Diode Lasers. The great range of combinations of plastics in association with a steadily growing diversity of colors is constantly followed by advances in laser welding technology. The joining process is now usable in almost all common sectors.

The diode laser covers the entire joining process in transmitted beam welding (photo: Prolas)

Diversity in Joining

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No joining technology is developing as fast as the laser welding of plastics. The process makes it possible to eliminate working steps, improve quality and reduce costs and ensures not only process reliability but also reproducibility.

In industry laser welding for joining plastics was first introduced at the end of the 1990s. The first industrial series application related to remote-control keys for the automotive sector. The high level of confidence industry now has in laser welding may be demonstrated with reference to a simple example from Prolas GmbH, Würselen, Germany. In three series products over 25 million parts per year are joined in this way for a large European automobile manufacturer.

Process Workflow and Variations

The laser welding of plastics is based on the simple principle that under the effect of energy supplied by a laser and pressure the plastics merge with one another at the joining point to form a hybrid structure. In the case of classic transmitted beam welding the parts to be joined must exhibit certain properties: one thermoplastic mating part must be transparent to the laser beam and the other must consist of an absorbent thermoplastic. In transmitted beam welding the laser beam passes through the transparent plastic. As soon as the beam strikes the absorbent layer the energy introduced is converted to heat. The layer then fuses together with the transparent plastic fitted against it. Under pressure an integral joint between the mating parts is produced.

Fig. 1. In this laser welding unit the process variants of simultaneous and contour welding can be combined; a possible application is the watertight joining of functional electronic components

To date numerous variants of the process have been developed (Fig. 1). Simultaneous welding allows simultaneous fusion of the entire welding seam by means of individual diodes having one or more lasers. In quasi-simultaneous welding the laser beam is guided with the aid of scanner mirrors at high speed along the weld contour several times a second. In contour welding even difficult weld seam geometries and 3-D contours can be mastered in that the weld seam is traversed sequentially by a focused laser beam.

Both quasi-simultaneous welding and contour welding are the methods most frequently used. The trend towards these two variants became apparent quite early and has persisted continuously up to the present time (Table 1).

Combinations of Material and Color

Originally only thermoplastics could be welded to one another. Now thermoplastic elastomers (TPEs) can also be com- ▶

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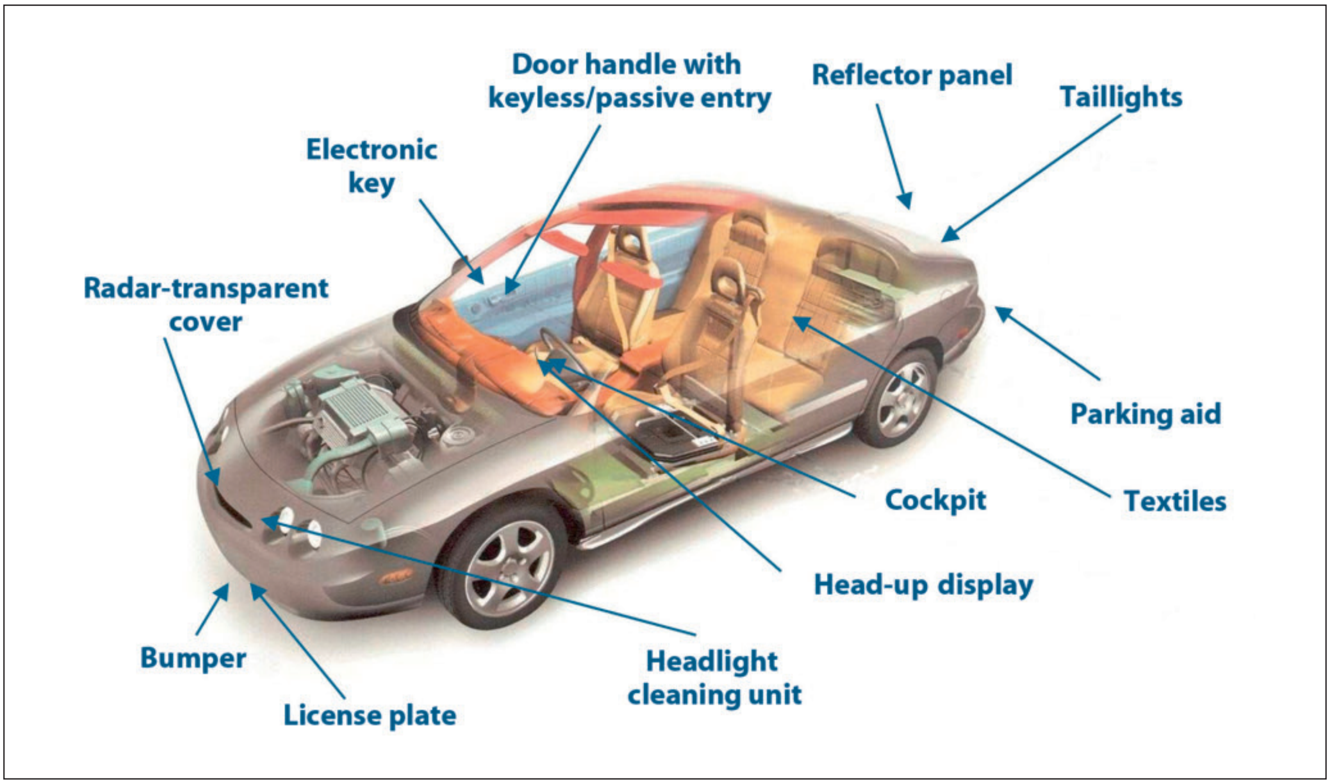

Fig. 2. Laser technology is already used for exterior and interior applications in automobiles (source: AVR – Allgemeiner Vliesstoff-Report)

bined with thermoplastics or with other TPEs. Such pairs of materials, however, are employed much more rarely in industry.

The welding of thermoplastics to metals is coming to the end of the trial phase and the first industrial implementations will soon follow. For example, in joining plastic to metal laser-transparent plastic is indirectly heated via the metallic material. On fusion the thermoplastic then encloses the metal to form a strong durable joint.

A key focus of current development is the combination of different types of thermoplastics that are incompatible, such as joining polypropylene (PP) to polybutylene terephthalate (PBT) or polyamide (PA). The aim is to employ these expensive and high-grade plastics only selectively in accordance with actual requirements and in other areas to substitute them by less costly ones. To achieve this objective advances in laser technology are essential. The automotive industry in particular is showing great interest here and is supporting this trend which is associated with enormous potential for cost savings. There is widespread documentation of the broad range of combinations of materials already possible.

Apart from the different materials, ever more combinations of colors are being welded by means of lasers. For years combining colors has been one of the challenges in development. In addressing this initially in the research phase, first welding successes were achieved in combining natural with black using the classic approach of transmitted beam welding. When laser welding of plastics was first introduced into series production the combinations natural-black and black-black were possible.

The welding of uncolored, highly transparent plastics, such as polymethyl methacrylate (PMMA), acrylonitrile-butadiene-styrene (ABS) or polycarbonate (PC), by means of the diode laser was a challenge. As a result of advances in laser technology and the use of new wavelengths it was possible finally to weld these plastics also, and immediately applications for the new welding variant were found in the field of medical technology.

In the meantime even colored plastics can be welded to one another. New combinations of colors are constantly becoming available for laser welding so that scarcely any limits are set to color design. A new trend in the application of laser

	Simultaneous welding	Quasi-simultaneous welding	Contour welding
Component size	small – medium	small – medium	small – large
Piece numbers	medium – very high	small – high	small – high
Flexibility (range of variants)	very flexible	flexible	not very flexible
Complexity, design	complex (2-D)	complex (2-D)	very complex (3-D)
Attainable tolerances	high	medium – high	medium
Laser	diode laser	Nd:YAG and diode laser	Nd:YAG, diode or fiber laser
Fusion path	yes	yes	no
Process monitoring	yes	yes	yes (also locally)
Quality assurance and monitoring	yes	yes	yes (also locally)

Table 1. In an overview production-related characteristics of three variants of transmitted beam welding are listed in more detail

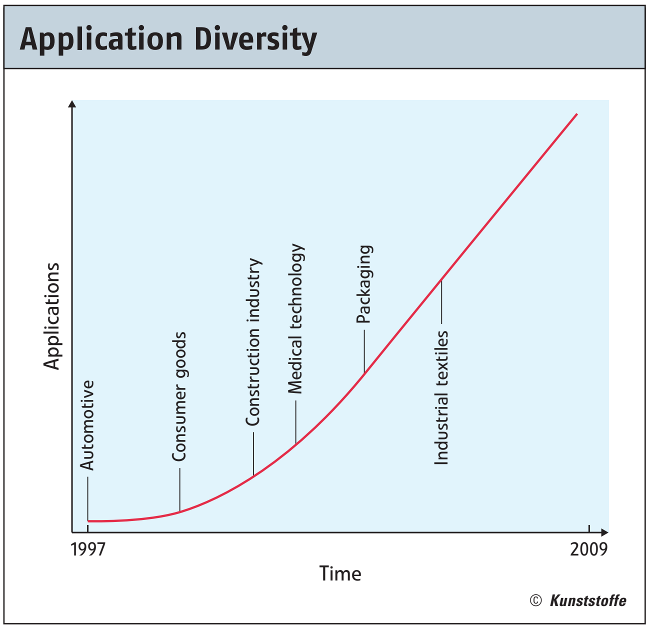

Fig. 3. Since 1997 the diversity of fields of application of laser welding has been growing steadily

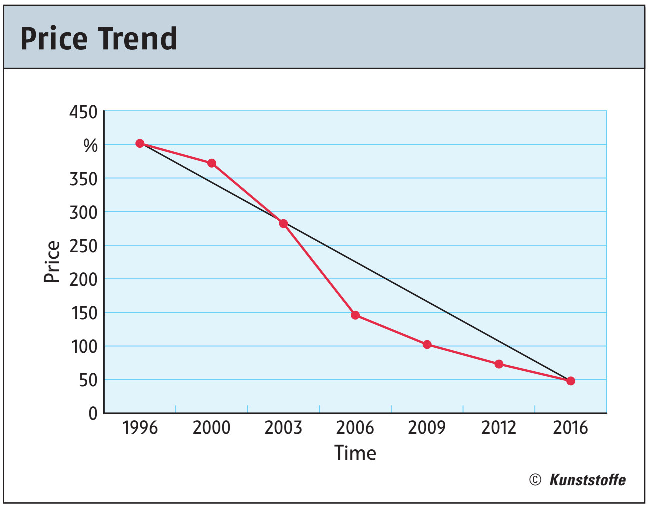

Fig. 4. Ten years ago a diode laser cost four times as much and the price continues to fall as power increases

technology is in decorative design. Here the weld seam is integrated into the actual design so that the color combinations play an important role in the decoration itself.

State of Developments

Although the first implementation of laser welding was developed for the most part by a university institute, in the meantime almost exclusively specialized and qualified companies are working on further applications.

In the series production of remote-control keys this innovative technology was profitably employed by Marquardt GmbH, Rietheim-Weilheim, Germany, so that this joining method quickly gained general acceptance in other production systems and companies.

Currently the laser welding of plastics is used in the automotive industry for both exteriors (e.g. reflector panels, bumpers, door handles, taillights and parking aids) and interiors (e.g. in the driver's area, in seat covers, linings and the head-up display) (Fig. 2). The process has also been successfully used for years in other sectors such as packaging, consumer goods, medical products, construction and textiles (Fig. 3).

Apart from the technical advantages of laser welding the changing price of diode lasers has also contributed to the fact that this process has enjoyed such headlong growth. In 1996 the cost of a 800 W laser was four times the current price. Due to increases in the power of diodes a marked fall in price of a further 30 to 60 % with respect to today's level is also expected in the next few years (Fig. 4).

Conclusion

The great diversity of combinations of colors and materials is appreciably extending the range of process variants and hence allows the deployment of laser welding in almost all common sectors. As soon as plastics are employed and value is placed on leak-proofness, strength, pinpoint accuracy of energy delivery, efficient production with high process reliability and reproducibility, laser welding could be an alternative to current joining methods. The experience gathered over the years in the field of the laser welding of plastics in association with innovative know-how make it possible to deliver solutions from concept via process development through turnkey installation. ■

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