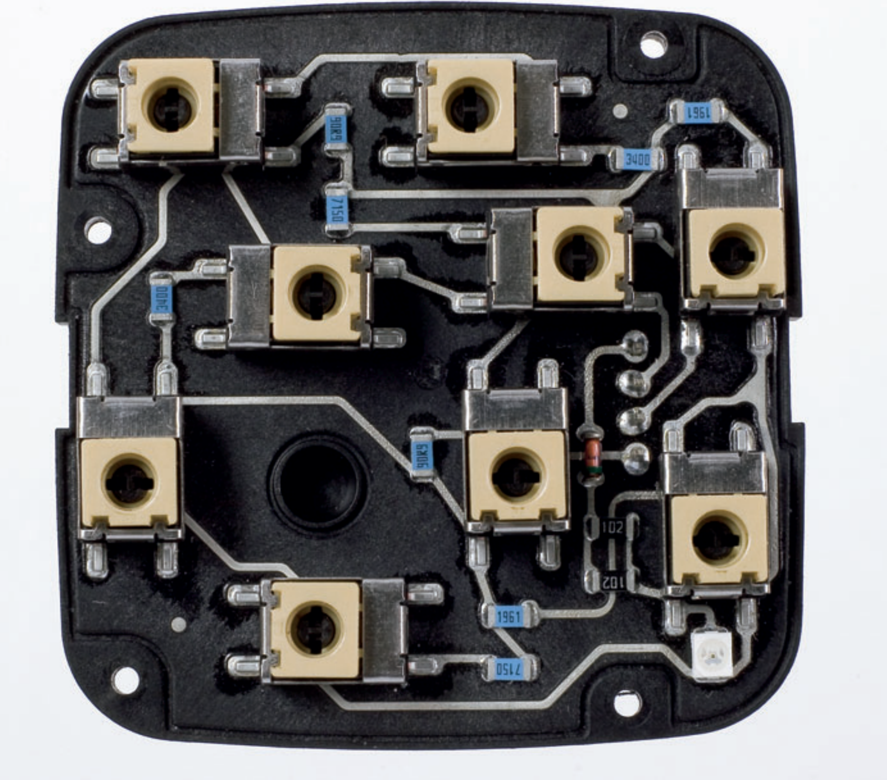

Lead-free soldered MID assembly made from high-temperature polyamide (part: Delphi)

Lead-free Soldering

High-temperature Polyamides. New high-performance polyamides allow manufacturers of electrical and electronic components to make their products flame-retardant without the use of halogens in compliance with the new legislation. At the same time, new materials based on polyphthalamide (PPA) permit economic soldering processes, which can also be carried out without defects at the significantly higher temperatures required under lead-free conditions.

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Polyamides occupy an importance place in the electrical/electronics industry because of their balanced property profile. In particular, their electrical insulating properties, high tracking resistance, excellent dimensional stability under heat, high glow wire ignition temperature and effective flame retardant systems make them indispensable moulding materials for this sector.

Last but not least, the suitability of polyamides for rapid and economic processing into complex parts without secondary finishing and their long service life are also compelling reasons for the widespread use of this material class. Reinforced and unreinforced polyamides are used in housings and components for electrical appliances, switches and connectors.

High-temperature polyamides (e.g. polyphthalamide PPA) have now also found their way into electronic components that must be soldered. These include connectors, microswitches and microsensors, and even semi-conductor components such as the reflector housings of light-emitting diodes (LED). The widely used surface mount technology (SMT), which is the preferred assembly method, and associated reflow soldering require materials with extremely high dimensional stability under heat.

Changed Specifications Necessitate a Rethink

The European WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of Hazardous Substances; Fig. 1) Directives passed in 2003 and the household appliances standard (IEC 60335-1), which has recently been

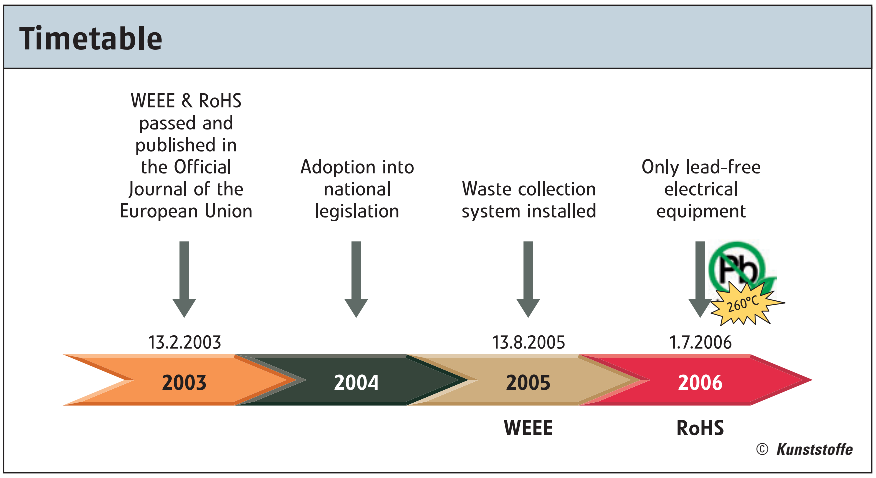

Fig. 1. Timetable for implementation of the European WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of Hazardous Substances) Directives

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tightened up, are creating a stir in the electronics industry because these statutory regulations are compelling appliance manufacturers and their suppliers to rethink material selection. After adoption in national legislation, WEEE and RoHS will become effective by July 1, 2006 at the latest.

The first EU Directive, WEEE, favours halogen-free flame retardant systems. Since responsibility for cost-free take-back and recovery of waste equipment now passes to the manufacturers, they are trying to avoid the increased costs that will be incurred by the requirement for selective recovery of halogen-containing plastics. The second EU Directive RoHS aims to ban the lead which is used in soldering pastes to reduce the soldering temperature.

The household appliances standard (IEC 60335-1) is raising the hurdle for glow wire testing of current-carrying parts in unsupervised household appliances and now specifies a very challenging GWIT (Glow Wire Ignition Temperature) of 775 °C. This will cause particular problems for flame retardant systems based on red phosphorus.

Materials for use in the electrical/electronics sector must now have completely new property profiles, depending on the application. This affects both their constituents and level of heat resistance. Through the use of lead-free alloys, soldering temperatures, for example, will have to be increased by about 30 °C to 260 °C. Many of the materials previously used in industrial-scale manufacture no longer satisfy requirements and must be replaced.

Regulation-compliant Material Solutions

For these applications, Ems-Grivory, Domat/Ems, Switzerland, has developed thermoplastic materials based on polyphthalamide (PPA) that enable users to manufacture regulation-compliant products. The new PPA, marketed under the trade name Grivory HT XE 3876, is flame-retardant and free from halogens and red phosphorus.

The material is already approved for fire protection classification UL 94 V-0 down to a wall thickness of 0.35 mm. This rating is important for applications such as circuit breakers and connectors, and also for thin-walled coil bobbins (Table 1). Initial tests have shown that the material even satisfies the stricter conditions of UL 94 5V A at certain wall thicknesses. It also has a comparative tracking index (CTI) value of 600 V (class 0), which is significantly higher than the CTI of typical LCP or PA 46 materials.

For safety reasons, the glow wire ignition temperature for unsupervised appliances has been considerably increased in the new household appliances standard (IEC 60335-1). The GWIT value of 775 °C now specified is attained by the new Grivory materials. For special requirements, grades with 40 and 50 % glass fibre reinforcement are available in addition to the standard 30 % glass-fibre-reinforced product.

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Reflow soldering

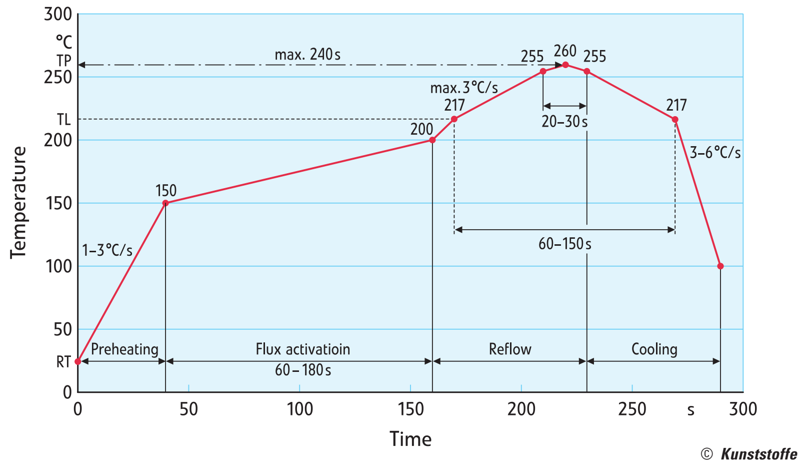

Fig. 2. Typical lead-free reflow soldering profile for surface mount technology (SMT)

Colour	Wall thickness [mm]	Flammability class	RTI elec. [°C]	IEC GWIT [°C]	IEC GWFI [°C]
All	0.35	V-0			
All	0.75	V-0	150		
All	1.0	V-0	150	775	960
All	1.5	V-0	150	775	960
All	2.0	V-0	150	825	960
All	3.0	V-0	150	825	960
Comparative Tracking Index (CTI) class 0 (600V)					

Table 1. Overview of the characteristic data required for the use of the PPA Grivory XE 3876 in electrical and electronics applications (corresponds to the UL Yellow Card)

In Competition with LCP

The most economic and by far the most widely used soldering process is reflow soldering associated with surface mount technology (SMT), in which the circuit boards fitted with SMT components are passed through a series of heating zones (Fig. 2). In contrast to wave soldering, the components and their plastic housings are exposed to the same temperatures as the metal contacts being soldered.

The solderability of electronic SMT components is normally validated in accordance with standard IPC/Jedec J-STD-020-C. In this standard, the components are classified by moisture sensitivity levels (MSL), i. e. the level of moisture at which under standard soldering conditions no cracks due to moisture absorption are formed (known as blistering, popcoming or delamination). The standard distinguishes eight MSL classes, which each correspond to a so-called (out of bag) floor life under specified conditions. Experience in many different applications has shown that components

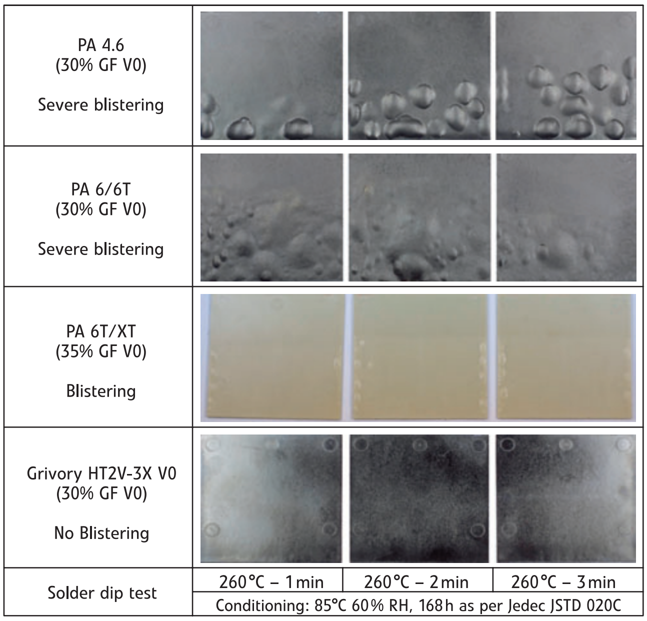

Fig. 3. Results of a solder dip test to determine the blistering behaviour of four high-temperature polyamides

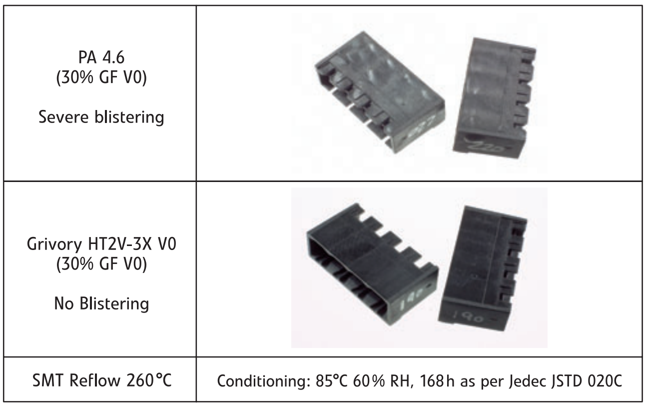

Fig. 4. Results of a blistering test with SMT reflow soldering technology on a connector housing

produced from Grivory HT attain the second-best class (MSL2). For MSL2 suitability testing, the test specimens are stored in a climatic test chamber for 168 h at 85 °C and 60 % relative humidity and then tested at temperatures of 260 °C. According to Jedec, this corresponds to an unpacked storage life (floor life) of one year at an ambient temperature of 30 °C and 60 % relative humidity.

In the solder dip test, material specimens are first conditioned and then dipped in a soldering bath. To test the new PPA materials in comparison with three other high-temperature polyamides (Fig. 3), the specimens were heated to 260 °C, which is the soldering temperature for lead-free solder. Conditioning was carried out in accordance with the specifications described for the MSL2 classification.

The tests clearly showed that Grivory HT XE 3876 was the only material not to exhibit blistering. Some of the other specimens had substantial damage. The reason for this is easy to deduce in the case of PA 46, for example, since this material can absorb considerably more moisture. In contrast to many other materials, however, Grivory HT XE 3876 can be soldered without blistering over a very wide temperature range (Fig. 4).

In the high-temperature solderable materials sector, PPA from Ems-Grivory is also competing with LCPs, which are known to have high thermal stability and very good flow properties. However, the new PPA material offers a significant price advantage, which fits well with the present cost-cutting programmes that many manufacturers are implementing. In the past, components were often produced from LCP because, in terms of solderability, few alternative materials existed. Now it is possible in numerous cases to cover the same applications equally well with a new material, while obtaining additional cost and design benefits. Examples of such applications include coil bobbins, SIM card components and connectors (Table 2).

Better High-temperature Performance

The high heat deflection temperature (HDT/A 280 °C) of PPA ensures its suitability for challenging processes and applications. Both the flame-retardant and non-flame-retardant materials in the HT range demonstrate high dimensional stability in practice.

Grivory HT XE 3876 achieves a remarkable relative temperature index value (RTI elec.) of 150 °C (Table 1). This RTI value is defined in UL 94 as the maximum service temperature at which the critical electrical insulating properties remain within acceptable limits for an extended period of time.

Applications using PPA materials also benefit from the good chemical resistance of this material class and its good flowability, which makes it suitable for thin-walled parts.

Halogen-free flame-retardant PPA grades have a lower density and better elongation at break than halogenated grades. The latter property is particularly important in connector pin stitching.

More Economic for Individually Tailored Applications

The excellent high-temperature properties of the Grivory HT grades, due to their partially aromatic structure, coupled with modern flame retardant systems, make

General-purpose grades High temperature applications UL94 HB	**Connectors, coil bobbins, component housings** UL94 V0 bei 0.35 mm	**Special grades LED reflector housings** UL94 HB
HTV-3H1 (PA6T/6I 30%GF)	XE 3876 V0 (PA6T/66 30%GF)	FE5643 (PA6T/6I 33%GF)
HT2V-3H (PA6T/66 30%GF)	XE 3902 V0 (PA6T/66 40%GF)	FE5683 (PA6T/6I 33%GF)
	XE 3903 V0 (PA6T/66 50%GF)	

Table 2. List of PPA materials suitable for different high-temperature applications involving SMT soldering

them ideal candidates for challenging electrical and electronic applications. They can open up market segments that were previously the domain of far more expensive, inherently flame retardant thermoplastics. In this sector, plastics processors will gain cost benefits and can also cover additional speciality applications and requirement profiles by individual product tailoring, e. g. with varied GF reinforcement.

In addition to all the advantages detailed above, these materials comply with the legislative requirements specifying the use of halogen- and phosphorus-free plastics in electrical and electronic equipment, which will finally take effect in the coming year. ■

THE AUTHOR

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