Laser Direct Structuring Methods offer freedom of design, miniaturization and precision in the manufacture of electronic components. But the possible applications for the components are determined primarily by the polymer used. There are various polymers to choose from.

The LDS method in four steps: Injection molding, laser direct structuring, metallization, mounting (photo: LPKF)

Looking for the Right Polymer

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There are electronic components that are too complex to be produced with conventional production methods. This is especially true when several features need to be integrated in a small space, the component has to be miniaturized or freeform design capability is a major consideration. This applies mainly to three-dimensional circuit carriers of the kind used in computers, medical devices, automotive electronics, cell phone covers or switch housings. Probably the best-known method for producing three-dimensional circuit carriers is laser direct structuring (LDS, developed by LPKF Laser & Electronics AG, Garbsen, Germany). It is one of a number of methods under the umbrella of molded interconnect device (MID) technology, which aims to integrate mechanical and electronic features in a single device.

The aim of the method is to incorporate circuitry into a housing. In LDS, an infrared laser beam generates a preliminary structure (micro-roughness) on the surface of the circuit carrier that matches the subsequent circuitry. The surface in this area is activated chemically and physically by a special additive in the polymer. Downstream metallization selectively creates firmly-adhering circuitry on the activated surface. The polymer used must therefore be tailored exactly to the LDS method.

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The Three Candidates

Electronic components are commonly made from polybutylene terephthalate (PBT), liquid crystal polymer (LCP) or polyphthalamide (PPA). These can differ widely in their properties, a fact which can significantly influence the potential applications of the components. PBT is an engineering polymer whereas LCP and PPA are high-performance polymers. Also within individual classes of polymer, there are differences. Thus, Evonik Industries, Marl, recently launched one of the newest generations of PPA under the brand name Vestamid HTplus. The company distinguishes between two grades: a PA6T/X offering increased heat resistance and a PA10T/X having particularly low water absorption. PA10T/X is moreover 50 % bio-based and is sourced in part from vegetable oil instead of petroleum.

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PPA versus PBT

There is a growing requirement to use lead-free solders in MID. For this, convection soldering or vapor phase soldering is frequently employed. However, the engineering polymer PBT and its blends are limited in their suitability for either method. Due to their relatively low melting points, the component would be damaged or even destroyed by the temperature peaks of up to 260 °C that occur in the solder bath. Accordingly, surface-mounted technology components (SMT) cannot be produced with PBT polymers under these conditions. For SMT components, the feature carrier is placed on the printed circuit board and fixed first, before being soldered.

There is another difference between PBT and the high-performance polymer PPA: PBT is a polyester and exhibits weaknesses in its chemical resistance. In this case, PPA provides a broader scope where process steps involve chemicals. This is where PPA's stress cracking resistance is hugely beneficial.

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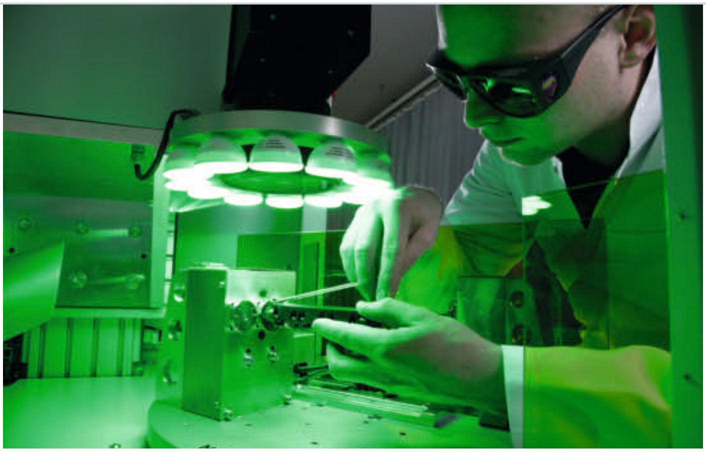

Fig. 1. Laser direct structuring with multiple lasers (photo: LPKF)

PPA versus LCP

Like PPA, LCP is a high-performance polymer. When PBT fails to provide adequate heat resistance, one of these two polymers is often chosen. PPA is usually more economical to use, partly on account of its lower density. This leads to commercial benefits specifically for SMT-based components. Vestamid HTplus therefore also closes a gap between PBT, which is often unsuitable, and LCP, its former alternative.

As for heat resistance, the advantages of LCP over PBT are similar to those of PPA. Direct comparison of PPA and LCP, however, reveals differences: First of all, PPA, as an unreinforced polymer, has greater toughness or impact resistance than LCP. This opens up scope for increasing the breaking strength of delicate parts for molding compounds based on PPA. When a cell phone falls on the floor, for example, it is the external connectors which experience the most stress. The good toughness of PPA would render the connectors more elastic and less vulnerable. Vestamid HTplus is ideal for realizing electronic components which are exposed to dynamic loads. And this property is useful not only in subsequent usage, but also during processing and assembly. The good ductility of Vestamid HTplus comes up trumps in snap-in tests.

PPA weld seams are comparatively strong. Consequently, it can be used for molded parts which withstand high mechanical and dynamic loads and whose weld lines have less adverse effects on the overall stability of the component. This is especially true in the case of "blunt" weld lines created by perpendicularly converging melt fronts.

PPAs are Not All the Same

There are differences between individual PPA compounds, too. The classic polyamide 6/6T on the market has a melting point of 290 to 300 °C, which is a little lower than that of Vestamid HTplus based on PA6T/X. The glass transition temperature of Vestamid HTplus is about 20 °C higher, at 125 °C. Operating temperatures in various application areas often exceed 100 °C, e.g. under the hood. Vestamid HTplus is the ideal material for long-term exposure to these temperatures, maintaining a high strength level over a wide temperature range.

Another known limitation of conventional polyphthalamide is its relatively high water absorption and associated dimensional and property changes. This can cause electronic components to fail. PA 10T/X from Evonik, however, has much lower water absorption and so offers twice the dimensional stability in comparison.

Turning Three into One

Overall, a whole swath of advantages speak in favor of using PPA – and especially Vestamid HTplus – in three-dimensional circuitry. The newly developed PPA, which has been qualified along with LPKF, is reinforced with glass fibers and mineral fillers. The good processability and thermomechanical properties of both materials ultimately allow for economic production of high quality components.

As a longtime member of the Forschungsvereinigung 3-D MID e.V., Evonik has been involved in the implementation of various research projects from the outset and will also be involved in the latest developments in the future **(Table 1).** ■

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Property	Vestamid HTplus M1000	Vestamid HTplus M3000	TGP 3586	TGP 3587
Melting range [°C] DSC 2nd heating	300–315	ca. 285	300–315	285
Vicat softening temperature Method A 10 N [°C] Method B 50 N [°C]	300	280	302 260	279 243
Dimensional stability when heated Method A 1.8 MPa [°C] Method B 0.45 MPa [°C]	126 235	128 230	– –	– –

Table 1. Comparison of the properties of two newly developed PPA products with TGP

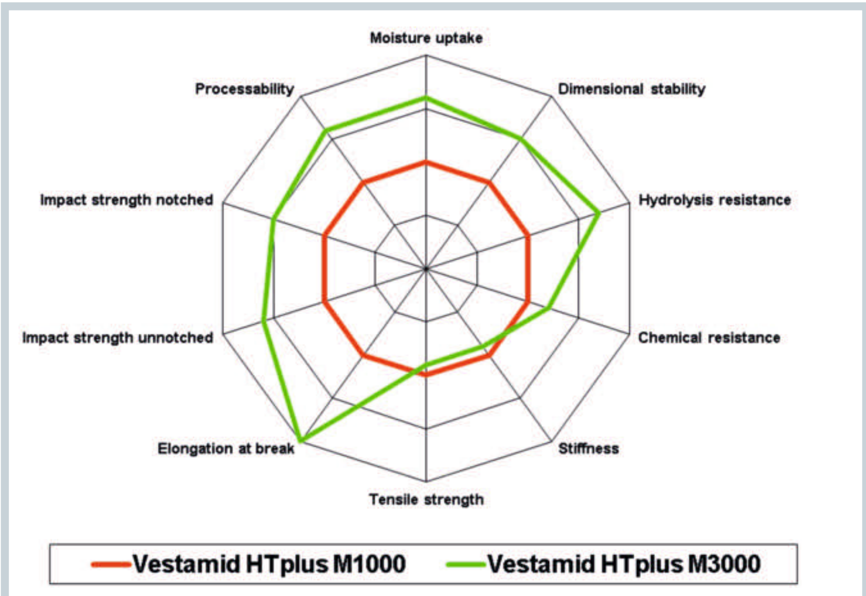

Fig. 2. Property diagram of Vestamid HTplus 1000 and 3000 (source: Evonik)

