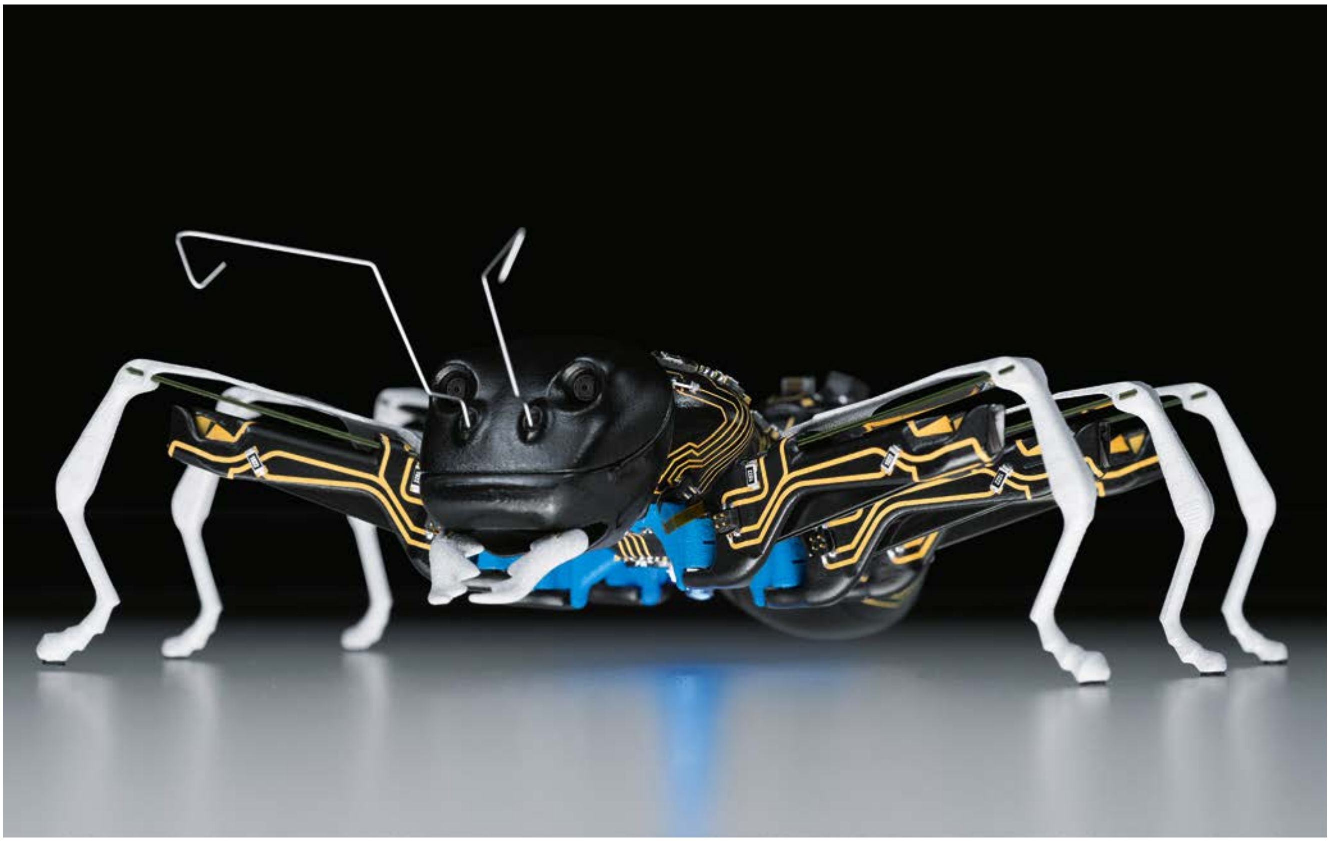
Copper Conductors from the Bath

3-D Printing for MIDs

With laser structuring and subsequent electroless metallization, three-dimensional plastic parts are made into three-dimensional circuit carriers. An innovative feature is the addition of an inexpensive rapid process for manufacturing prototypes to the process chain.



Molded interconnect device (MID) technology allows three-dimensional conductor tracks to be applied to the surface of injection molded parts in order to integrate mechanical and electronic functions into a single part. The artificial ant shows how self-organizing individual components communicate with one another and solve complex tasks as a networked overall system (figure: Festo AG & Co. KG)

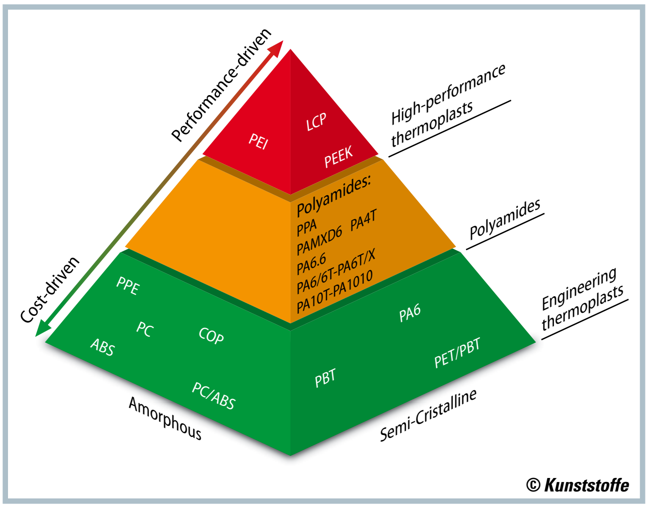
A black cube the size of a sugar cube, and a, by comparison, tiny black disk the size of a lens are both pressure sensors for car tires – before and after design as 3-D parts. The small lens shows the potential of this technology. Its volume is only a fifth of its predecessor. The complete contacting of the sensor has already been applied in the part housing. Lars Führmann, product manager at LPKF Laser and Electronics AG, Garbsen, Germany, is convinced that the market for three-dimensional circuit carriers will grow significantly in the next years.

Three-Dimensional Circuit Carriers

The basis of a molded interconnect device (MID) is an injection molded plastic part with conductor tracks mounted on its surface. Three-dimensional circuit carriers combine mechanical and electronic functions in one part to save space and reduce weight.

The laser direct structuring (LDS) process patented by LPKF holds a market share of over 50 % – and has the potential to be developed to enter new fields, such as LED technology or ultrafine structuring for chip stacking (e.g. integration of sen-

Fig. 1. The range of available LDS plastics covers all important material groups. All well-known manufacturers offer LDS grades of their plastics



sors and evaluation electronics in a compact housing).

Laser direct structuring is based on parts manufactured from a plastic containing additives. Conventional suppliers offer all important thermoplastics as LDS grades, and even the first thermosets are now available in LDS grades (**Fig. 1**). The plastic part is marked by laser. The laser process activates the additive and creates a microroughened surface for better adhesion of the subsequent conductor tracks.

Conductor tracks are subsequently built up on these structures in an electroless metallization bath by drum or rack metallization. Chemical metallization allows the production of conductor track thicknesses of up to 15 µm, followed in the series process by a nickel and gold finish. The steps from the unfinished part to the circuit carrier are illustrated in **Table 1** in individual steps.

This level of LDS technology is well known and tried and tested. It is established in the automotive, electronics and medical fields. Every second smartphone currently has at least one LDS part; the advantages of the technology are evident, particularly for antennas. A new trend is to use them in LED lighting – three-dimensionally disposed LEDs have radiation characteristics very similar to those of conventional light sources, and special processes and materials promise advances in heat dissipation.

LDS Prototypes by 3-D Printing

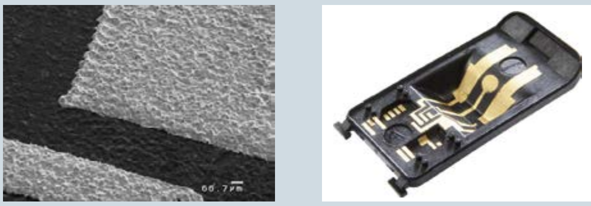
LDS prototyping closes the gap between design and series production. Near-series prototyping had been difficult until now. In LDS prototyping, the body of any desired part is coated with an activatable surface. Possible base bodies are, for example, plastic parts from 3-D printers with a sufficiently smooth surface.

The base body is coated from the spray can with the LPKF ProtoPaint LDS lacquer, which contains the LDS additives, and dried in the oven before structuring. A single thorough lacquering applied by crosswise spraying is usually sufficient.

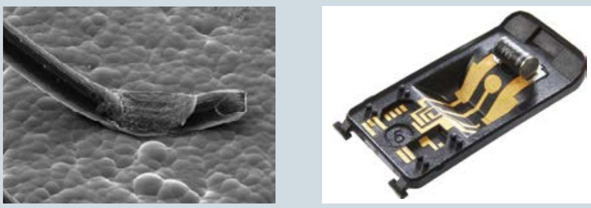
A specialized laser system is available for laser structuring. The LPKF ProtoLaser 3D shares the housing with the tried-and-tested 2-D ProtoLasers and is equipped with laser optics that are also used for LDS production systems. It has a vertically adjustable working platform for structuring parts of different dimensions. The working range covers 300 x 300 x 50 mm; the scan field is 100 x 100 x 25 mm. For practical structuring of the parts, only simple workpiece mounts are necessary. **Figure 2** shows ramps at angles of 30 and 45 degrees. The parts are fixed »

The injection molding of a plastic containing LDS additive.

The laser activates the additive and creates a microroughened surface for good bonding strength.



In the metallization, metal layers are built up on the activated paths.



Electronic parts can be bonded, conductively glued or soldered on the metal layers.

Table 1. Sequence of the LDS process

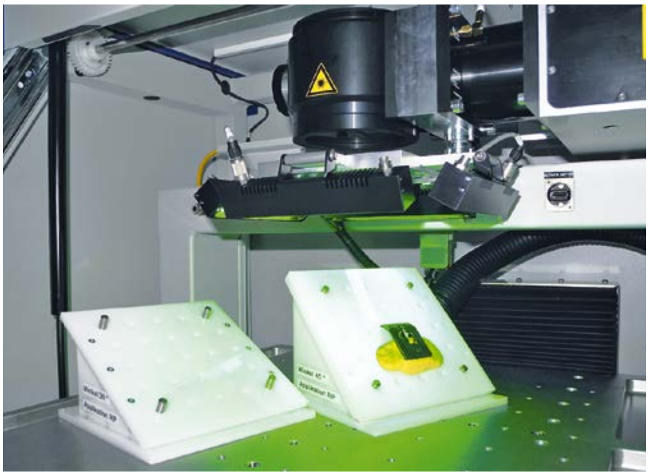


Fig. 2. Simple part holders are adequate for reliable feeding of the LDS parts in the ProtoLaser 3D

Fig. 3. At productronica in Munich, Germany, LPKF presented three process steps for manufacturing LDS prototypes

in a non-shrink paste – e.g. from dental technology. This is another advantage of the laser process – there are no mechanical stresses.

Chemical metallization is performed by the ProtoPlate LDS process. It uses a protective housing for process control and ready-made bath chemicals as consumables. The metallization process is as easy as brewing coffee. The basic metallization solution is poured from the supplied canister into the glass beaker, where it is raised to a process temperature of about 44 °C. The process is started by an activator solution, which is also pre-portioned. The parts are then hung in the bath on a copper wire. The thickness of the copper layer de-

Fig. 4. Front: an antenna with contacts for galvanic reinforcement. Rear: the part with purely chemical copper structure

Current Developments

LPKF ProtoPaint LDS in Industrial Use

LPKF ProtoPaint LDS is available as a ready-to-use option in the spray can and as lacquer system with separate components. The lacquer system must be mixed and can then be applied with the spray gun or by printing. This option is provided for industrial use, e.g. for antenna structures on the reverse side of monitors or smartphone covers. Developers thus profit from the fact they can use plastics with known surface or dielectric properties.

Galvanic Reinforcement

Chemical metallization is relatively simple, but has disadvantages. Galvanic reinforcement is ideal for mechanically loaded or thick-layered parts. First a thin metallization is applied chemically in a short time (~3 µm). Then the part is electrically contacted and reinforced by electroplating (**Fig. 4**). In practice, this process offers layer thicknesses up to 70 µm with a smooth surface. Resistance to mechanical and thermal stresses is improved due to the more homogeneous layer.

LDS Powder Coating

Lacquering metal circuit carriers with an LDS-capable powder lacquer offers great potential. This process is particularly suitable for LED applications because the good thermal conductivity of the base body offers great freedom of design.

Fine-Pitch Structuring

The resolution of 300 µm (150 µm line, 150 µm spacing) represents a peak value for three-dimensional MIDs. Electronics developers have even more ambitious aims. With an optional fine-pitch laser unit, applications with 75 µm/75 µm (line/spacing) are already in production; even finer structures will be available in future. These ultrafine conductors are desirable, for example, in sensor technology or for stacking ICs to form circuit carriers (**Fig. 5**).

Fig. 5. Laser machining of MIDs and circuit boards (figures: LPKF)

pends primarily on the time they are in the bath. After two hours in the bath, a copper layer of about 10 µm has built up. Then the consumed bath chemicals are returned to the canister, identified with the supplied labels and disposed of (**Fig. 3**).

LDS Lacquer in Series Production?

The ProtoPaint lacquer extends the LDS process in prototyping and also shows new possibilities in series production. The process offers the option of manufacturing a housing component from a tried and tested polymer, the interior of which is coated with the LDS lacquer in order to apply an antenna structure there. These sorts of considerations are currently supported by corresponding investigations. The first results lead to the conclusion that the dielectric properties of the base material are not significantly affected by the LDS lacquer and even the bond strength of the metallization is comparable with that of certain LDS series plastics. These are all good prerequisites for antennas integrated into housings. ■

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Insert Molding with EPDM

Automated Elastomer Processing

At the Deutsche Kautschuk-Tagung DKT 2015 in Nuremberg, Germany from June 29th to July 2nd, **Arburg GmbH + Co KG**, Lossburg, Germany, presented a compact manufacturing cell for removal suction cups with a threaded brass insert. The system is centered around a vertical injection molding machine (type: Allrounder 275 V) fitted with an elastomer processing package.

As soon as the metal insert is placed in the single-cavity mold (manufacturer: Edegs Formenbau GmbH), the mold is evacuated by means of a vacuum system integrated in the Selogica machine control unit. The insert is then overmolded with EPDM in cycle time of about 60 s. Injection takes place via a pneumatic cold runner system with needle valve. Two P 160 S tempering units (manufacturer: Regloplas AG), which are also fully integrated in the machine controller, regulate the temperatures of cold runner and cylinder module. A six-axis robot (type: Agilus from Kuka Roboter GmbH) removes the finished molding, puts it in a camera inspection unit, and places the OK part on a conveyor. The robot then places a new insert in the mold, which starts the next cycle.

To prevent premature vulcanization, a precisely defined temperature profile must be maintained. This is achieved by means of liquid-cooled tempering jackets on the injection molder's elastomer cylinder module. The injection unit contains an automatic band feeder and a special conveyor screw for processing the strip material. The mold is heated via adaptive temperature control units, which are programmed and controlled directly via the machine's Selogica control system. In addition, the vulcanization times and dosing delays can be entered, and venting as well as brushing or demolding devices can be controlled.

At the Deutsche Kautschuk-Tagung, removal suction cups with threaded brass insert were produced in a compact manufacturing cell (figure: Arburg)

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To the manufacturer's product presentation:
www.kunststoffe-international.com/1065876