subsystems or into the final product, the device under test (DUT) fails. Signal harmonics and interactions among subsystems in the DUT can be difficult to foresee and often do not present themselves until final compliance testing. Any type of failure at this point is costly because it will result in product modification, delayed shipments, and potential customer dissatisfaction.

Your challenge is to incorporate sufficient component-level isolation using shielding products that minimize crosstalk. While most engineers are familiar with strategies that reduce EMI issues at the board level — for example, adding extra ground planes, isolating power signals, and careful component layout — these solutions become more difficult, and in some cases more costly, as electronic devices get smaller and new features are added. GORE™ EMI Shielding Products have been proven to increase reliability of electronics by reducing interference and signal harmonics without increasing the size of your end product.

Figure 1



Highly Compressible GORE-SHIELD® Supersoft SMT Grounding Pads are compatible with standard surface mount technology installation processes.

Incorporating EMI shielding materials as part of an initial design is the most cost-effective way to prevent these last-minute issues during testing. For example, by assuming that you will need to use surface mount technology (SMT) ground pads to protect the final product, you can incorporate trace pads and corresponding GORE™ SMT 4442 Ground Pads at the outset, giving you the option during testing to evaluate whether you need a full complement or some subset of the pads (Figure 1).

Figure 2

GORE-SHIELD® GS500 EMI Shielding Gaskets used in casting seams eliminates the potential for slot antenna effects.

If you encounter compliance issues as you are preparing to launch a new product, your options are more limited; however, there are solutions that can be incorporated without requiring a complete product redesign. One of our customer's telecommunication base stations was running at a very high frequency and needed cabinet-level shielding. Gore has engineered peel-and-stick gasket materials in a variety of widths and thicknesses that can be dropped into a previously designed product. By inserting GORE-SHIELD® GS500 EMI Shielding Gaskets (which come in thicknesses of 0.25mm to 2mm) into the base station's casting seams, the customer was able to eliminate the slot antenna effects without redesigning the product (Figure 2).

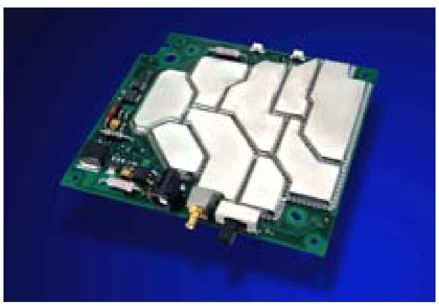
The goal is to find the most cost-effective solution that fits the design envelope while minimizing unwanted interference. A wide variety of gasketing and shielding products are available on the market today, but selecting the best option for a particular application depends on a range of application-specific issues:

- materials selected for the covers and housings
- product performance
- product volume and application
- environmental factors

Material Selection

The type and thickness of an enclosure's material can have a significant impact on potential EMI solutions. You want to construct a completely conductive Faraday cage around the device and between components to prevent any energy transfer in or out. The enclosures themselves usually serve this purpose for larger devices, but smaller devices — such as a cell phone or GPS — may need a separate board-level shield within the enclosure to provide shielding. In these situations, design engineers reduce potential interference by separating sensitive components using traditional cans. This approach means that you must design the board to conform to the size and shape of shielding cans rather designing to best use space and functionality. By using GORE™ snapSHOT® Board-Level EMI Shield instead of traditional shielding technologies, you can place components and circuits on a printed circuit board based on the components' functions rather than having to comply with the predefined geometry of the shield (Figure 3). GORE™ snapSHOT® Shields are thermoformed, which means they are created in a shape to fit any board regardless of its geometry, without increasing the complexity of manufacturing the shield itself. This product improves PCB design flexibility and performance by eliminating the constraints caused by the shape of traditional shielding cans.

Figure 3

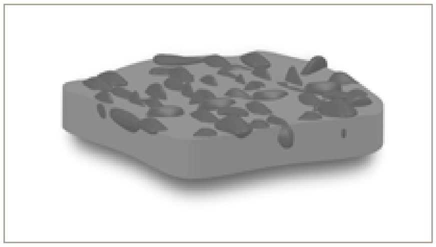


GORE™ snapSHOT® Board-Level EMI Shields are thermoformed in a shape to fit any PCB, regardless of its geometry.

Good design principles dictate using a housing material that resists corrosion. Two factors play into this consideration — the galvanic compatibility of materials in contact with one another and the use of protective coatings. First, because dissimilar metals more readily react with moisture in the air, you should select housing and gasketing materials that are as similar as possible, which means that they have the lowest potential voltage between them on the galvanic scale. For gasketing, Gore generally uses nickel and silver for commercial applications and carbon for military applications, because these metals are close on the galvanic scale to the materials used in housings and reduce potential voltage when they come into contact.

Second, engineers often use a coating to protect metallic components like the housing. If you need a protective coating for covers and enclosure components, the best approach is to select one that is conductive. Gore has found that chromate coatings used over aluminum for corrosion control add a nonconductive layer that can prevent the substrate of the enclosure from engaging the gasket or mating cover. This insulative chromate layer defeats conductive sealing efforts and can contribute to adverse EMI effects.

Figure 4



Durable GORE-SHIELD® GS5200 EMI Gaskets contain sharp particles of nickel, are conductive, and are compatible with the metals they will contact in the device.

If you select a nonconductive coating for protection, then if possible you should design the enclosure and cover such that the mating surfaces do not have any coating. Enclosure seams and mating surfaces can be masked off during the coating or painting process and exposed once the process is complete. If less ideal coatings are necessary to protect the housing, you can use the GORE-SHIELD® GS5200 EMI Gasket that will pierce the coating under pressure. This gasket, which contains sharp particles of nickel, is conductive, holds up over time, and is compatible with the metals with which it will come into contact in the device (Figure 4).

When selecting the cover or housing material, you should consider its mechanical strength. The cover needs to make full contact with the mating surface, compressing any gasket material and maintaining a Faraday shield. If the cover material is thin or flexible, such as plated plastic, gaps may occur in locations where the cover meets the circuit board or the enclosure (at points away from the screws, where the cover bows). These gaps can lead to slot antenna effects that can radiate EMI energy. GORE-SHIELD® GS8000 Conductive Foam is a nickel-plated, polyurethane foam bonded to an adhesive package that contains copper foil, conductive pressure-sensitive adhesive, and a polyethylene terephthalate (PET) carrier film. This conductive foam conforms as needed, so it maintains the connection as the cover material flexes and eliminates potential slot antennas.

Another consideration is whether the cover or housing materials are stable and do not degrade or exhibit compression set over time. Changes in the material have a direct impact on a component's performance as an electrical seal. This is important for gaskets, ground pads, and other flexible components used to provide continuity between variable gaps. For filled-type gasket materials, you need to consider both the matrix that holds the conductive material and the filler used. The matrix needs to remain dimensionally stable so that the conductive filler can maintain its location and contact throughout the bulk material. By controlling the plating weight and other variables during production, Gore has developed a product that delivers the same performance years after being installed. GORE-SHIELD® GS8000 is ideal for applications in which conformability, high conductivity, and low compressive forces are required. Made of nickel-plated polyurethane foam bonded to a package that contains copper foil, conductive pressure-sensitive adhesive, and a PET carrier film, GORE-SHIELD® GS8000 is hydrolytically stable and does not break down over time.

After extensive accelerated life testing, Gore has found that using nickel or carbon in a PTFE matrix provides a reliable, long-lasting electrical seal, ideal for use in applications that demand long-term reliability. This durable combination of materials is available in the GORE-SHIELD® GS500, GORE-SHIELD® GS5200, and GORE-SHIELD® GS2100, all of which perform well over time without degrading because they are chemically inert and can handle operating temperatures between -200°C and 200°C.

In more challenging gasket formats, a high-performance material's conductivity can allow a smaller interface that still maintains the connection between the board and the cover. A smaller interface area allows more space for components or a smaller overall package. In contrast to the industry norm of gaskets having a trace width of approximately three millimeters, the GORE-SHIELD® GS5200 and GORE-SHIELD® GS8000 provide comparable shielding performance at a width of only one millimeter.

Product Performance

Overall product performance is based on expected life cycle, electrical performance, and mechanical performance. When selecting the right EMI material, you need to consider whether the product will be used short-term or indefinitely. Anticipated length of service can affect the end-product cost because more durable materials are generally more expensive. For example, in cell-phone applications, the GORE-SHIELD® GS8000 Grounding Pads provide highly flexible polyurethane foam that provides continuous grounding for the life of the phone. For telecommunications infrastructure applications where downtime is very costly, the GORE-SHIELD® GS5200 and GORE-SHIELD® GS500 are highly durable and reliable solutions that provide EMI shielding for longer service life. For commercial and government satellites, the lightweight GORE-SHIELD® GS2100 is an excellent choice because in addition to its proven reliability and durability, it passes outgassing tests required for space applications.

When considering electrical performance for EMI materials and gaskets used to seal enclosures, manufacturers typically provide shielding effectiveness (SE) data. Much of this testing is ultimately based on aperture transmission principles or coaxial transfer impedance which are derived from MIL-STD-285 and SAE ARP 1705 respectively. Data from these testing methods can vary depending on the vendor's modifications to the standard. SE really depends on a variety of application-specific factors, such as the housing material, gasket material, gasket width, and the amount of compression or force applied to the gasket material. This and similar methods should only be considered a baseline performance comparison because these factors are unique to each electronic application. Therefore, it is important that you review the SE data for each gasket or shield completely, including the list of testing modifications noted by the manufacturer. Test specimen trace width can have a large impact on system performance. Therefore, Gore tests using trace widths between one and two millimeters to confirm the product's SE performance while using a minimal design footprint.

Ground pad performance is driven by several factors: surface area of the pad, the type of compression, the dwell time after compression (i.e., the amount of time required for the material to return to its original form), and the pad's ability to make full contact with components of different heights. As the market moves toward using more sophisticated ground pads made of multiple materials and laminates, evaluating their electrical performance becomes more complicated. Ground pads made of homogeneous materials can be evaluated using the traditional volume resistivity equation[1]; however, this equation does not take into account the interactions among non-homogeneous materials used in some ground pads. For example, homogeneity is lost once an adhesive layer is added to

Figure 5

Gore's micro-ohmmeter with four-point probe measures the amount of resistance that passes through all layers of the ground pad.

Figure 6

Custom-shaped GORE-SHIELD® GS500 Strip Gasket are installed simply by peeling off the backing material and pressing them into place.

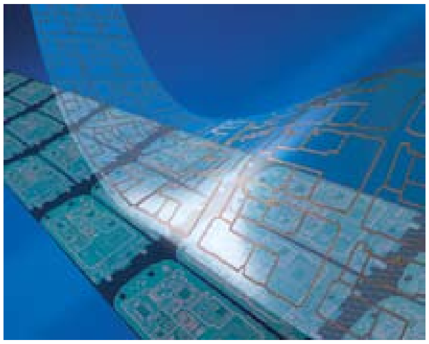
bond these materials to a substrate. For composite ground pads, calculating the Z-axis resistance at a target compression provides a better assessment of its electrical performance. This test measures the amount of resistance that passes through all of the layers from the top of the ground pad to the bottom, including any adhesives. Gore uses a micro-ohmmeter and four-point probe setup to determine resistance for these measurements (Figure 5). This procedure ensures accurate single-digit milliohm resistance measurements on small highly conductive material samples. One of Gore's core business values is to ensure that all of its products meet or exceed the needs of its customers' specific applications — a value referred to as fitness-for-use. By using a customized micro-ohmmeter with four-point probe, Gore is able to verify that its results are not skewed by the resistance in the probe. When one of our customers tested its product with a standard ohm meter, it had a performance issue in which the engineers were seeing more than one Ohm of resistance between a micro-coaxial cable and a ground plane surrounding a battery. Using the customized micro-ohmmeter, Gore was able to determine that the resistance was, in fact, significantly less than one Ohm and through further junction-to-junction testing, found that the resistance was less than 10 milliohms. This troubleshooting allowed Gore to deliver a GORE-SHIELD® GS8000 gasket that made the connections very reliable.

Compression is the key to consistent electrical and mechanical performance of flexible EMI materials. It is essential that the material sufficiently engages adjoining parts to minimize surface contact resistance. Additionally some materials require a compressive force (i.e., the force required to deflect a material to operating thickness) to become fully conductive and ensure proper functionality of the EMI shielding design. Recovery (i.e., the distance that a material rebounds after compression) and softness are also important attributes. Materials need to recover both at the same rate as surrounding materials and to the same position to account for flex in a product's housing. If this does not happen, slot antennas can temporarily occur. If the material is not soft enough, then board flexing can occur. For example, an LCD screen can become distorted if the EMI gasket puts too much pressure on the display. Gore's testing indicates that soft materials with large working ranges like the GORE-SHIELD® GS8000 and GORE-SHIELD® Supersoft SMT Grounding Pads perform best because they continue to function even when compressed to about half of their thickness. With this wide range of operational functionality, these shielding products allow for substantial flexing and tolerance take-up in a device design without compromising electrical performance and without exerting additional force on the device.

Product Volume and Installation

When selecting an EMI shield, you should also consider the quantity that you will need during the product's manufacturing life. For example, if you are manufacturing over one million cell phones per year, you can consider designing a customized board-level shield specifically for your product. However, if you only need 75 gaskets for a specialized program, it may be more cost-effective to use readily available materials that can then be custom cut to fit your application. For example, GORE-SHIELD® GS500 Strip Gasket material allows you to build custom picture frame shapes from

Figure 7

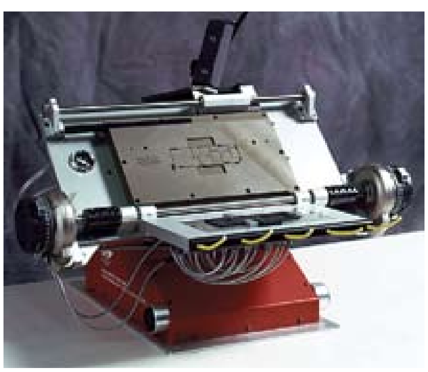


For intricate gasket designs, GORE-SHIELD® GS8000 Gaskets are die-cut to your specific design and delivered in sheet or roll form.

Figure 8

Like GORE-SHIELD® GS8000, the GORE-SHIELD® GS500 is also custom cut for intricate gasket applications.

Figure 9



Label machines can be incorporated into a manufacturing line to place adhesive-backed gaskets automatically.

standard rolls and install them simply by peeling off the backing.

The quantity needed also affects the gasket design when it comes to shape. Gaskets can be created in all shapes and sizes, but if only a small quantity is needed, it may be more cost-effective to combine several standard profiles/extrusions to form custom geometry rather than design a custom-shaped gasket. Large sizes and custom shapes also limit the type of materials that can be used in the manufacturing process. If you need an intricate plan view shape, you should consider die-cut gaskets by Gore. Application specific formats using high-performance materials enable these difficult designs. GORE-SHIELD® GS8000 is a highly flexible plated foam (Figure 7) and GORE-SHIELD® GS500 is a carbon-loaded PTFE elastomer (Figure 8). Less complex geometries can be constructed from products like fabric-over-foam profiles.

The third issue related to product volume is the manufacturing process itself. The smaller the gasket trace, the more challenging the shielding product can be to handle and install accurately. So when selecting the material, you should consider the EMI solution's format and size as well as its installation method. Options for installing EMI shielding materials have steadily evolved. Now more sophisticated and complex gaskets and shields can cost-effectively be installed automatically. Probably the most familiar alternative for automated installation is standard surface mount technology (SMT) equipment, which is available at most electronic manufacturing sites. Another alternative is label machine technology, which can automatically place adhesive-backed materials (Figure 9). This technology is ideal for installing a range of materials, from simple rectangular designs to intricate designs that have features like islands and multi-level gaskets. These automated technologies improve reliability, decrease labor costs, and allow smaller gaskets to be accurately placed with minimum operator contact (Figure 10).

Such issues as confidentiality constraints, product lead time, and total product cost can drive the selection of the best EMI shielding solution.
If you work with highly proprietary technology, you may prefer to select a solution that can be implemented directly on your own manufacturing line. Also, a gasket installed in-line "just in time" may be a viable option when evaluating the total cost of ownership. For example, consider a casting made at another location with form in place (FIP) gasket applied by the casting manufacturer. In addition to accounting for lead time and possible repair, there are additional shipping costs associated with protecting a casting with an installed FIP gasket. Gore has worked with several defense industry customers who cannot subcontract electronic product manufacturing due to confidentially constraints. Gore has delivered custom GORE-SHIELD® gaskets — including installation machinery in some cases — that enable the customers to install peal and stick gaskets cost-effectively as part of their own production process without compromising their proprietary information.
Environmental Factors

Environmental Factors

The environment in which the electronic device will be used is another area that should be carefully considered when selecting a shielding solution.

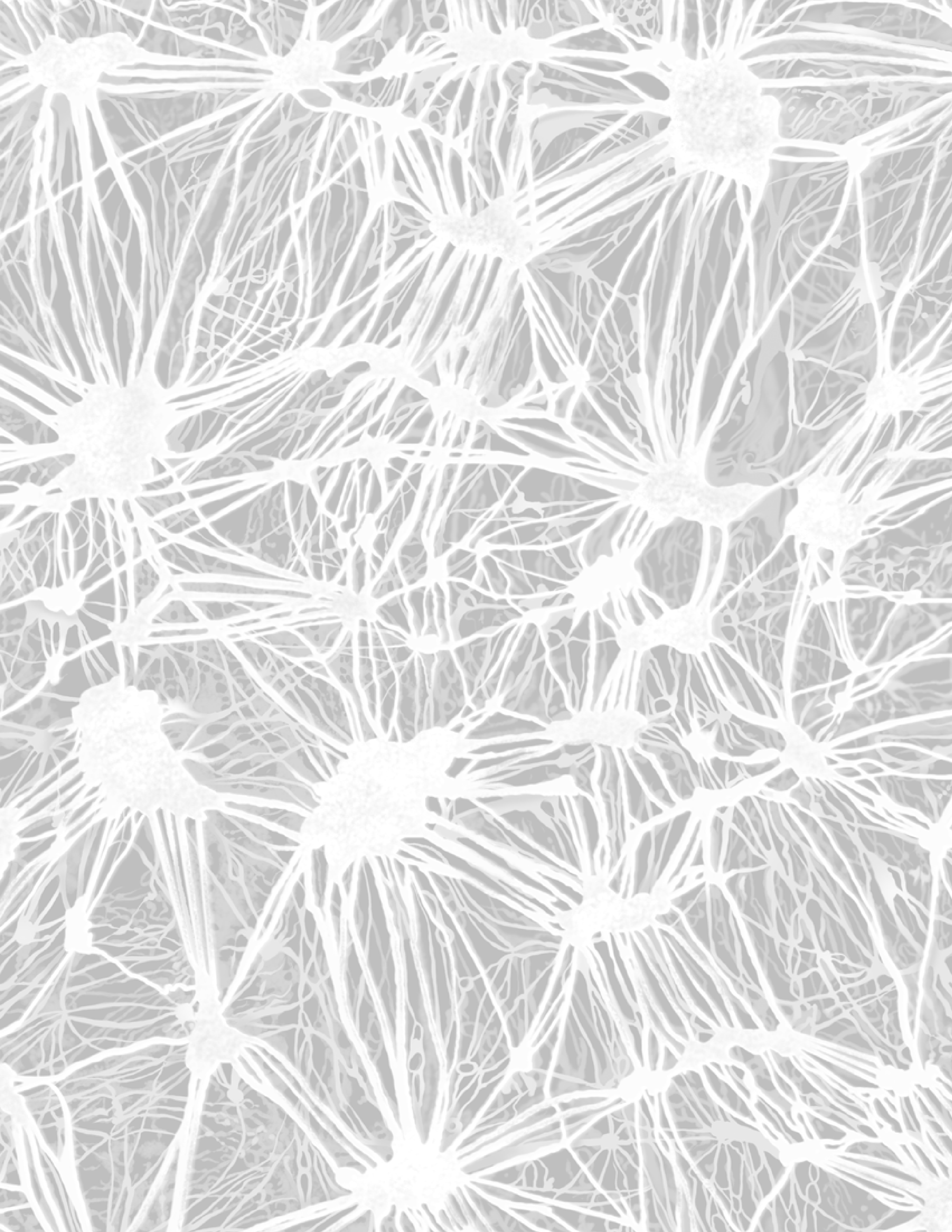
Figure 10

Automated label machine technologies improve reliability, decrease labor costs, and allow smaller gaskets to be placed accurately with minimum operator contact.

As the electronic industry moves in the direction of ruggedized products, environmental standards like Ingress Protection (IP) are considered. For example, IP65 is a common level of protection required for portable devices. Enclosures or devices meeting this IP level have basic splash and dust protection. Before deciding on a particular material set for shielding, be sure to determine whether the product needs to comply with a specific standard for such things as liquid immersion/splash, flame retardance, dust, acoustic performance, and service temperature. Because of the chemical properties of the PTFE matrix used in GORE-SHIELD® GS500, GORE-SHIELD® GS5200, and GORE-SHIELD® GS2100 Gaskets, these products meet the requirements of many standards for temperature, flame retardancy, and chemical protection when installed in properly manufactured products. In addition, GORE™ snapSHOT® meets environmental standards for shock and vibration resistance.

Conclusion

Many factors affect the choice of the best EMI shielding materials for an application, including the materials used in the product's enclosure, the environment in which the product will be used, the performance requirements for the shielding materials, the quantity of products to be manufactured, and the installation equipment preferred. Evaluating the need and type of EMI shielding materials as part of the initial design is the most cost-effective way to prevent last-minute failures during compliance testing.



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