

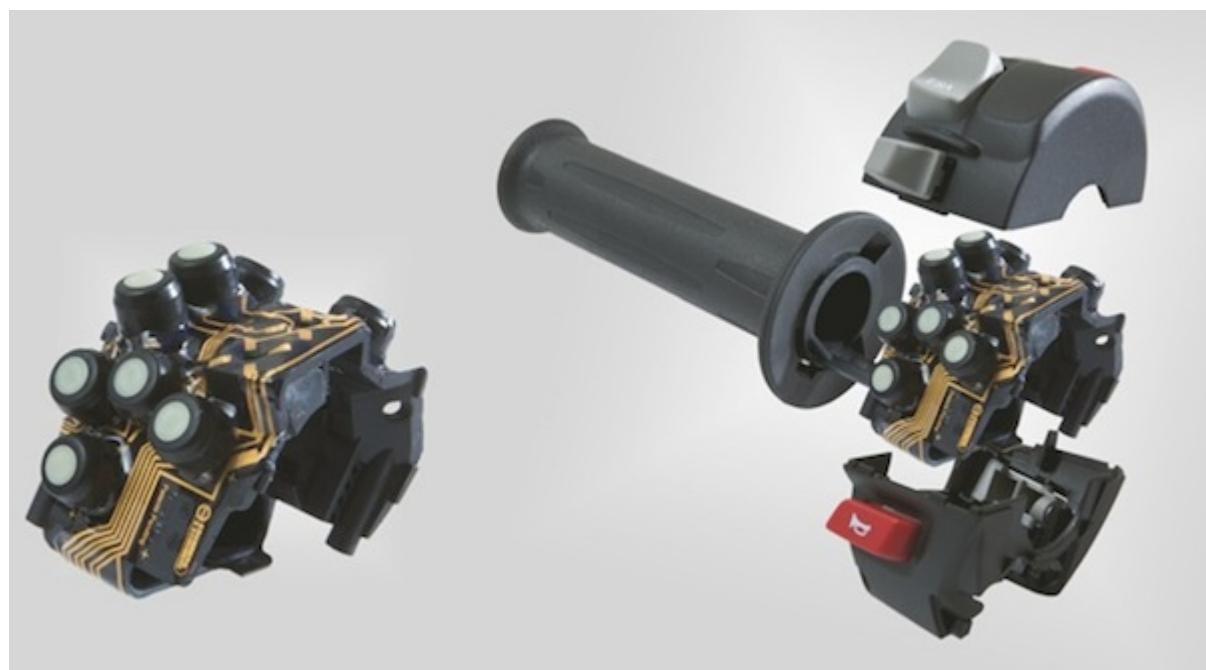
# What are molded interconnect devices?

shanes1007 - January 24, 2014

*In this article, Shane Stafford explains what MIDs are and explains how they can be manufactured using LPKF's laser direct structuring process.*

Molded interconnect devices (MIDs) are 3-dimensional electromechanical parts that bring together the best of both mechanical and electrical engineering. MIDs combine the circuit board, housing, connectors, and cables that comprise traditional product interfaces and merge them into one fully functional, compact part.

The appeal of a device such as the MID is easily recognized. By reducing the amount of parts that go into a product, space is saved, fewer components are necessary, and the weight of the unit is reduced. In addition, the possibility of a 3D workspace lets engineers think outside of the square geometries that have previously limited circuit board design.



**Figure 1: A molded interconnect device used in an automotive user interface**

Originally developed in the 1980s, MIDs came on strong as a hot, new concept. Despite the early fanfare, however, MIDs didn't catch on at first. High tooling costs and high volume manufacturing thresholds limited the market for MIDs. Before long, it appeared that the molded interconnect device was nothing more than flash in the pan technology.

All that has begun to change since the turn of the century, as MIDs have seen a comeback. The original touted benefits of MIDs - saving space, reducing weight, limiting part count - haven't changed, but their importance has risen as the trend of miniaturization continues its march forward. The classic Motorola "brick" cell phone as made famous by Oliver Stone's Wall Street may not have had much use for miniature parts, but the smart phone in your pocket that doubles as your computer, personal assistant, GPS, and gaming device sure does.

As functionality of electronics has increased, we've demanded that their size does the opposite. In

short, technology has evolved but the size of our hands hasn't.

For this reason, we've reached a point in time where, more than ever, electrical and mechanical product designers must be on the same page as far as making everything work in the limited space modern devices possess.

Fortunately for development teams, modern manufacturing methods make implementing MIDs a more pragmatic option than before. Amongst these methods are insert molding and hot stamping, but the two most widely used processes are two-shot molding and laser direct structuring. Two-shot molding was the first manufacturing method to provide cost-effective production of highly repeatable interconnect devices. It involves the use of two separate plastic parts, one platable and one non-platable.

The platable part, usually palladium doped plastic, forms the circuitry. The non-platable part, often polycarbonate, fulfills mechanical functions and completes the molding. The two parts are fused together and then undergo electroless plating. In this step the platable plastic is metallized, while the non-platable plastic remains non-conductive.

Due to the nature of having multiple parts, tooling for the two-shot molding process is often complex. With the device's circuit design tied to the molding of the two plastics, flexibility for late cycle design changes is limited. These two factors make two-shot molding ideal for producing MIDs with simple electrical designs set for very large manufacturing quantities.

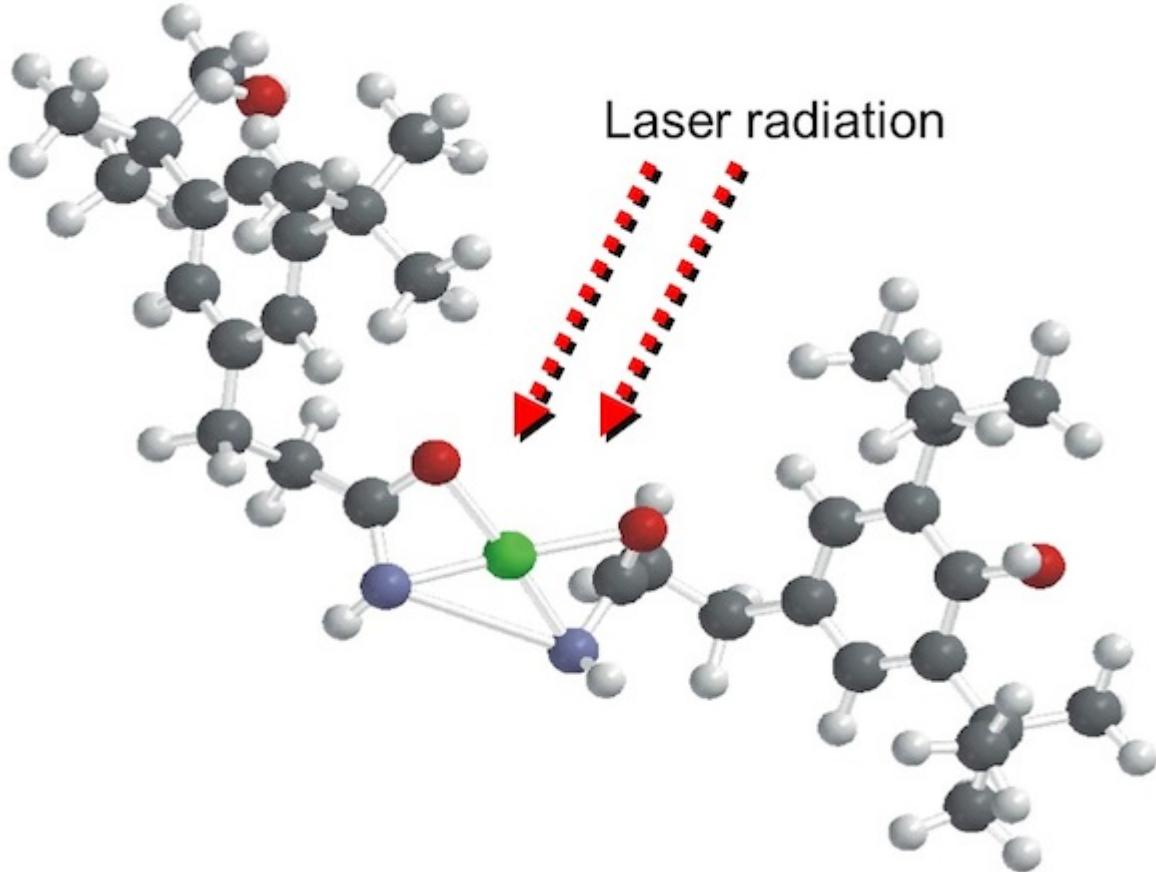
Another method for producing MIDs is laser direct structuring (LDS). A three-step process (patented by [LPKF](#)), laser direct structuring builds on the benefits introduced by two-shot molding.

### **The Laser Direct Structuring Process**

Laser direct consists of three basic steps: injection molding, laser activation, and metallization. With LDS, only a single thermoplastic material is required to make an MID, making the molding step a one-shot process. Having only one part means that the circuitry is created on the plastic itself, one of the distinct features of LDS. The second step of the LDS process is laser activation. Here a physiochemical reaction occurs that etches the wiring pattern onto the part and prepares it for metallization.

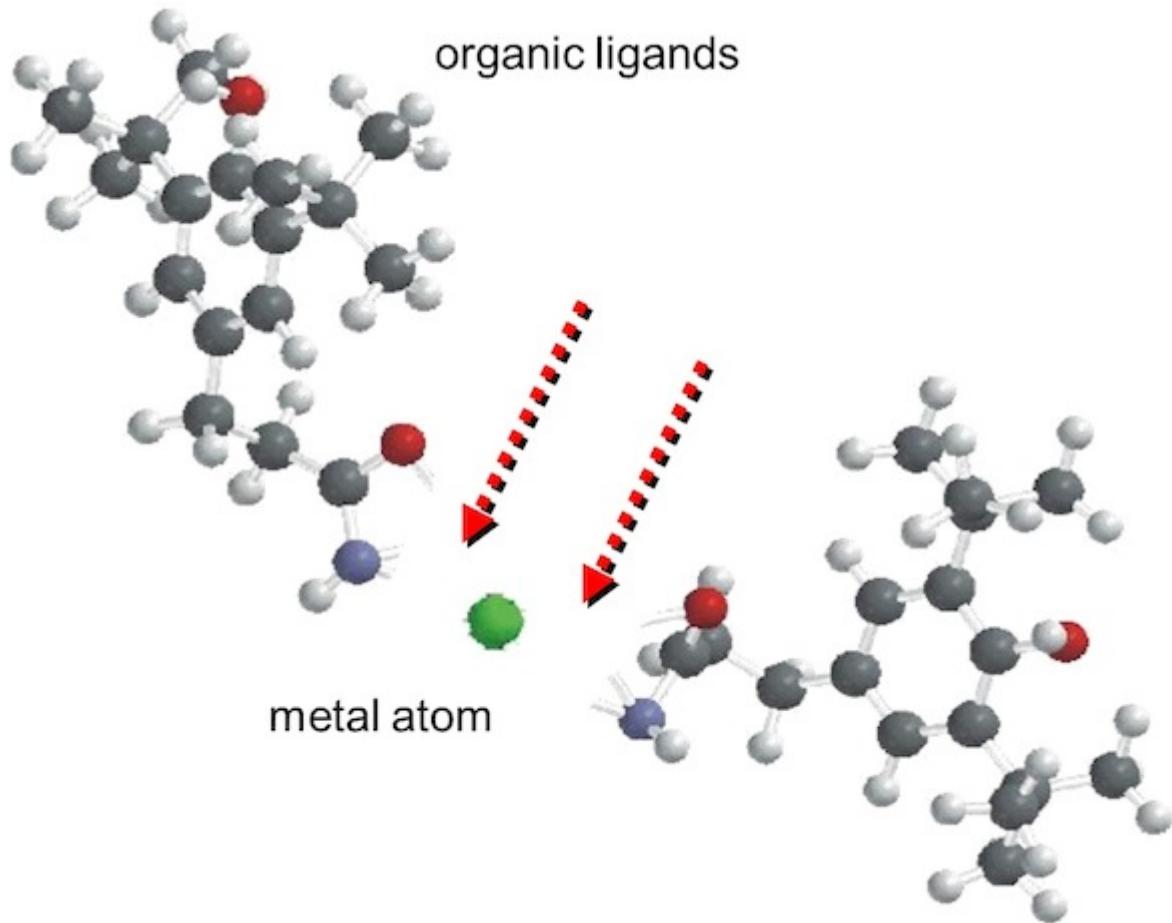
In order for LDS to work as intended, the part molded in step one must be made from an LDS grade material. Available from most major plastics suppliers, these materials are variants of common plastics, such as nylon or acrylonitrile-butadiene-styrene (ABS), that are doped with a metal-organic compound.

Figures 2 and 3 display the molecular structure of an LDS grade thermoplastic. In Figure 2, you can see nonconductive atoms (red, white, blue, and gray) surrounding a metal "seed" atom (green) buried inside the material.



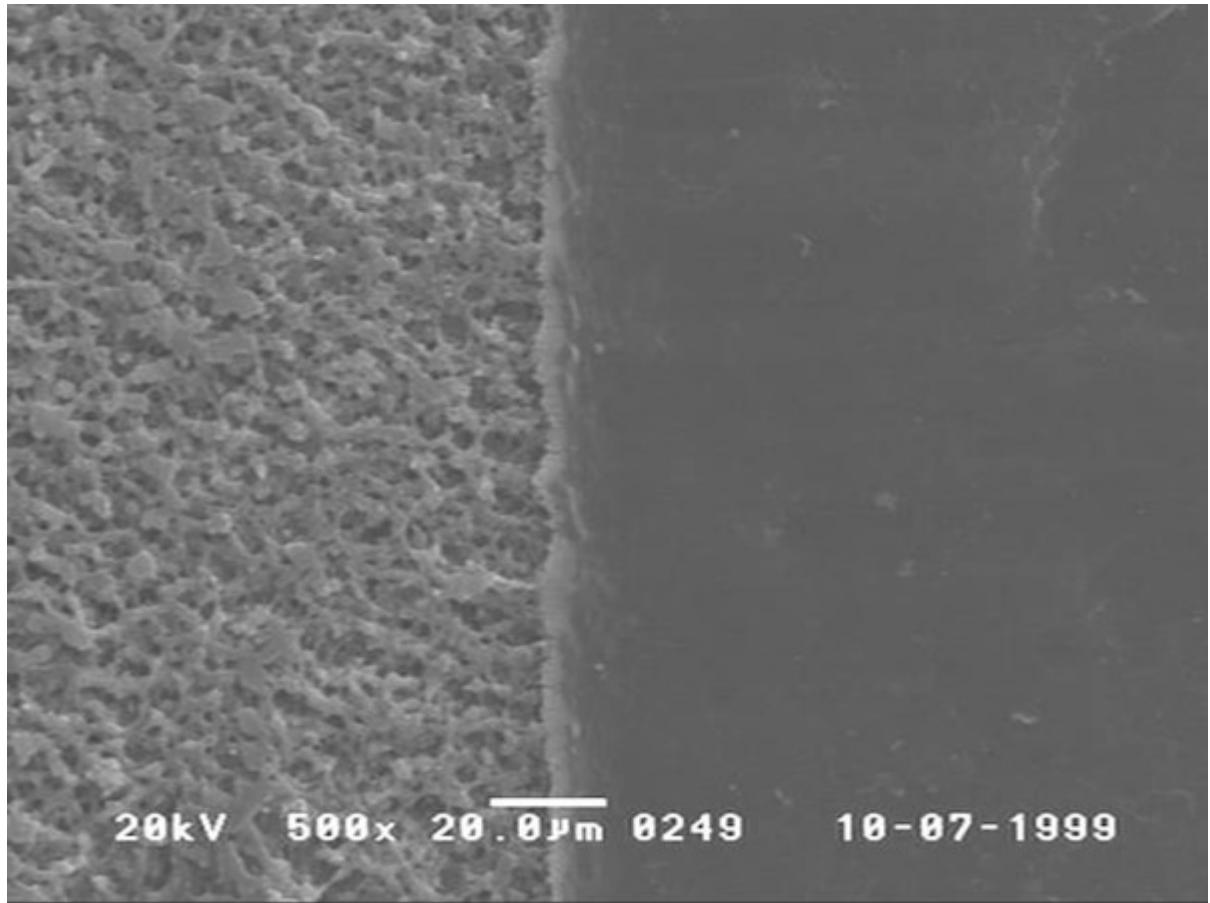
**Figure 2: Inside an LDS grade material**

When the laser energy hits the surface of the part (see Figure 3), it breaks the nonconductive atoms away from the conductive “seed” atoms, exposing them and selectively activating the material for metallization. This fulfills the primary function of the LDS laser.



**Figure 3: The laser activates the conductive metal atoms within the material**

Figure 4 displays what the surface of an LDS laser-activated part looks like. On the left is the laser-activated area where conductive features (such as circuit traces) will reside, and on the right is the smooth, non-conductive portion of the device.



**Figure 4: The conductive (left) and non-conductive (right) surface of an LDS grade material**

The rough-looking, micro-etched texture as seen on the left fulfills the secondary function of the LDS laser, which is to provide a strong mechanical bond for metallization - the third step in the LDS process.

Like two-shot molding and other MID manufacturing methods, LDS takes advantage of the benefits of electroless plating in order to metallize circuit traces and other conductive features. The makeup of the metallized surface is typically a Cu/Ni/Au coating, which provides good conduction, adhesion, and surface finish.

Once the plating is finished, the LDS process is complete. Figure 5 shows a LDS-created MID in all three stages of the LDS process.

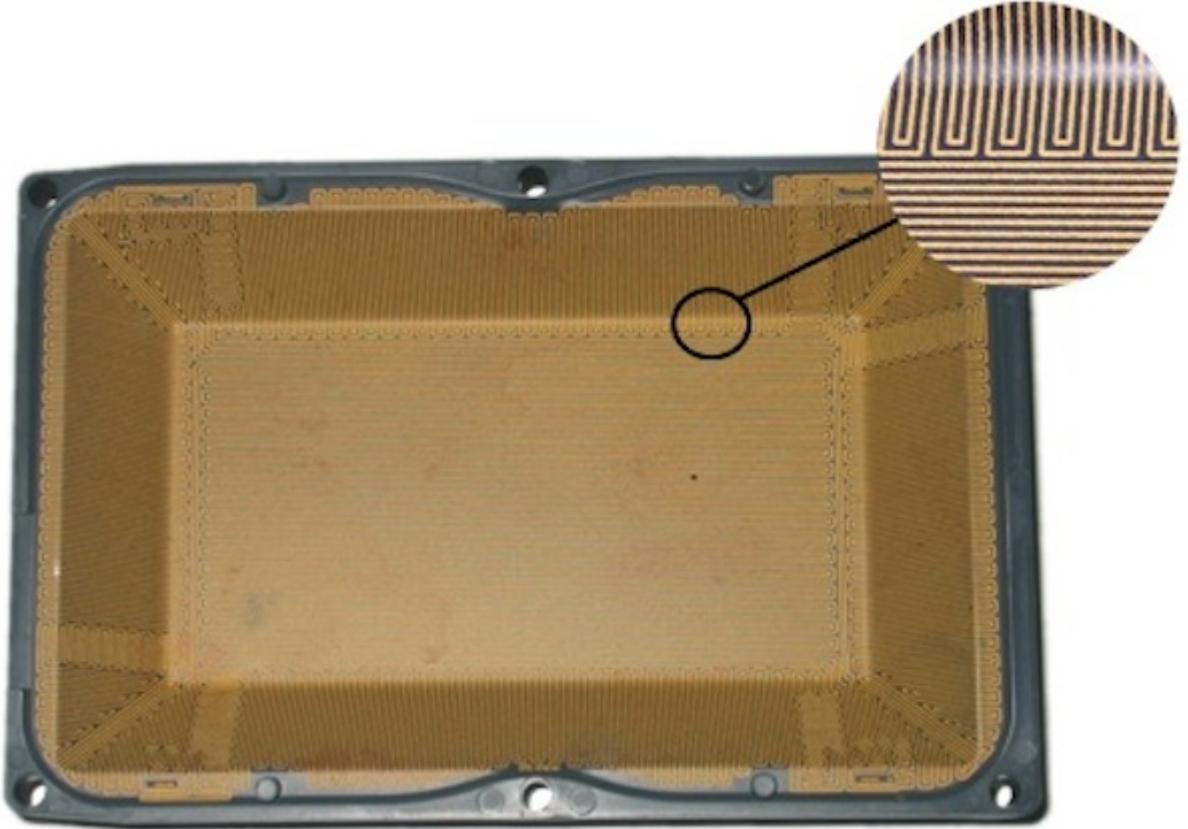


**Figure 5: A completed MID. From left to right, injection molding, laser activation, and metallization**

## Applications

Because of the universal benefits they possess, MIDs are found in all industries - from telecommunications to automotive to medical. Applications range from the simple (mobile phone antennas) to the complex (security shields for ATMs). What separates LDS from other MID manufacturing methods is the way it unites mechanical and electrical elements of the design, allowing for the creation of complex parts that could not be produced any other way.

150  $\mu\text{m}$  circuit traces are common when it comes to LDS, and traces as small as 75  $\mu\text{m}$  are possible, depending on the material being used for the design. LDS systems work straight from CAD data and possess positioning accuracy of  $\pm 25 \mu\text{m}$ , ensuring such intricate designs are formed with precision. The application found in Figure 6 displays the type of application that's possible when using LDS. A drill shield for securing ATMs, this device could not be made by laying two plastics together, due to the nature of its intricate circuitry (150  $\mu\text{m}$  traces).



**Figure 6: An ATM security shield on the inside of a component cover**

Another benefit of separating electrical and mechanical design elements is that it allows for late cycle design changes to be made with efficiency. If a designer discovers that the performance of his RF antenna is not quite right, he can change the electrical design of the MID without having to retool the molding.

In a world where time to market time continues to shrink and the price of change orders are rising, this has a positive impact on both the R&D and production sides of development.

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