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NEW CONCEPTS AND EMERGING TECHNOLOGIES

Aluminum Base Circuit Technology: Structures & Manufacturing Methods

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3D LDS Components: New Opportunities in PCB Layout and Production

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LPKF

One clear trend has dominated electronic and mechatronic products for many years: components must get smaller in size while also packing in more functions. Manufacturers in the communications technology sector are under tremendous pressure to continuously launch new products on the market at shorter and shorter intervals, to maintain their commercial positions. As if that were not enough, these new products have to stand out from the crowd by offering unique selling points. Innovative technologies such as MIDs (molded interconnect devices) enable new products to be produced with unprecedented functionality. And this is where LPKF's LDS technology comes in because it opens up a huge opportunity for businesses that need very reliable and efficient production technology. Economic prototyping processes and a short production pipeline are also added advantages.

The current main application is the production of smartphone antennas. In the future, the German Research Association 3D-MID expects a significant growth in tablet or laptop antennas as well as new applications in the automotive and medical field.

Molded Interconnect Devices for Higher Function Density

MIDs allow the integration of electronic circuits and components directly on three-dimensional plastic components. This enables chips to be elegantly stacked in their assemblies, and the antennae in smartphones or netbooks to be incorporated directly within the housing, which saves a great deal of space. Integrating functions also decreases the number of individual components required, eliminates a whole range of production steps, automatically saves additional costs, and creates higher quality components.

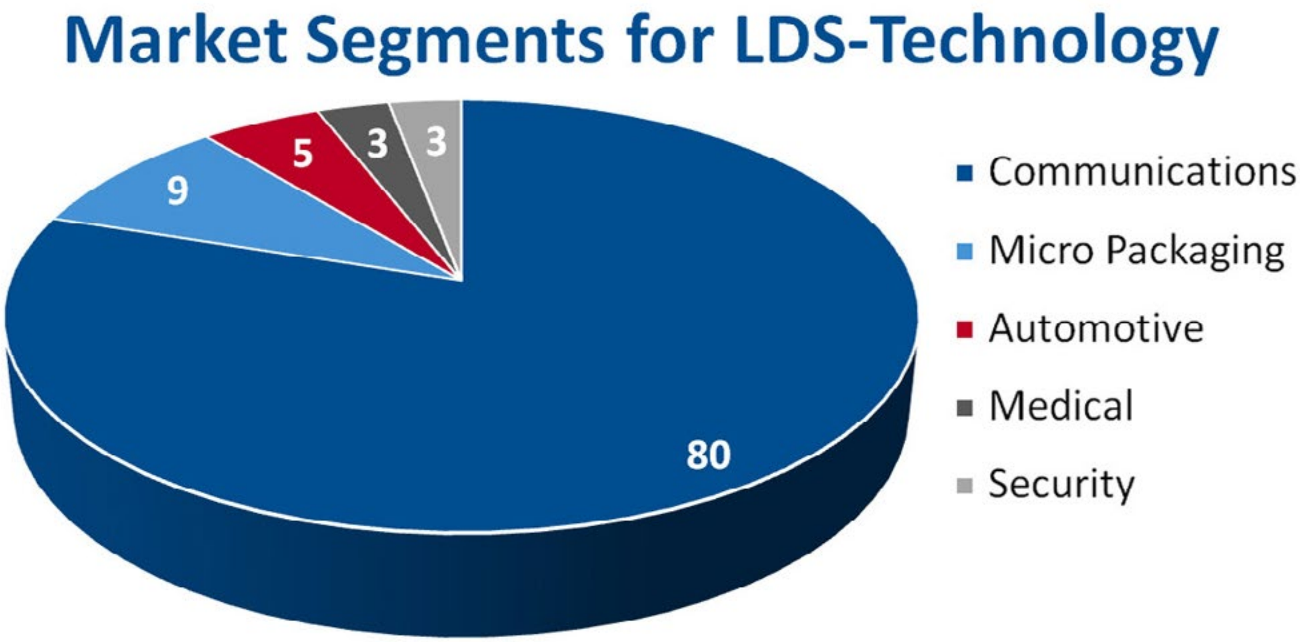

Figure 1: Differentiation of the use of LDS systems by market segments (3D-MID e.V.).

The most common methods for integrating electronic circuits directly on plastic components are:

• Hot stamping, using a die to press thin flexible films onto a plastic component: Excess film is then removed. This method is simple and works with a large range of materials. The problem is that this method is incapable of creating fine tracks, real 3D structures, and complex circuits. A change of layout data also requires a new film or a new stamp tool.

• The two-component injection molding method: This works by using the first metallizable polymer to mold a structure with the circuitry at the surface. The second polymer is not metallizable and covers those areas without conductive tracks. This method allows a great deal of 3D design freedom, but it needs high upfront costs and is restricted to only a few types of plastic. Two complex injection molding tools are required. Creating fine tracks is also a problem. Another negative aspect is the relatively long time needed to successfully push products of this kind through the product pipeline and onto the market. The lead time for the development of injection molding tools alone is around two months, but in very high series without layout changes this method is very economical.

• The subtractive method: This method uses a laser to remove metal layers where they are no longer required, or to open a resist for the subsequent etching process. This method requires long laser exposures, and components with fully metallized surfaces.

• The Laser Direct Structuring method (LDS): Patented by LPKF, this method provides further advantages, both technically and economically. The LDS method uses a thermoplastic polymer doped with a laser-activatable metal-polymer additive. When the laser beam hits this polymer it activates the metal complex and creates a precise track with a rough surface. Exposed metal particles form the nuclei for the subsequent metal coating process. The laser beam therefore draws the structures required on the component so that the conductor layers are created precisely along these tracks in a currentless metal coating bath. Copper, nickel and a gold finish can be successively applied.

The LDS Process, Step-by-Step

All the special strengths of lasers such as high flexibility, speed, resolution and precision, are utilized in this process. If the circuit has to

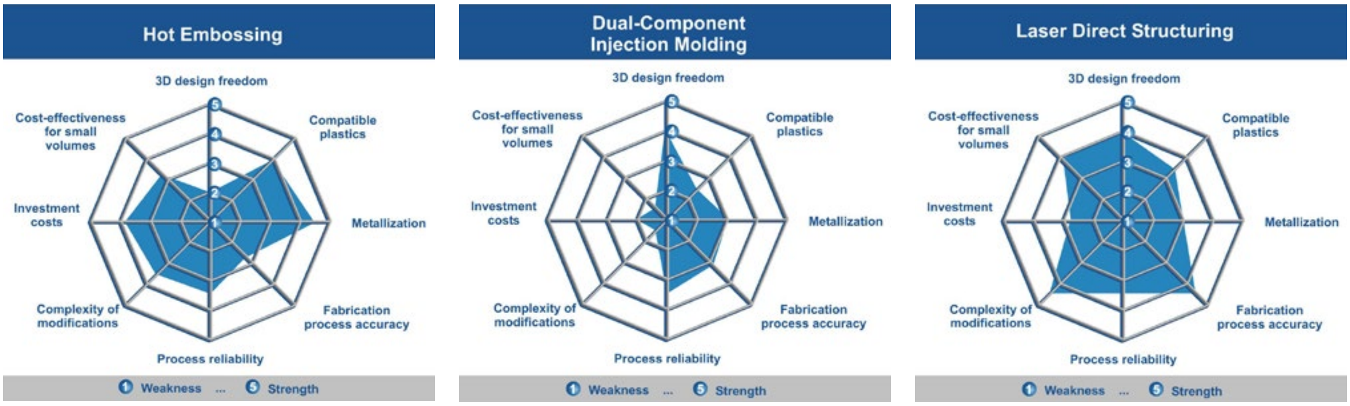

Figure 2: Assessment of 3D processes for interconnect devices, l–r: hot embossing, dual component injection molding, LDS.

be reconfigured, just feed a new set of control data into the laser unit. This means that one basic component can be used to create a range of parts with different functions—merely by changing the design of the circuits drawn by the laser beam. And because these control data can also be changed during production, companies can produce small- and medium-sized series in a highly cost-efficient manner. Even producing one-off products is no longer an expensive technical headache. The pipeline from prototype to volume production is short and inexpensive—businesses can react quickly to the changing demands of the market.

LPKF uses processing units with a laser wavelength of 1,064 nm and a pulse frequency

Figure 3: The plastic part, made by an LDS doped thermoplast.

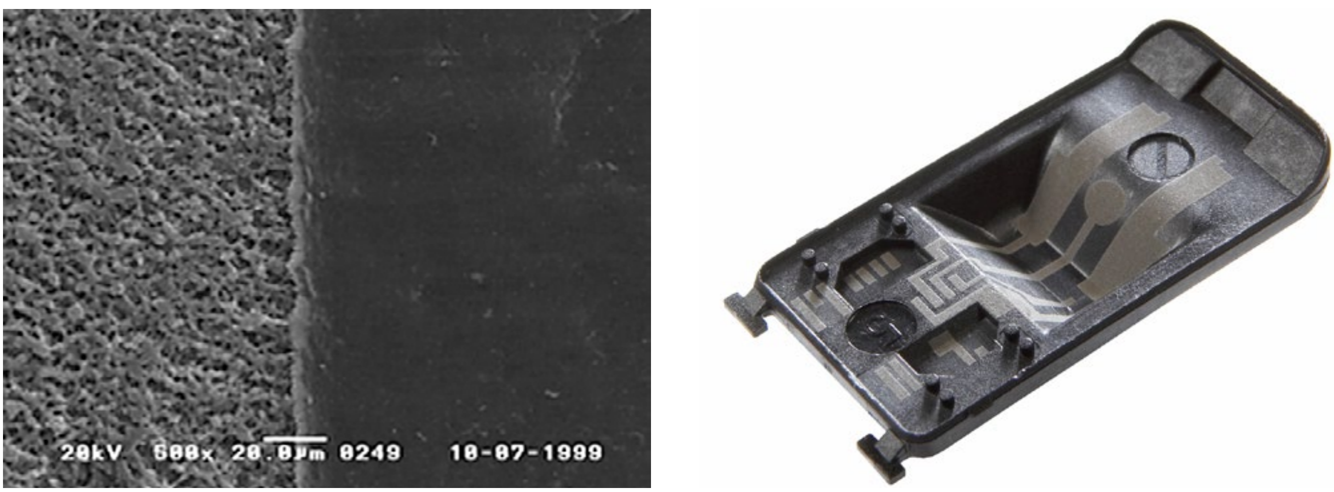

Figure 4a and 4b: The laser beam has structured the blank and has activated the additive.

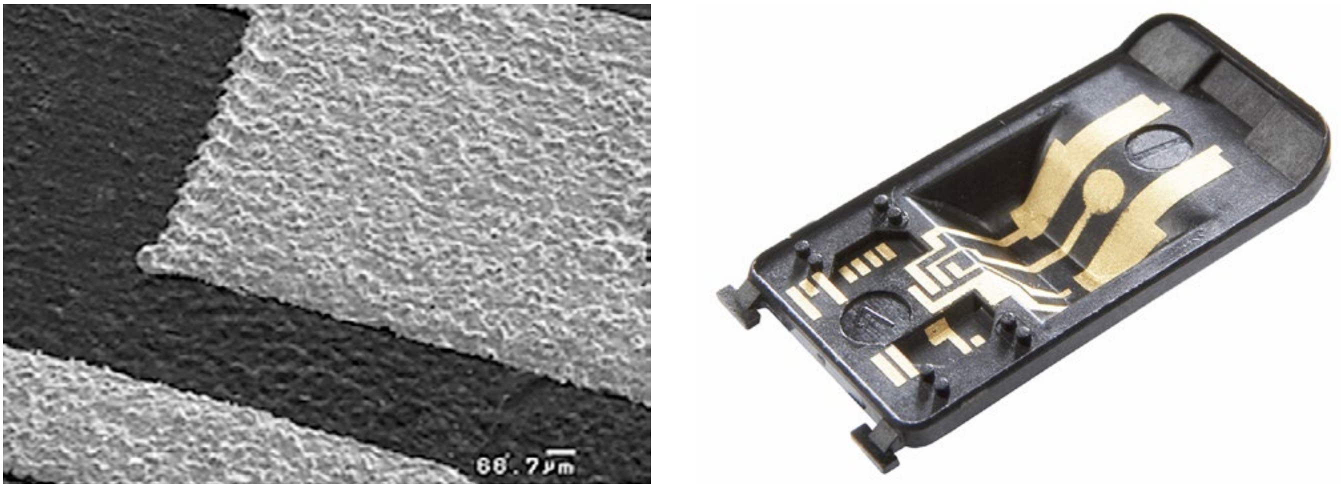

Figure 5a and 5b: In a currentless metallization bath copper settles on the structured parts.

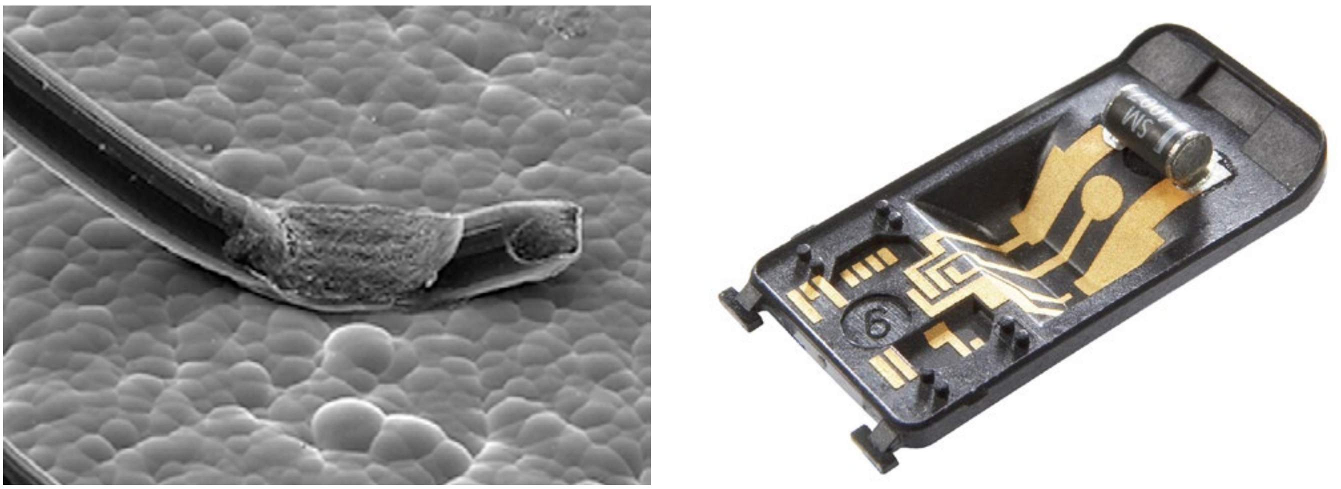

Figure 6a and 6b: The structure may be connected via bonding or can be assembled with electronic components.

between 10 and 200 kHz. With its underlying technologies, the LDS method is particularly accurate. Implementing laser technology, circuit paths of 150 µm width and 150 µm spacing between the interconnects can be realized with the standard equipment, the standard system used up until now writing at a speed of 4,000 mm/s. With specialized laser sources and optimized focusing even finer circuit structures up to the ultrafine range are possible.

The laser structuring has to take place in a scan field up to 160x160 millimeters. A specialized laser system uses these parameters and a stitching routine to machine larger parts up to 400 millimeters in length. The LDS systems in the Fusion3D product line can be equipped with up to four processing units to greatly decrease the processing time.

Materials

The main prerequisite is that the metal oxide-containing additive has to be evenly distributed and sufficiently concentrated in the thermoplast. Now almost all leading plastic manufacturers offer LDS versions of their thermoplasts. The spectrum consists of amorphous and partially crystalline polymers, with thermal stability ranging from standard to high temper-

ature thermoplastic. These include numerous types of materials that are suitable for lead-free soldering.

Here are a few examples of materials:

- Pocan® is a thermoplastic polyester based on polybutylene terephthalate (PBT) and polyethylene terephthalate (PET) developed by Lanxess. Pocan possesses a high resistance to heat distortion, and good strength and hardness characteristics. In addition it has high abrasion resistance, good chemical resistance, good electrical insulating and dielectric properties, high creepage current resistance and low moisture absorption. There are several variants of Pocan available to meet different temperature requirements. The material can be easily soldered and laser welding also produces the best results.
- PA6/6T is a partially aromatic polyamide based on Ultramid® from BASF AG. The material is distinguished by a high resistance to heat distortion and good mechanical properties. The short-time heat resistance can be increased up to 400°C (750°F) by using a crosslinkable variant of this material.
- A crosslinkable PBT (polybutylene terephthalate) based on Vestodur® from Degussa AG, with the good qualities of a standard PBT, also guarantees a high degree of distortion resistance.
- LCP (liquid crystal polymer) based on Vectra® from Ticona GmbH has a low melt viscosity and very high heat distortion resistance.
- PC/ABS (polycarbonate/acrylonitrile/butadiene/styrene) from DSM also has very good surface and mechanical properties.

Past LDS plastics were black because of the inherent color of black LDS additives. Now this restriction has also been lifted, as the innovative

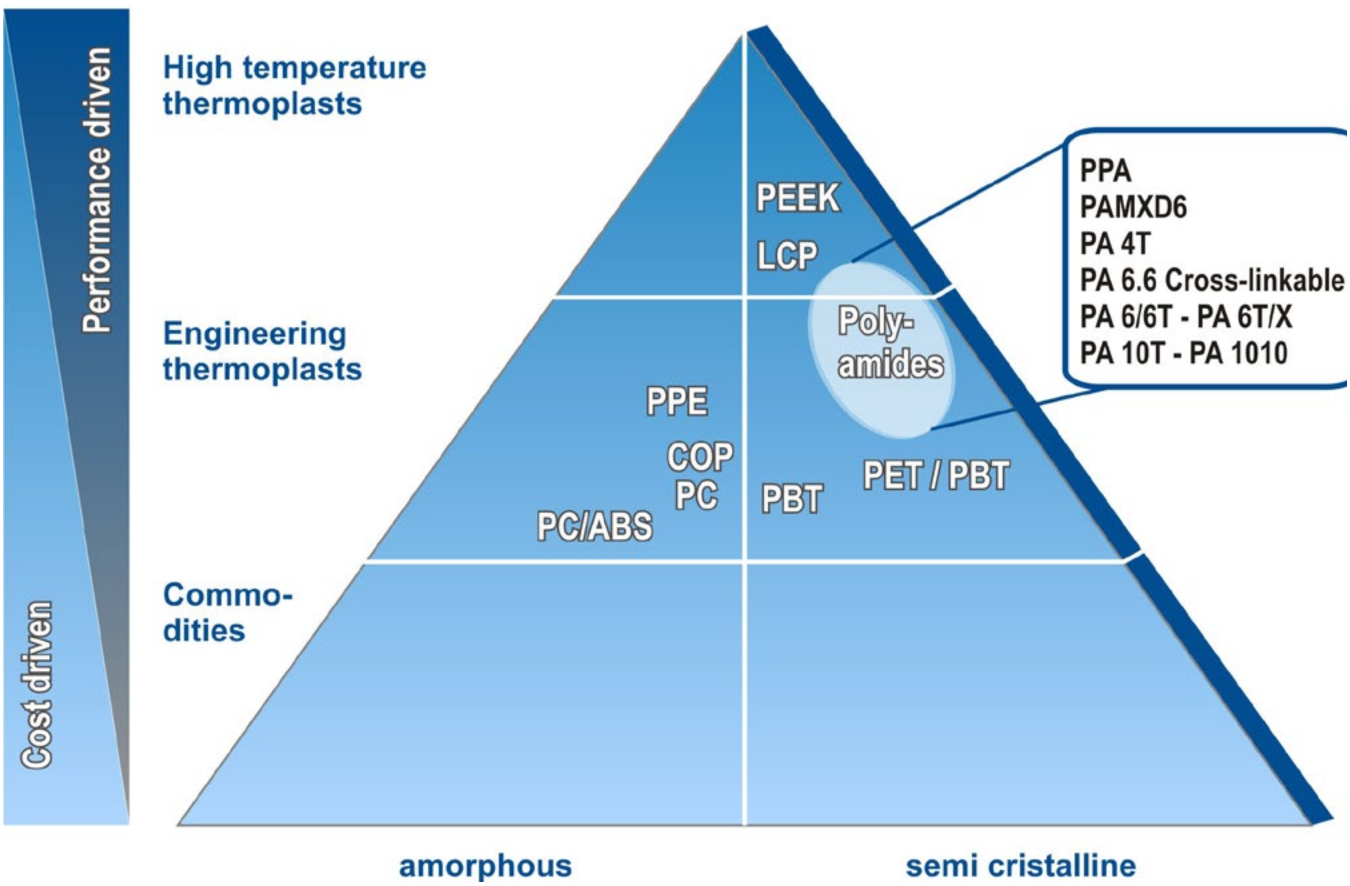

Figure 7: Plastic pyramid: almost all manufacturers offer their thermoplastics with LDS additive ex factory.

plastics units at SABIC and Mitsubishi Engineering Plastics (MEP) have both recently presented LDS materials which can be adapted to nearly all pigments that customers demand.

Design Rules

A complex procedure such as laser direct structuring of three-dimensional bodies requires some design guidelines for trouble-free and safe production. Here is an excerpt:

- The design should involve as few clamping and positioning steps as possible (short cycle times)
- Sharp-edged transitions should be avoided in the area of the structures to be metallized
- The recommended edge radius is 150 µm (100 µm is possible)
- Circuit paths must not be directly adjacent to walls. The steeper the wall, the greater the distance from the track should be. At a wall inclination of 45° a distance of 150 µm has been tried and tested, as has a wall inclination of 70° and distance of 250 µm

To facilitate the work of developers, LPKF provides a direct LDS interface in the MID module of NEXTRA. With this, 3D injection mold-

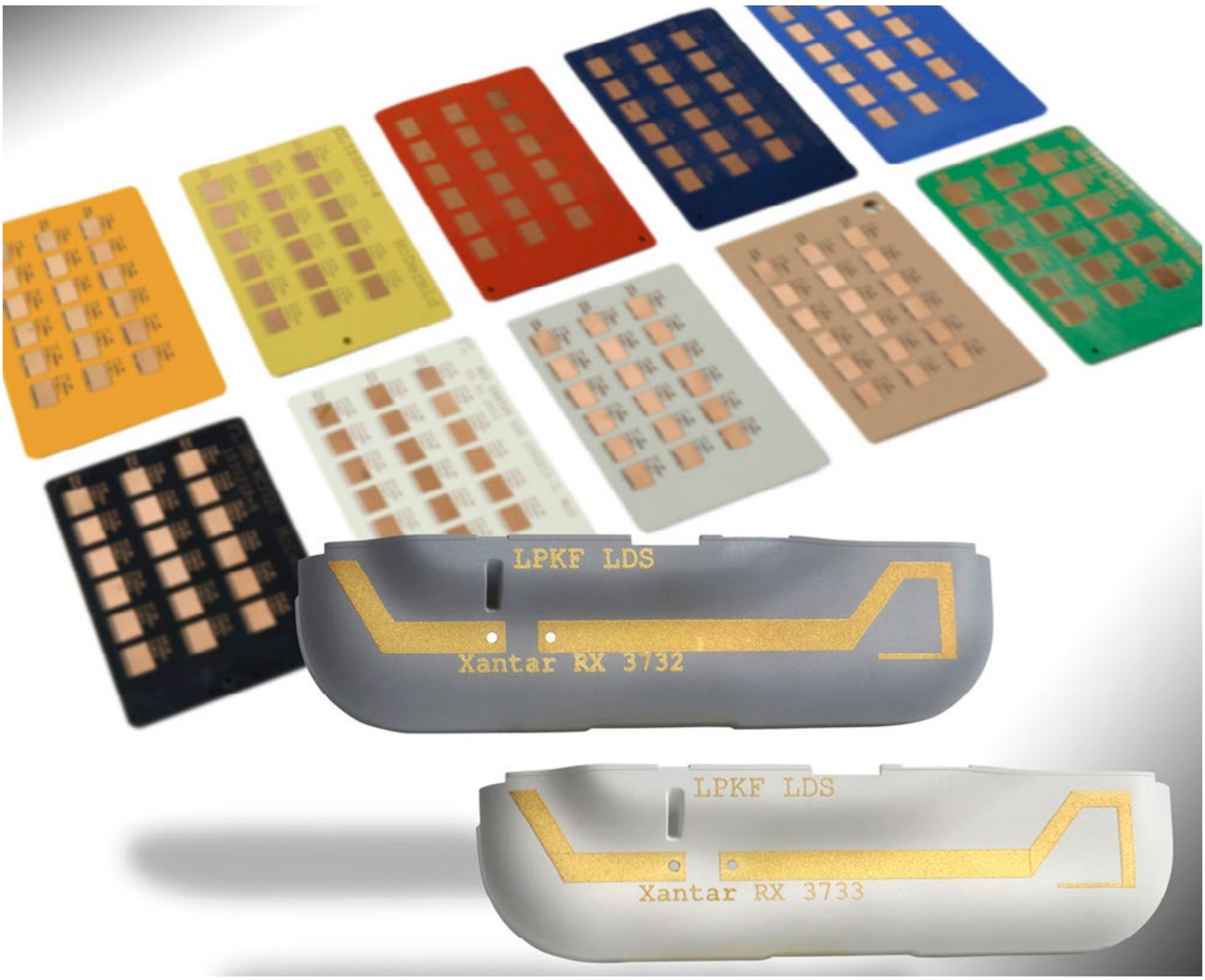

Figure 8: Colorful world of LDS using Xantar LDS from Mitsubishi Engineering Plastics (Source: MEPPR008, MEP).

ed bodies can be designed comfortably and equipped virtually with strip conductors and electronic components[1].

LDS prototyping

Between the layout of an MID part and series production there are several prototype stages —assembly studies or, more generally, to accelerate product development. Serial production prototyping had, until now, been either expensive or impossible. The two-component process, for example, requires expensive injection molding tools. Other technologies were limited to milled bodies or components produced by vacuum casting.

In generative manufacturing processed parts are generated layer by layer directly from CAD data and without the use of forming tools. The most important procedures are fused deposition modeling (FDM), selective laser sintering (SLS) and stereolithography (SLA). The range of plastics available for the different process technologies is expanding. Developers can therefore obtain MID prototypes with characteristics that are already optimized for later use.

The LDS prototyping presented by LPKF at the productronica 2013 was based on a special lacquer. It is used to coat the surface of a plastic body created by rapid prototyping. LDS laser-activatable additives are incorporated in the

Figure 9: After building up a body in rapid prototyping it is painted with ProtoPaint LDS. The laser transmits the projected circuit structures and metal layers are built up using an electroless bath.

lacquer LPKF ProtoPaint LDS. It is available as a simple spray can. This paint can coat almost any plastic surface with a laser-activatable coating.

LPKF ProtoPaint LDS considerably accelerates the prototyping of mechatronic components in conjunction with modern generative manufacturing processes. First, a blank is made and varnished with a layer thickness of about 30–40 µm. Very often, one step is sufficient for a homogeneous layer. The lacquer has to be hardened in an oven for approximately three hours. Afterwards, this component can be structured like a series part. The adhesive strength of the conductors after metallization is similar to plastic components made of LDS plastic.

The last step in the prototyping process is to metallize the plastic parts. In collaboration with Enthone GmbH, LPKF has developed a very simple solution: LPKF ProtoPlate LDS is a copper bath, which can be used without any prior chemical knowledge. Just put the copper bath into a beaker, heat it up to 42°C, add a vial of activator and put the structured parts into the bath. It is active for approximately two hours and can build up platings with a thickness between 3 µm and 10 µm.

This fully developed prototyping process fully closes the gap between layout and series production. It becomes very comfortable, quick

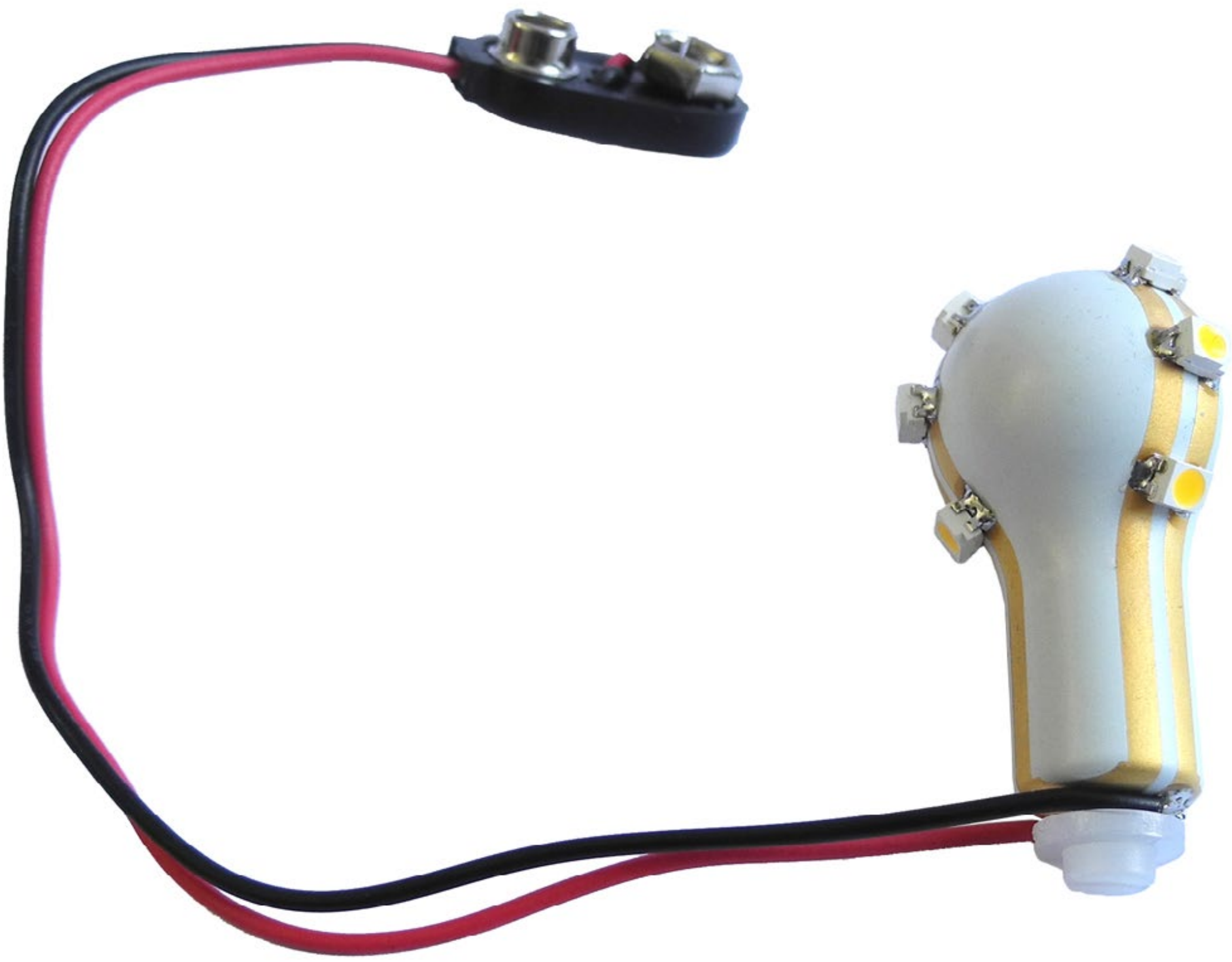

Figure 10: LEDs on a metal body, covered with LDS PowderCoating, etched by a 3D laser system, and metalized in a metallization bath.

and economical and uses the same technology as the mass production to follow.

Circuitry on Metal Parts

With two versions of an LDS-capable powder coating, three-dimensional metal parts can be turned into circuit carriers. New product layout possibilities enable any spatial arrangement of LEDs and offer good thermal properties, opening up opportunities for fields such as production of LED lights with the LDS powder coating.

With LPKF LDS PowderCoating, a metal base substrate, not an LDS plastic, is coated. Powder coating is ideal for metal surfaces such as steel or aluminum, but also works on electrically conductive plastics. The powder is applied in an electrostatic process, which guarantees a homogeneous coating of precisely controllable thickness.

The metal substrates assume mechanical functions, aid in heat dissipation, and serve as contacts for the electronic parts applied to them. The coated metal parts can be laser-structured and metallized in the same way that plastic parts are.

Powder Coatings: Two Versions

Two versions of LPFK LDS PowderCoating—PES 200 and PU 100—are available. The satin PES surface has been optimized for high mechanical stability, whereas the glossy PU 100 features more robust chemical and thermal properties. At the minimum coating thicknesses of approximately 80 µm and 60 µm, the two powders offer good dielectric strengths when tested using AC voltages greater than 4 kV. To ensure mechanical stability and adhesion there should be a minimum corner radius of 2 mm when PU 100 is used. The adhesion strength of the electronic components on the traces is 90–120 N, similar to the values found in FR-4 and other conventional circuit boards.

PU 100 is approved for soldering for a duration of five seconds at 270°C, whereas PES 200 is limited to 240°C for the same period. According to the results of preliminary tests, PU 100 is suitable for V-0 (UL-94) certification. Applications for certification have been submitted for both materials.

Both powder coatings are available in 2 kg (test sample) and 20 kg (series production) containers. LDS PowderCoating is neither a dangerous good nor a hazardous material and can be processed like a conventional powder coating product. **PCB**

References

1. Design rules are available for free download at www.lpkf.com.

Malte Borges is the press officer of product communication at LPKF.

3D Printers Create Custom Medical Implants

A team of researchers at Louisiana Tech University has developed an innovative method for using affordable, consumer-grade 3D printers and materials to fabricate custom medical implants that can contain antibacterial and chemotherapeutic compounds for targeted drug delivery.

The team from Louisiana Tech's biomedical engineering and nanosystems engineering programs collaborated to create filament extruders that can make medical-quality 3D printing filaments. Creating these filaments is a new concept that can result in smart drug delivering medical implants or catheters.

"After identifying the usefulness of the 3D printers, we realized there was an opportunity for rapid prototyping using this fabrication method," said Jeffery Weisman, a doctoral student in Louisiana Tech's biomedical engineering program. "Through the addition of nanoparticles and/or other additives, this technology becomes much more viable using a common 3D printing material that is already biocompatible. The material can be loaded with antibiotics or other medicinal compounds, and the implant can be naturally broken down by the body over time."