

Thermoplastic Solutions for Photonics and Microelectronics Packaging

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Abstract

Thermoplastic injection molding is a technology that has yet to be fully utilized by the microelectronics packaging industry. Thermoplastic components have been used in opto-electronics packaging for years, namely in high volume telecommunications devices such as fiber optic transceivers. We have shown in the past that some engineered thermoplastic resins allow for producing micro-features into small parts, while maintaining micron-level tolerances. This is a requirement in many fiber optic devices. Most radio frequency modules would benefit from using thermoplastic for packaging, however a common problem with plastic is its lack of conductivity for shielding. We have demonstrated that metal coatings can be applied to plastic as a means of providing necessary shielding for EMI/RFI. We have made several key acquisitions and facility upgrades to improve our capability to deliver thermoplastic-based solutions to packaging related problems typically associated with high cost, high weight materials such as glass, ceramic and kovar. In this paper we present a variety of examples of manufacturing methods common to the injection molding industry, but found within one technology company that has serviced the microelectronics packaging industry for years.

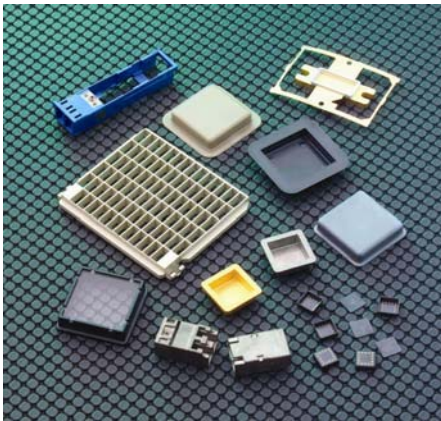


Figure 1: Thermoplastic components

Complex Insert Molding

Over molding of a metal or plastic insert is a common practice in the injection molding community. Levels of complexity exist, microelectronics components provide a multitude of challenges due to the number and configuration of required interconnects. The precision of fabricated metal inserts is vital to avoid mis-match in the mold cavity. Trying to shut off properly around a metal insert that is

out-of-tolerance is nearly impossible without the eventual appearance of mold flash in perhaps crucial functioning areas of the component.

Design of the metal insert is important for ease of loading/unloading in the mold but also to ensure that high molding pressures (potentially up to 30,000 psi in some micro molding applications) do not distort the metal insert. Figure 2 illustrates an insert molded component with a displaced metal insert due to high mold cavity pressures. For this particular application, the metal insert needed to be ultra thin (0.010" thickness) for best fit inside a low profile chemical sensor. The need for an ultra thin contact insert decreased the amount of fabrication options. Chemical etching was selected over metal stamping due to delicate features and thin stock material requirements. Costly mold modifications were also required to better handle and secure the insert during processing. Additional core pins needed to be designed and added to the mold cavity.



Figure 2: Side view of distorted metal insert in over mold.

An Alternative to metal inserts in plastic: Laser Direct Structuring (LDS)

Plating on plastics is a relatively new development in the thermoplastic manufacturing industry. A new technology has been developed by companies such as LPKF and Tyco Electronics for producing Molded Interconnect Devices. One method is to encapsulate a plateable thermoplastic with a non-plateable thermoplastic.

This method would require two separate molding steps and a preparation/plating step to achieve a final part. LDS – laser direct structuring – is a newer technology that requires a specialty thermoplastic and a laser surface preparation step which exposes the thin thermoplastic molded top layer from the surface to enhance direct plateability. Current laser tracing capability is 0.120mm width. Specialty materials – custom fillers – are available in LCP, PC/ABS, PA 6/6T, PET/PBT blend, PC, PPA.



Figure 3: Matrix molded LDS assembly.

Current applications include GPS and collision avoidance antennas. Advantages include less assembly – no metal fabricated inserts used as electrical contacts and less difficult registration and alignment issues common with traditional antenna applications.

Figure 3 illustrates an LDS molded component that has been over molded after laser treatment and plating. The over molded (white) material needed to be positioned and flowed carefully so as to not damage the plated surfaces/traces. Matrix successfully added this mechanical feature to the LDS finished assembly. Electrical continuity was achieved through the over molded section. The part illustrates a molding capability that was not known to the industry prior to this development exercise.

Molded Plastic Optics

Injection molded optics require special tooling, processing and handling techniques. Design of the part is crucial as injection molding has inherent parameters which cannot be eliminated – gating, ejection, flow of material, de-gating finished product.

Single Point Diamond Turning is a specialty method for polishing a mold insert to the exact optical specifications required for molding a lens or optical surface. Mirrors and lenses with geometries ranging from spheric to free-form shapes and micro structures are possible, ultra-precision of surface position, smoothness and finish are the norm.

Non-ferrous metals are required for diamond turning optical mold inserts. Purified nickel plated stainless steel is preferred, however copper and aluminum can work well for prototype or short run programs.



Figure 4: Mold cavity with diamond turned insert.

Material selection is the next design criteria to consider for plastic optics. Materials such as PMMA (Acrylic) and PC (polycarbonate) are common. PEI (Ultem) has been used for years in telecom/datacom applications due to its high operational temperature capacity. COC (Topas) and COP (Zeonor) materials have found a place in both microfluidics applications – requiring low fluorescence – and LED lenses due to zero/low yellowing with time (1,500 hours typical LED test for commercial lighting).

In figure 5 there is a photo of an injection molded multi-lens component used in a datacom transceiver module. The goal was to produce a multi-channel lens component that could be easily mounted (passive alignment) onto a circuit board and also be as low profile as possible. The part has 12 lenses measuring 0.250mm diameter facing the diode/printed circuit board side and another 12 lenses of the same size interfacing with the fiber. A “turning mirror” is molded on the back side of the part and provides the low profile 90 degree internal reflection. The part is designed to be used with an 850Nm VCSEL diode and an MT fiber ferrule. Insertion losses are less than 2.5dB, the tolerances between lenses are sub-micron. This part requires a final annealing step before assembly into the transceiver. Annealing will relieve stress that is molded into a plastic part.

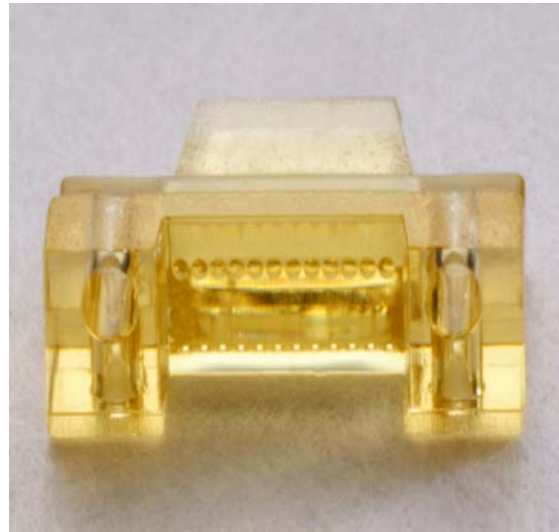


Figure 5: Molded micro lens array made in Ultem

Injection molded optics offer several advantages over glass. Weight reduction and cost reduction are certainly amongst the first benefits one would think of with thermoplastic. Freedom of design: ability to put mechanical and optical features on the same part is a space, cost and assembly savings. Multiple optical surfaces on a single part is something that can be achieved with diamond turning. Diamond turning can provide multiple optical surfaces on the same part: mirrors, lenses.

Metrology of plastic optics

Many times a functional test using the same circuit board and diode receiver can be the most accurate way to verify molded optical components. An in-process test fixture is common for many lens applications where minor mechanical subtleties may not effect the overall performance of the optic. A fast and efficient functional test serves a manufacturer well. A laser interferometer scanning instrument is used to verify exactly what an optical surface measures. It is common practice to perform an interferometric scan on the tool steel prior to molding, then again on the molded part to determine how close the mold shrinkage factor was predicted.

Miniaturization in Manufacturing

Microelectronics packaging, components and assemblies have been shrinking for years in an effort to get more on the same printed circuit board or in a module that needs to be lightweight for avionics applications, for instance.

Telecommunications fiber optic connectors and transceiver modules have gone from large, bulky single fiber units to miniscule, multi-fiber, multi-functioning parts (as seen with the multi-channel micro lens array previously in this paper).

Micro injection molding is typically done in specialized molding machines and processing cells. Micro molding machines have smaller barrel and shot sizes in order to maintain material integrity once melted. Minimal residence time in the barrel is key to maintaining a robust process. Extended time in the barrel is the major contributor to material degradation.

Tooling for micro sized parts can be challenging. Features such as micro holes (under 0.005" diameter) and thin wall sections (under 0.010") are typically below the standard tooling/molding thresholds. Mold components need to be built accordingly, securing a core pin from both sides of the mold or gating a part so that filling a thin section can be achieved.



Figure 6: Micro injection molded parts along with micro metal stampings.



Figure 7: Micro over molding of metal component.

Combining metals and plastics is a great way to eliminate or reduce the amount of assembly in a manufactured component. Micro machining and stamping of metal parts can be added to a micro molding tool. Handling is difficult, however robotics can provide precision and fast cycling as well as high repeatability.

Conclusions

Thermoplastic injection molding is currently a viable manufacturing process for a wide variety of industries and applications.

We've proven that molded optics can be used in medical, military and telecommunications devices. Material research is relentless and new high performing resins are now competing with glass and silicone for challenging applications in long term use LED modules and also bioscience microfluidics chips.

New technologies such as LDS can be an interesting method for all-plastic interconnects. Over molding additional mechanical features can be useful to eliminate extra parts and assembly.

Micro manufacturing is a new and exciting direction for thermoplastics...and metal stampings. Working on a micro scale requires a different mind set and certainly one that is open to challenges.