

## Application note: Fiber Laser Welding of Plastics

Fiber lasers have now matured into exceptionally reliable and stable industrial tools. These lasers have unique capabilities that enable a wide range of high quality micro-machining processes; of interest here is their ability to produce high quality welds between plastics. Many different methods of plastic welding have been found since the need to join plastic parts became of great importance. Methods like vibration, linear/orbital, ultrasonic, spin, and hot plate welding have been used but with the development of the fiber laser, it has been noticed that laser welding is very efficient, precise and time saving. Several methods of making plastic welds with fiber lasers are: Contour Welding, Mask Welding, Simultaneous Welding, Quasi-simultaneous Welding, Globo Welding, and Radial Welding.



Figure 1: © bielomatik Leuze GmbH + Co KG.

### How laser welding of plastic works (IR wavelength)

In this process, the two layers, to be joined, must differ in such a way that the top one allows the infrared light to pass through while the bottom layer absorbs it in order to allow a heating effect to occur. The following picture gives a better illustration of the procedure.

#### Transmission Welding:

- 1: Transparent Joining Partner
- 2: Absorbing Joining Partner
- 3: Fiber laser beam
- 4: Melt Zone
- 5: Weld Seam
- 6: Clamp Pressure

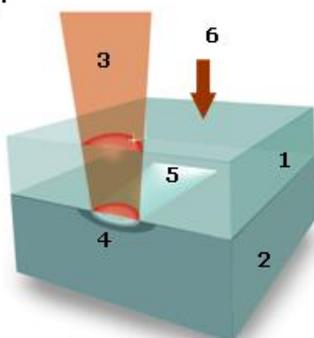


Figure 2: Transmission welding procedure.

### Contour Welding

In contour welding, the laser is guided along a prearranged welding pattern, melting it locally. The welding volume remains comparatively small due to geometric conditions (small sections), and extrusion of the melt is avoided. Relative motion is achieved by moving the component, the laser, or a combination of both. Contour welding is more suitable when joining the edges of a plastic component to a surface, and fiber laser has proved to be more efficient as the laser beam needs to be focused to a specific spot.

#### Characteristics and application:

- High flexibility
- Arbitrary 2D joining line
- Ideal for frequent changes of component.
- Laser beam focused to a spot.
- Can be done with a Diode Laser, Nd:YAG, or a Fiber Laser

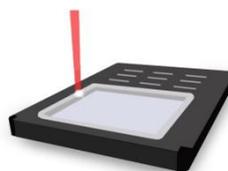


Figure 3: Mobile Phone Screen.

### Quasi Simultaneous Welding

Two scanner mirrors deflect the laser spot and guide it along the welding contour at a very high speed. The joining surface is traversed several times per second, whereby the laser beam effectively heats and plasticize the entire welding seam at the same time. Part tolerances can be melted off forming a welding bead, as both joining parts are pressed together during the

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welding process. This type of welding has also been patented by ©bielomatik Leuze.

### Characteristics and application:

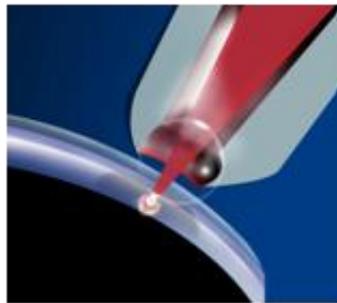
- Laser beam focused to a spot.
- Great flexibility.
- Gap filling possible.
- Suitable for small series and mass production.
- Can be done with a Nd:YAG or Fiber Laser.

### Globo Welding

Globo welding (patented by LEISTER ®) works almost the same way as in contour welding. A laser beam is focused at a point on the joining plane via an air bearing, frictionless, freely rotating glass sphere. The glass sphere not only focuses – it also serves as a mechanical clamping tool. While the sphere rolls on the component, it applies continuous pressure at a point on the joining plane. This ensures that the laser beam is only incident at the point at which the contact pressure is also applied.



\* Car rear light



\* Globo Welding

Figure 4: \*Images from: LEISTER Process Technologies LEISTER ®.

### Characteristics and application:

- Arbitrary joining geometries in two and three dimensions.
- Welding without a clamping device.
- Optimal synchronization of clamping pressure and energy application.
- Suitable for robotic applications.
- Can be done with a Diode Laser, Nd:YAG, or a Fiber Laser.

### Radial Welding

A unique method for bonding cylindrical components, developed by LEISTER ®, whereby a mirror deflects the laser beam such that it impinges radially on the outside symmetrical surface of the component. The tight fit between the joining parts ensures the clamping pressure required for the welding process. The component remains in a fixed position during the circumferential, continuous welding process.

### Characteristics and application:

- Suitable for different diameters.
- No rotational movement.
- High throughput.
- No clamping device required.
- Can be done with a Diode Laser, Nd:YAG, or a Fiber Laser

### Simultaneous Welding

In this technique, one or more lasers heat the entire weld area simultaneously. High power diode lasers are generally used as a result of their compact design. It is very easy to achieve linear welding seams. Almost any beam geometry can be generated by means of special, state-of-the-art beam shaping elements.

### Characteristics and application:

- Short processing time.
- No relative motion.
- Gap filling possible.
- Suitable for mass Production.
- Typically a diode laser application; can also be done with an Nd:YAG or a Fiber Laser.

### Mask Welding

With this LEISTER ® patented technique a mask is inserted between the laser source and the parts to be welded. A curtain or collimated laser beam is moved across the entire joining area of the parts. The laser beam is only incident on the components where they are not obscured by the mask. The mask makes it possible to project extremely fine structures in the order of micrometers. Mask welding therefore achieves a very high resolution. The most diverse welding seam structures can be

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produced with mask welding – for example straight and curved weld lines of different width, as well as two-dimensional structures – all in a single operational step.

### Characteristics and application:

- Line-shaped laser beam.
- Any desired joining geometry within a plane.
- Fast and flexible.
- Very fine 2D joining structures.
- Suitable for micro and macro applications.
- Typically a diode laser application.

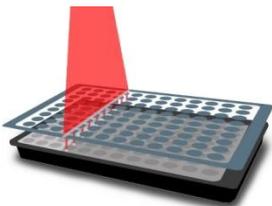


Figure 5: Line-shaped laser beam.

### Conclusion

Welding processes to use a fiber laser are: **Contour Welding, Quasi simultaneous welding, Globo welding, and Radial welding**; these benefits more from the laser stability and small spot size.

Fibre lasers often have sufficient beam intensity to avoid the need to focus the beam. This has the advantage of eliminating any z-axis positioning by using a collimated/parallel beam as used in these trials significantly reduces the complexity of welding equipment.

Fiber laser costs on the basis of \$ per Watt are now comparable with those of flash-lamp pumped and solid state lasers.

Plastics appropriate to the medical industry have been shown to be weld-able in a very controllable manner using the fiber laser. (See the SPI application note on Clearweld).

The footprint of a fibre laser allows for a significant reduction in total system size compared to Nd:YAG.

Power levels required to achieve large area coverage were well within the range currently available by SPI.

### Benefits of SPI Fiber Lasers

- Significant improvement in the quality of the weld due to the stability and controllability of the laser source.
- Beam intensity and spot size enable the use of small weld widths.
- Beam quality of fiber lasers allows users to eliminate the focus lens.
- The collimated beam has sufficient intensity to weld unfocussed while offering wide welds and therefore rapid coverage.
- Output power stability over time enables complex weld patterns without power fluctuations - no weld defects.
- High power density allows large weld areas to be processed rapidly.
- The high beam quality of a fiber laser allows for the use of a long focal length lens. This in turn gives a greater depth of focus and so allows greater tolerance to piece part distortion.
- Maintenance free (no replaceable parts).
- No thermal lensing, no alignment or calibration required.
- High efficiency energy source – up to 10x more energy efficient than Nd:YAG.
- Robotic mounting of the fiber laser allows the beam to access hard to reach areas.
- 3-Dimensional welding can be easily achieved.

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