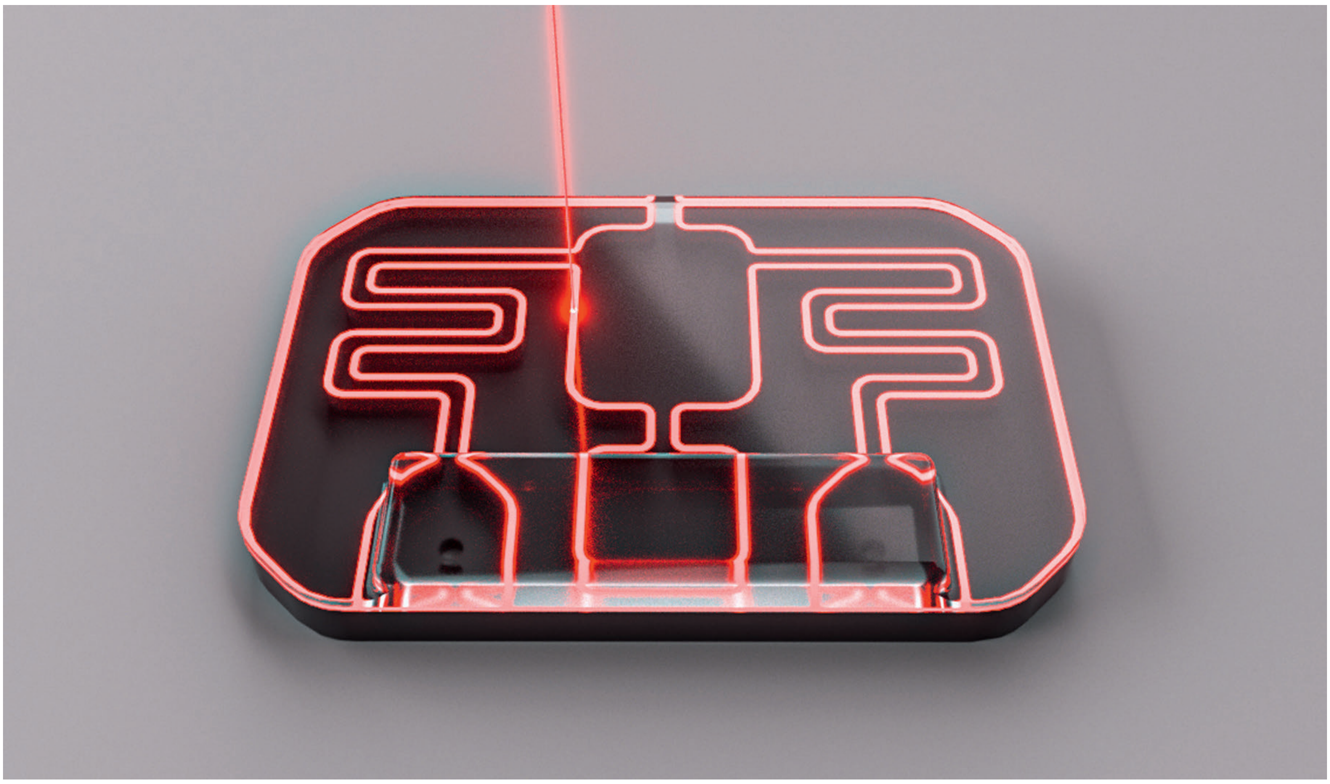
Laser Polymer Welding

Welding in Mind When Designing a Product

Laser polymer welding offers several advantages over other joining methods, but implementing it right requires an understanding of the technology, and often benefits from discussions with a knowledgeable equipment supplier early on in the product development cycle.



In quasi-simultaneous welding, the laser beam is scanned rapidly over the entire weld path in order to melt it all at once (simultaneously).

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The increasing use of polymer parts, especially in high precision products, is driving manufacturers to look for joining technologies that offer better welds, increased production throughput and reduced costs. Laser polymer welding promises to deliver in all of these areas. But, getting a laser process implemented so that it consistently produces optimum results and minimizes cost requires an understanding of the technology. And, it is often helpful to partner with a vendor that is expert with it as early as the product design phase to accomplish this. This whitepaper reviews the basics of laser polymer welding and outlines some of the key issues that should be considered before starting production.

Promise and Challenges

Polymers offer several unique characteristics and advantages over other materials. These include a high strength-to-weight ratio, mechanical flexibility, corrosion resistance, biocompatibility, electrical and thermal insulating ability, and even optical transparency in some cases. In terms of manufacturing, polymer parts can often be produced using various molding techniques. These methods offer high production throughput and low unit cost.

All this has led to greater use of polymers in areas as diverse as packaging, automotive production, microelectronics, and medical devices. A common requirement across many of these appli-

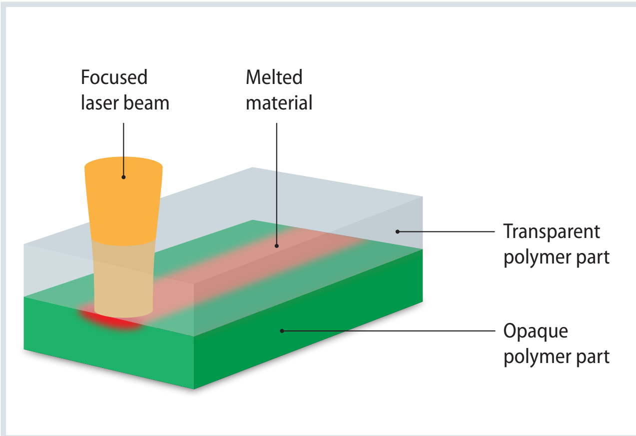

Fig. 1. In transmission laser welding, a laser beam passes through a clear plastic part and is absorbed by an opaque part beneath it. This heats the bottom part and melts it to weld the parts together. Source: Coherent; graphic: © Hanser

cations is for joining of two or more polymer parts during product assembly. For applications involving sophisticated products, such as medical implants and electronic sensors, this joining must be accomplished with high mechanical precision, minimal particulate debris production, and excellent bond strength.

For volume production, this is usually done using some kind of welding, rather than simply gluing. This is because welding can usually be performed much faster and more accurately than adhesive bonding, and makes a stronger and more reliable connection.

There are numerous different polymer welding methods in use. Usually these involve selectively melting the material using applied heat, through friction or vibration, or even by the use of chemical solvents. Each of these techniques has its advantages and uses.

Laser polymer welding has become increasingly popular for the most demanding applications because it delivers a unique combination of advantages (**Table 1**).

Laser Polymer Welding Basics

Laser polymer welding utilizes a laser as the heat source to melt the material. There are many different ways this can be implemented depending upon the materials being joined, the specific requirements of the application, and various production considerations such as cost or speed.

One of the most useful and commonly employed techniques is called "through transmission laser welding" (TTLW). This method involves joining one part made from transparent plastic to another which is opaque. In this instance, "transparent" and "opaque" specifically refer to whether or not the parts absorb or transmit the wavelength of the laser being used, as opposed to being visually transparent or opaque (**Fig.1**).

There are several different ways that TTLW can be performed depending upon the part size and shape, the required throughput speed, the desired weld quality and characteristics, as well as other factors. One of the most useful and versatile of these methods is called quasi-simultaneous welding.

In quasi-simultaneous welding, the two parts are either clamped together or brought into direct contact, with the clear part on top. The laser is focused in through the clear part, and down towards the opaque one. The opaque polymer absorbs the laser light, heats up and melts. The heat from it also melts some of the clear part.

The laser beam is rapidly scanned to trace out the pattern of the desired weld seam. Typically it is scanned over the pattern numerous times, and has the effect of melting the entire weld path simultaneously (hence the name). After the entire weld path is molten, the laser is turned off, and the melted material quickly resolidifies to form the weld joint.

Quasi-simultaneous TTLW is a fast, versatile method that provides excellent bonds and high production throughput. It is most useful for welds seams that are entirely in a single plane (flat), or have minor height changes.

Works without Tight Tolerances: Collapse Rib Method

One particular part configuration frequently used for quasi-simultaneous TTLW is called the "collapse rib" method. Here the bottom part has a thin protruding rib which mates into a corresponding groove in the top part. However, the groove is a bit wider than the rib.

The bottom rib is partially melted by the laser during welding while clamps actively press the two parts together. Some of the bottom rib becomes molten, and this material flows and fills some of the gap between the top »

Precision	Highly localized application of laser energy produces little or no part distortion, delivers tight dimensional tolerances, and can be used with complex shaped parts.
Repeatability	The laser process is inherently highly consistent and can be closely regulated with process monitoring equipment.
Weld quality	Weld seams are narrow and cosmetically excellent (no flash), and post processing is rarely required.
Strength	Laser welding delivers a strong weld, which is free of gaps, and can provide hermetic sealing.
Contamination	Laser welding does not use filler materials, and produces virtually no debris.
Speed	The process is fast and well and lends itself to automation.

Table 1. Advantages of laser polymer welding. Source: Coherent

and bottom parts. This then resolidifies to make the weld joint (**Fig. 2**).

This particular embodiment of TTLW is especially useful because it delivers a good weld joint even if the parts are not perfectly flat or tightly toleranced. Moreover, the "collapse height" – that is, the amount that the top part moves down during the welding process – can be monitored and used for closed loop process control. This enables very consistent results in volume production, even in the presence of part-to-part variations in dimensions or material absorption of laser energy. It can even compensate for changes in laser output power or focused laser spot characteristics.

Criteria for Successful Transmission Laser Welding

When using transmission laser welding of polymers, some details have to be considered. Some of them have to be regarded already in the product development or before starting production:

- **Material selection:** It is essential that there must be some temperature range over which both polymers (clear and opaque) will remain molten (but not decompose) for the method to work. The greater this overlap, the wider the process window. And, a wider process window makes production easier and more robust. **Figure 3** summarizes which common polymer combinations are compatible with laser welding.
- **Design for manufacturing:** For example, implementing the collapse rib method requires a part design having sufficient space in the appropriate location for the clamps to engage during welding, while also permitting unobstructed access to the entire weld path for the laser beam.
- **Dimensions and shapes of the rib and groove:** They must also be chosen to provide enough material for the welding process and to accommodate the melt flash that is produced. In addition, it is necessary to design the parts to allow for a sufficient collapse height. For high precision applications, alignment features, such as locating pins, may have to be incorporated into the part design. The goal is to achieve a strong weld and good weld cosmetics, while eliminating the need for post-processing to trim or remove flash.
- **Process development:** Picking the right laser source for the polymer materials to begin with, determining the optimum laser operating parameters, and identifying what process variables must be monitored or controlled to achieve the desired yields. There may also be various practical issues in terms of part handling, the mechanical and software interface of the polymer welding system with other production equipment, and, of course, cost of ownership.

Service Providers Support System Configuration

The simplest way to address all these factors is to partner with a supplier who can provide applications development assistance. Specifically, this means finding a vendor who can run tests to determine what system configuration will yield best results, and perhaps even help identify the optimum laser parameters for the production process. Coherent Labs provides precisely that service, and Coherent also produces laser polymer welding systems that are readily integrated into production environments.

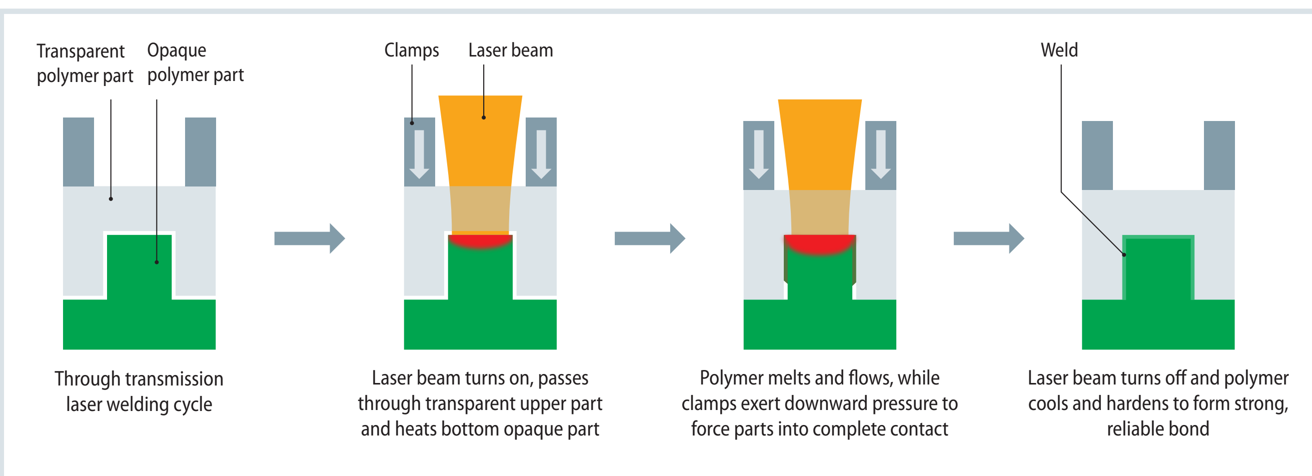

Fig. 2. Schematic of the major steps in the "collapse rib" method of quasi-simultaneous TTLW. Source: Coherent; graphic: © Hanser

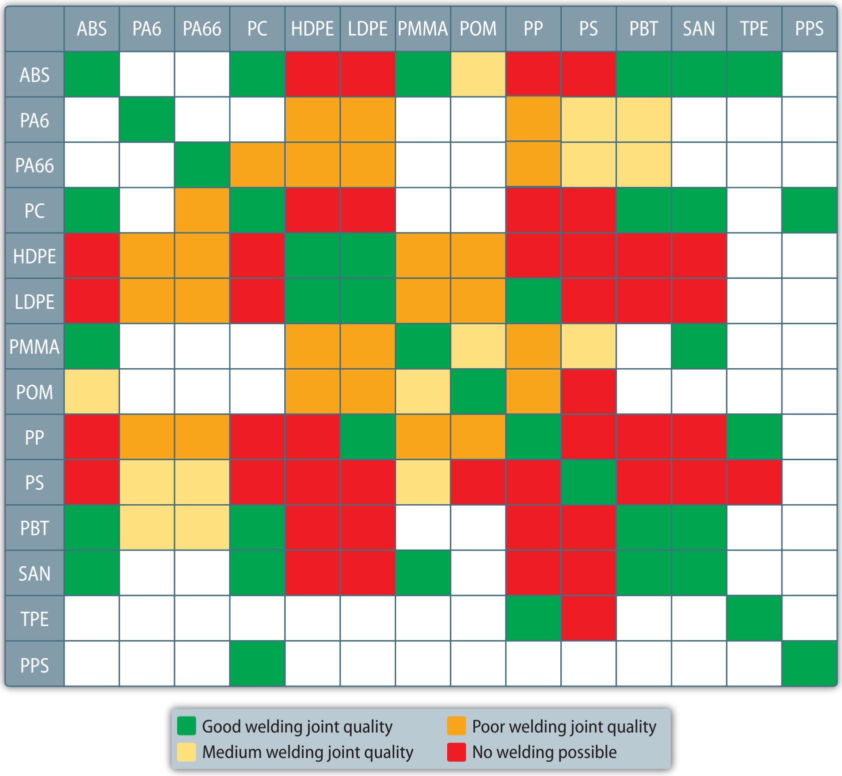

Fig. 3. Material combinations which are compatible with TTLW. Source: Coherent; graphic: © Hanser

Conclusion

In conclusion, laser welding enables precision joining of polymer parts, and is a cost-effective method over a wide range of production volumes. It can help deliver on the promise of polymers to lower cost, save weight, and provide advanced functionality in a wide range of products. ■

Info

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Color Masterbatches

Laser without Color Loss

New or revived trends and styles are constantly emerging both in the packaging and in the design of containers for the cosmetics industry. A metallic look and decorative design using lasers have been very popular for some time. To meet this demand, Rowa Masterbatch includes optimized raw materials in its portfolio. The company offers color masterbatches that ensure metallic looks and laser possibilities without any loss of quality.

Laser marking has become a popular method of identification because of its many advantages: laser markings are more stable and more permanent than pad printing, for example. They can be used on a wide variety of surface structures and shapes, even curved designs, and they are abrasion and weather resistant, lightfast and resistant to chemicals. A further plus point of laser marking is the flexibility that templates can be created quickly and various layouts are possible.

In addition to marking, using lasers for decorative purposes is currently in high demand in many industries, especially for packaging and in the cosmetics sector, where metallic looks are very fashionable.

The laser treatment of metallic-looking surfaces used to be associated with a loss of quality, as the laser additives that were required made the metallic look less shiny until now. Rowa Masterbatch has developed different color masterbatches that replicate a metallic surface extremely well. They can now be lasered without loss of quality, maintaining the rich, brilliant color tone with a shiny metallic look – not only for light-dark color changes, but also for bright colors with a metallic appearance.

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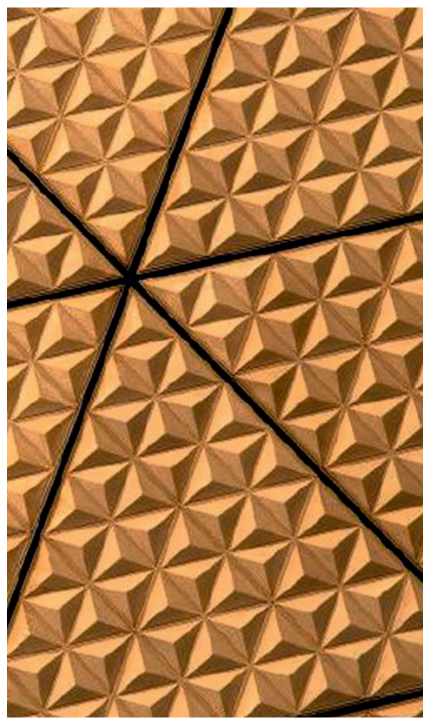

Metallic surfaces are very popular for personal care products and packaging. The fact that they can also be lasered without any loss of quality is ensured by a specially developed masterbatch. © Rowa Masterbatch