Insert Molding
Tech Bulletin

Integration of Insert Molding Processes to Optimize Production of Plastic Modules for Electronics, Sensors and Medical Applications

Upfront Planning and Design for Manufacturing (DFM) helps assure higher product quality and lower production costs.

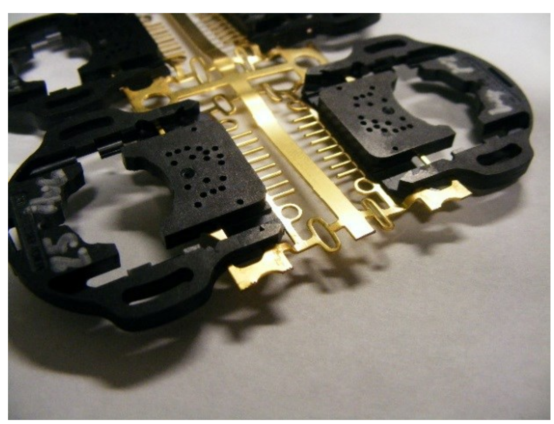
This Tech Bulletin provides an overview of insert molding processes and how they can be leveraged to meet advanced design and production goals. Insert molding technology is applicable for a wide variety of encapsulated plastic modules for electronics, sensors, and semiconductor devices used in automotive, medical and other industry sectors.

Topics addressed in this Tech Bulletin include:

- Overview of Insert Molding
- Elimination of leak-paths
- Reducing risks from thermal stresses
- Laser-welding lid sealing methods
- Atmospheric pressure venting
- Insert molding of non-electrical components
- Cost-savings opportunities
- Vertical integration and Design for Manufacture

Overview of Insert Molding

Insert molding is an integrated process in which thermoplastic injection encapsulates a part, often a metal stamping, to create a discrete component that combines structural elements and environmental protection with specific embedded interconnect functionality.



There are several applications that naturally benefit from insert molding. These include electronic modules, sensors and medical devices in which there is an internal electronic circuit or other part that has to interface with the outside world.

The key challenge is to make the packaging watertight and structurally robust to protect the internal circuitry from damage, while simultaneously providing electrically reliable connections to the outside circuitry.

The following sections describe the key issues required to achieve success with insert molding design and manufacturing.

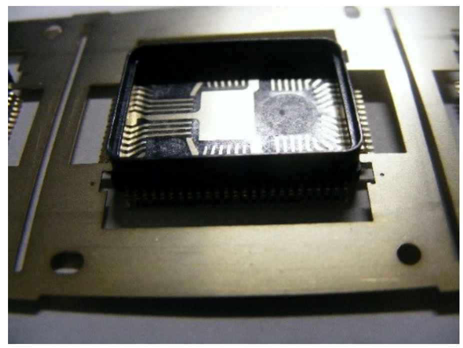
Elimination of External Leak-Paths

A primary reason that insert molding is employed to create packaged modules is the elimination of leak-paths that can potentially allow moisture to invade the device and damage the internal circuitry.

Conventional post-insertion assembly processes, where the molded part is formed first and then interconnects are inserted into the finished package, have a higher likelihood of leakage because the insertion process cannot achieve a perfectly tight fit between the plastic and metal parts. Insertion is inherently a displacement process as the metal is pushed into the plastic, which creates the potential for leak-paths along the insertion pathway. In contrast, insert molding is an integrated encapsulation process with the plastic forming tightly around the metal parts to create a gap-free fit.

Reducing the Risks from CTE Stresses

In many designs, it is also important to protect against potential damage from thermal expansion forces over the course of the product lifecycle. Certain modules, such as automotive sensors must withstand repeated heating and cooling cycles over a wide range of temperatures. As a result, differences in the Coefficient of Thermal Expansion (CTE) between the plastic packaging and metal interconnects can impose significant stresses within the device.



Even though insert molding can provide a very tight fit around the external interconnect, products intended for environmentally harsh deployment may often need extra protection for extended lifecycle performance. A common method of protecting against damage from CTE stress is to include application of a flexible sealant at the interface between plastic packaging and metal leads inside the package. Available sealants can compensate for a wide range of thermal cycling scenarios and extreme operating temperatures.

While it is true that an insert molded product generally has fewer leak paths than a post inserted product, that does not necessarily mean it is leak proof. There are different levels of leak proof associated with this process. For example the differential pressure between the inside of the finished package opposed to the outside pressure is a key factor. With a large pressure differential difference there still can be a leak path. The differential pressure is hard to define, it really depends upon resin selection coupled with environment, and product design. The differences between coefficient of expansion between the metal components and resin varies with the different temperature extremes that also encourages leak paths.

In extreme leak protection environments we would normally recommend a sealant be applied inside the package at the points where metal enters from the outside package envelope. This can be an automated dispense with cure process or with lower volume programs it can be a semi-automated operation. Both approaches are something we commonly perform. Types of sealants and cure methods vary and are dependent upon the products end use.

Lid Sealing Methods

Another key consideration is the proper sealing of open-cavity insert molded parts. This typically requires attachment of a lid after other production steps, and sometimes also basic testing procedures, have been completed.

One preferred method of attachment often used today is laser-welding of the lid to form a waterproof enclosure. The cover is a separately molded part, designed to fit perfectly on the insert molded package and to provide sufficient surface for a robust welded interface. Use of a laser-transmissive resin enables the laser beam to pass through the lid without extraneous heating of the overall module. Heating occurs only of the sealant between the two plastic parts, which reflows to form a consistent waterproof seal between the lid and module.

While ultra-sonic welding is preferred for many applications, it is important to note that insert molding is compatible with a wide range of lid attachment and sealing methodologies, which offers flexibility to tailor the process to specific environmental specifications and cost constraints of each application.

Atmospheric Pressure Venting

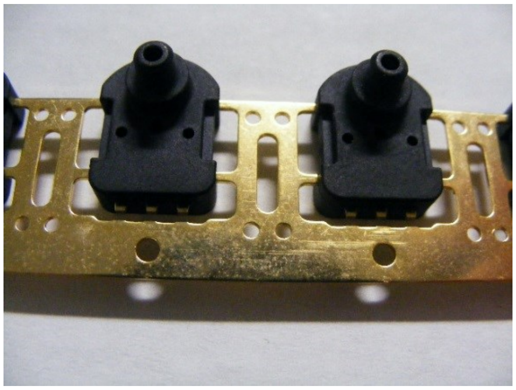
In some special situations, sensitive parts need to allow atmospheric self-calibration to surrounding air pressure but without compromising the integrity of the packaging. In these scenarios, the final part needs to be waterproof but still allow equalization of air pressure between the internal and external environments. The best solution for this requirement is to include a venting aperture in the mold or the lid and to laser weld a section of venting membrane fabric (similar to Gortex) over the vent that allows air infiltration but blocks any moisture from passing through.

Insert Molding of Non-Electrical Components

While this Tech Bulletin is primarily focused on electrical circuitry, it is important to note that the inherent flexibility of the insert molding process can also be applied to a variety of other items. These can provide structural benefits, RF shielding capabilities, support physical attachment of the parts, or a range of other functions.

One particular example is the incorporation of torque limiters. These are items molded in place and are used to absorb the torque generated by a screw fastener so that the pressure from tightening will not damage the plastic housing. We have also effectively used insert molding to directly incorporate RF shielding into the module during the molding process. This has the dual benefits of precise and consistent shield positioning and also significant cost reduction by eliminating secondary processes that would be needed to add shielding at a later step in the assembly sequence.

Basically the opportunities for leveraging insert molding are only limited by the imagination. As discussed in the following section, the involvement of insert molding experts with product designers early in the development process can yield significant opportunities to improve design quality and reduce costs.



Vertical Integration and Design for Manufacture

Because electronic modules require a seamless integration of both the molded packaging and the internal circuitry, it is critical to take a holistic approach.

Whether the metal parts inside the mold consist of a single stamping, multiple terminals, a lead-frame or complex specialized circuitry, it is critical for the insides to mesh perfectly with the outer packaging.

Best practices in Design for Manufacturing call for early involvement of all key participants to assure that design and production processes meet the product specs and provide optimal production efficiency.

With insert molded electronic components, this can best be accomplished through a vertically integrated process that encompasses both the metal and plastic elements within a single production environment.

This not only eliminates the risk of defects and misfits between processes; it also shortens time-to-market and can significantly reduce product costs.

A vertically integrated supplier assures conformance and delivery of the final product to meet specifications and requirements. Highly experienced suppliers also have a wide range of flexibility to provide finished components in whatever formats best suit the production environment, such as in continuous reeled formats, singulated loose piece parts, tray mounted, etc. It also greatly simplifies inventory and logistics planning. Instead of having to coordinate deliveries and work-in-process between multiple vendors, production planners can schedule a single vendor to provide finished components that are ready for immediate use on the customer's assembly lines.

Cost Savings with Insert Molding vs. Post Insertion

Insert molding offers significant advantages from a cost saving perspective as compared to post insertion. Post insertion requires a secondary operation dealing with loose piece parts that can add significant cost. In contrast, by insert molding we can either mold over loose piece terminals (singulated at the molding press) or mold over terminals on a reeled format.

By molding on a reeled format the parts are presented to the next step in the assembly process in a format that can be more easily and efficiently handled. The molded product on strip is supplied on a carrier with exact registration that needed for process automation. While not all applications are on reel but for those that require automation-friendly parts, it can be a big economic benefit.

Summary

Understanding the issues involved with insert molding for electronic packaging is the first step toward success. The next step is to approach each design from a holistic viewpoint and to consider all of the implications from design through manufacture. The final ingredient for success is to work closely with vertically integrated partners who know the process "inside and out" to create and deliver completed parts that meet or exceed requirements.

More information regarding insert molding and electronic packaging technologies can be found on the web by visiting www.interplex.com/electronic-packaging or by contacting Rob Souza at (401) 434-6543 extension 378 or by email at rob.souza@us.interplex.com.