Innovation in Package-level EMI/RF Shielding

With the trend towards smaller implementation sizes and higher functionality, older can shields may not always be the answer.

Integrated Plated Shield Technology

Electromagnetic shielding is a common need in radio frequency/microwave applications; however, it is often an afterthought in the design of electronic components. This practice can potentially cause problems in both form factor and performance. The integration of a shield prior to reaching the OEM's application results in a more robust product and a faster time to market.

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Original equipment manufacturers (OEM) are continually looking for ways to achieve a quicker time to market when launching new products. To accomplish this, common platforms are used to keep costs down and speed up development time. The designer will standardize a majority of the individual components so they can move from one product design to another. This helps to minimize cost and improve on economies of scale. However, electrical interference cannot always be predicted between designs. This complicates the standardization of components and platforms. That, in turn, can delay the time to market.

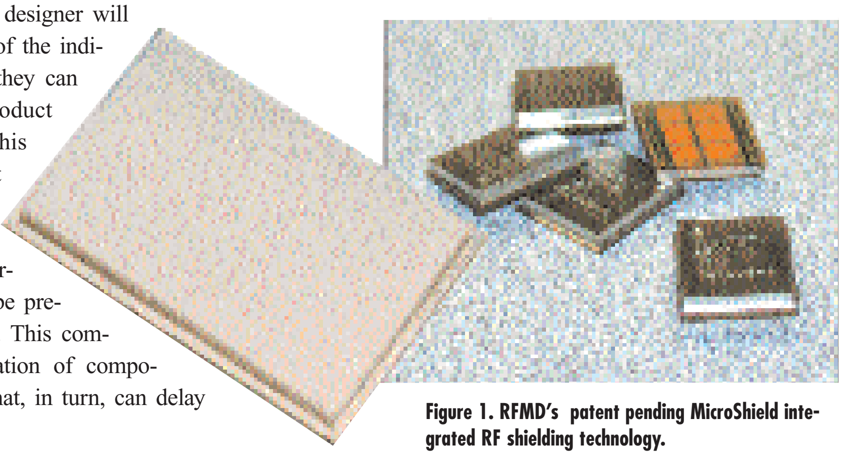

Figure 1. RFMD's patent pending MicroShield integrated RF shielding technology.

Electromagnetic shielding is a common need in radio frequency/microwave applications and, in many cases, a requirement from the customer. Commonly, it is an afterthought in the design of electronic components. This methodology can potentially pose a large consequence to the design in terms of both form factor and performance. For example, when a shield is put in place at the customer level, the original performance can be significantly altered due to the electromagnetic coupling between the design's components and the shield. This often results in the need for multiple iterations with OEM involvement to arrive at the final solution. Thus, the integration of a shield prior to reaching the OEM's application becomes valuable to both the designer and the OEM. This results in a more robust product and a faster time to market. It also reduces the amount of re-tuning required since the shield is now an integral part of the package. The development and implementation of this type of self-shielding technique (RFMD's patent pending MicroShield™ integrated RF shielding technology) has been developed and implemented as a package-level plating process. It will be further discussed in this article.

Are Metal Shields Still Up to the Task?

Spurious noise is the bane of electrical devices. Interference comes in many forms. It is caused by emissions originating from inside, outside or between devices. All of these can be detrimental to the intended performance of the component. Historically speaking, metal shields have provided the remedy for correcting the problem. They come in many forms and shapes, but primarily consist of stamped and formed sheet metal sometimes referred to as a can shield. They have been in use for many years with great success. With the trend towards smaller implementation sizes and higher functionality, the older can shields have become outdated. People are always on the lookout for a better mousetrap; we believe that MicroShield is a good option.

Can shields are relatively cheap to produce, easy to design and common in the marketplace. Since it is commonly made from sheet metal, high speed stamping equipment is used to produce it. Can shields have been in industry for so long, and there is much design expertise, manufacturing and knowledge necessary in their use. The flipside of this is that the can shield must be specifically designed for each application. This requires the reworking or retooling of expensive stamping dies. Therefore, to support multiple sizes the cost adds up quickly. In addition, as miniaturization occurs in the final application, the physical shield size is reduced, making the stampings difficult to manufacture. The application board will also need additional real estate for shield grounding points. This is due to accommodating keep-out areas around the underlying components. This also poses an issue if one needs to shield individual components on the printed circuit board (PCB).

Multiple Shielding Techniques

To improve upon standardization between platforms, the shielding must be done at the package level. There are multiple techniques in the marketplace that can be utilized to shield a package. Different conformal shield application approaches like plating, paint and sputtering can be implemented at the batch level. By doing these at the batch level, the cost of implementa-

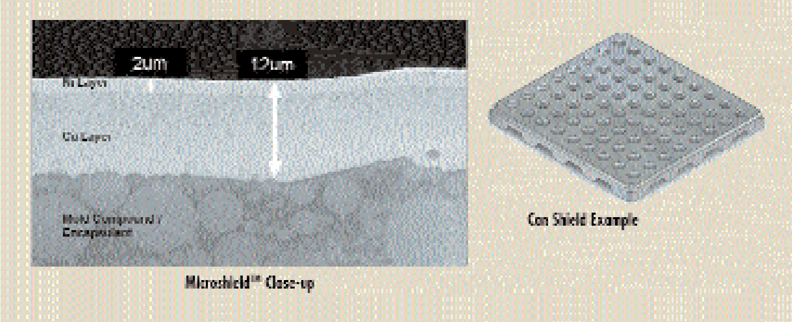

Figure 2. Views of shields.

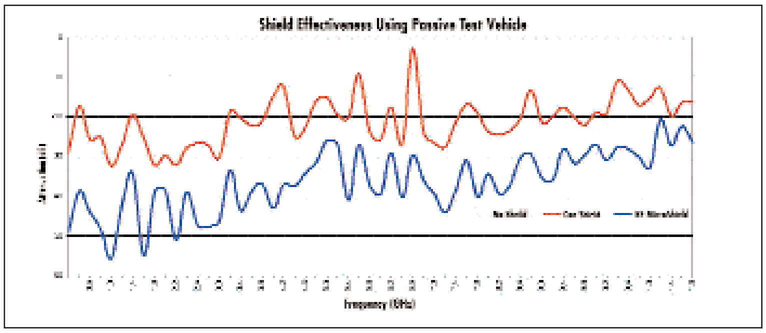

Figure 3. Shield Effectiveness Chart.

tion is reduced. Each of these materials and techniques has its benefits and drawbacks. With plating, one can easily install and maintain a process that provides consistent thickness variation. With paint application, ease of use and installation is reasonable. The disadvantage is surface preparation and thickness variation over the total surface area. Sputtering is also easy to implement but there are issues with thickness variation and adhesion. All of these materials were tested to see if they could be executed at package level. Through our testing, the plating process yielded the highest reliability and higher performance in comparison with all other shielding techniques. The goal was to develop a highly reliable process which can be implemented in high-volume manufacturing that has improved performance over a can shield solution, while maintaining a batch process.

Multi-chip modules are typically produced with organic laminate substrates. Alternately, some applications are built using metal lead-frame technologies. Using either base material, the components are mounted on the laminate and then overmolded for environmental protection. To shield the individual components, contact must be made to the grounding in each individual part. This can be achieved by use of either mold tooling or mechanical removal of the mold compound. Once the ground is exposed to the environment, the conformal material can be applied. Multiple materials were evaluated for compatibility with this manufacturing process. The best candidate was plating.

Plating Process at the Package Level

Plating is a very common process with respect to plastics in the PCB industry. However, the same is not true with respect to the package level. At the package level, the process begins with masking the backside of the strip and/or front to prevent plating on critical areas. The mold compound is chemically roughened to promote the adhesion of the electroless Cu layer. This thin Cu layer is used to carry current for subsequent electrolytic Cu and Nickel (Ni). The second layer of Cu is critical for shielding performance. The final Ni layer is used for environmental protection along with cosmetic purposes.

Since this technique will replace a well-ingrained process (can shields), the reliability of the plating is critical. To meet RFMD and customer quality requirements, the plated shield must withstand various package reliability tests outlined by Joint Electron Device Engineering Council (JEDEC) standards. To ensure the process was reliable, several tests were performed such as reflow, MSL, temperature cycling, salt spray and others. The failure criteria included delamination and degradation of shielding performance. Delamination of the shield indicates when the integrity is compromised and is considered a failure. A tape test was integrated into our inspection to better assess the adhesion of the plating. The tape test essentially consisted of cross hatching the

Table 1. Reliability Tests

TEST	TEST CONDITIONS	EXPLANATION	STANDARD
Low Temp Storage	for 96 hours @ -40°C	Parts must pass electrically and mechanical damage i.e. cracking, delamination, etc. should not occur from the effect of time and temperature.	IEC 68-2-1 Aa
Moisture Sensitivity	Moisture Absorption	Perform CSAM and electrical test. Testing to be performed to target level ±1 level	REL-30-1011
Temperature/Humidity Test With Biasing	85°C/85% RH, 5 volts, 1000 hours	Perform DC/RF electrical testing before and after test. Precondition to MSL Level 3	REL-30-1011
Fatigue/Flex Bend test	Force of 5N, 1 mm bend, 10 cycles for 10 seconds	To see any cracks/electrical discontinuity with the capacitor layer.	IEC-68-2-21
Temperature Cycling	-40°C +125°C, 1000 cycles	1000 cycles – precondition to MSL Level 3	REL-30-1019
High Temperature Storage	150°C, 1000 hours	Parts must pass electrically and mechanical damage i.e. cracking, delamination, etc. should not occur from the effect of time and temperature.	JESD22A103
ESD	50, 100, 250, 500, 1000 volts zap 3 devices per voltage	To determine the ESD sensitivity of the device.	JESD22A114 JESD22A115 JESD22C101
HTOLDC	125°C for 1000 hours with readpoints @168 hours, 500 hours, 1000 hours.	To accelerate the life, to identify unexpected failure modes, to continuously validate wearout parameters and to predict the fit value.	REL-30-015 REL-30-1016
Drop Shock	Drop from 1.8 m (6 ft.) onto concrete 3 times on all 6 different sides	Pass electrical and mechanical tests	IEC 68-2-27 Ea

shield and applying tape. The tape is then pulled vertically. If any blistering has occurred, the shield will peel off. This part is considered a failure. Multiple conformal materials were tested for reliability; plating was the only material to pass all testing.

Meeting Customer & Emission Requirements

EMI testing is performed to ensure the package is shielded and meets the customer's/emissions requirements. The test setup consists of a signal generator, a GTEM test chamber and network analyzer. A GTEM chamber is used to make sure that outside noise does not affect the testing. A signal generator generates the test signal and the network analyzer is used to measure the signal coming out to determine the electromagnetic radiation.

Several shielding techniques (plating, paint, sputter, can) were measured using the passive test vehicle. Based on this test vehicle, plating was chosen for having the optimum performance. After choosing plating, the active vehicle was used for more stringent shielding tests. The shielding test consists of comparing a known signal between a shielded and unshielded module. The difference is defined as the shield attenuation. A frequency sweep was done from 400 MHz to 12 GHz. The graph in Figure 3 shows the results.

Benefits of Integrated Plated Shield

The integrated, plated shield is called RFMD's MicroShield integrated RF technology. There are many positive aspects to the design that benefit the customer. These include the ability to fix the final design of the component with shield in place, faster total time to market (TTM) and lower cost than the industry-standard can shield solution. The shielded components are used within specification at the original design house, without the need for iterative tuning requiring customer involvement. This differs from most applications where the shield is applied post-design, and therefore needs multiple PCB (customer/design house) design spins to arrive at a final solution. This adds critical time to ever-shrinking product cycles. Another benefit of eliminating the can shield is that the designer realizes a 20 to 30% savings in PCB real estate. Beyond footprint reduction, the overall height is also reduced by utilizing .010 mm of plating instead of the typical 2 mm standoff needed for can shields. The final advantage is the simplification of reworking the module (if needed). Since there is no shield to remove, rework becomes much easier.

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