ALL COLORS

BASF TREFFERT ROFIN

POLYMER WELDING WITH LASERS

WHY LASER WELDING?

Every new technology must have strong arguments to replace established methods. Why use lasers for polymer welding? There are several decisive arguments:

- Laser welded joints resist high mechanical loads, they are gas tight and often achieve the same strength as the base material
- With lasers, almost any kind of seam weld contour can be realized and there is a solution for nearly every workpiece geometry
- Minimal thermal and mechanical stress input is applied: What you weld is what you see. The welding is so precisely localized, that even sensitive components very close to the weld remain unaffected
- The results are surfaces with perfect quality, no micro particles, glue or roughness
- Low reject rates and constantly high reproducibility
- No additional mechanical load due to contact-free welding
- Cost-efficiency with excellent precision and optical quality

WHAT CAN BE WELDED?

In summary, all thermoplastics and almost all thermoplastic elastomers, unfilled or filled can be welded. For example, in current applications, polymers with a glass fiber percentage of up to 30% are laser welded. Also different kinds of polymers can be joined without problems – provided they are chemically compatible and the two melting temperature ranges overlap sufficiently.

Some examples of materials which can be welded: PE, PP, PVC, PS, ABS, SAN, PA6, PA6.6, PC, PMMA, PSU, PES, PEEK, PET, PBT … There is also a rule of thumb for natural materials: What you can weld ultrasonically, can also be laser welded… and many more.

	PP	POM	PBT	PBT/ASA	PA6	PA6.6	PES	PSU	ABS	ASA	SAN	MABS
PP												
POM												
PBT												
PBT/ASA												
PA6												
PA6.6												
PES												
PSU												
ABS												
ASA												
SAN												
MABS												
ABS/PA												
PS												

[illegible] very good weldab[illegible] light bound not weldabl[illegible] joint

FOUR FACTORS FOR SUCCESS

As with any other process, laser welding of polymers needs specific conditions to be a success. There are the following key factors:

- Choice of suitable polymers, additives and pigments
- Use of the right laser source with suitable optics
- Appropriate joint configuration and small gap width
- Optimized clamping technology, allowing free access of the laser beam to the seam and applying sufficient pressure on the components

DIRECT COMPARISON

Glueing polymers often requires pre-processing of the surface with organic solvents. This rules out glueing for certain applications. In addition, some very common nonpolar polyolefins (PE and PP) are difficult to glue. Glueing often means complex handling. Welding with heated elements or hot air is inexpensive but slow and, in the first case, wears the tools due to direct contact with the polymer. These processes apply heat to a large area, which is unsuitable for sensitive components.

Friction, vibration or ultrasonic welding methods all subject the workpieces to high mechanical stress. Consequently, complex design and regular maintenance of the machines is required.

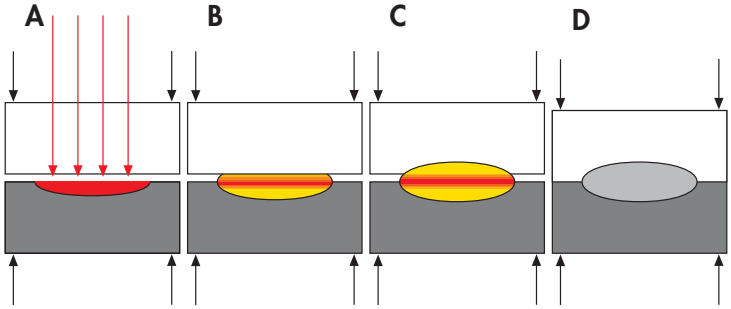
Ultrasonic welding, in particular, requires specifically designed workpiece geometries in order to transfer the sonic energy to the right locations.

Laser welding of polymers is already successfully implemented in numerous applications: in the automotive, electronic and telecommunication industries, medical device technology, human care and household devices.

PROCESS OVERVIEW

Low heat conductivity and viscosity of polymers means that the most practical welding geometry is overlap welding. Here, the laser beam penetrates the upper material and is absorbed by the lower material. The heating of the latter leads to plastification which bridges the workpiece gap and melts the upper material by heat transfer. Therefore, having a small workpiece gap is an important success factor.

Laser Welding Concept:

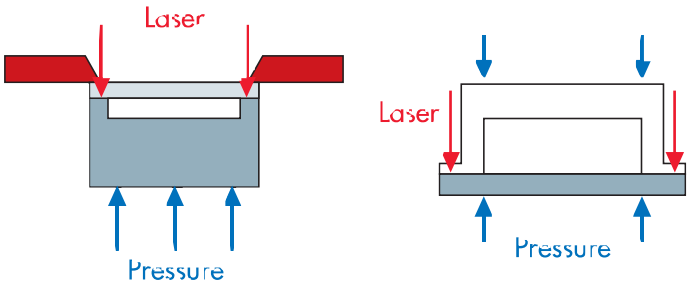


Laser light penetrates the upper layer and is absorbed by the lower material (A). The melting of the latter transfers (B) the heat to the upper layer (C). The mutual melting pool solidifies under external pressure to a high-quality weld (D).

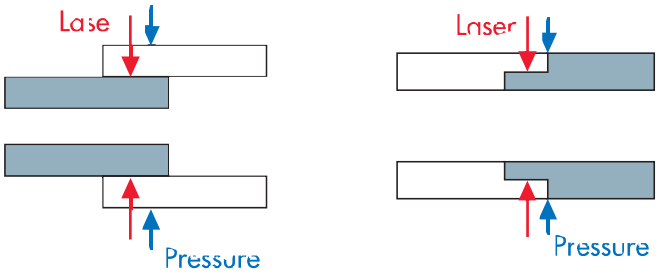
TRANSPARENCY AND ABSORPTION

All commonly used polymers are more or less transparent in undoped condition in the infrared wavelength range of the laser sources (except CO_2 lasers).
Filler materials, like pigments, provide for the absorption of laser energy. Many color pigments absorb within the infrared range and can be used for laser welding. Even simpler, and therefore most common, is the use of carbon black particles acting as absorbers, typically in a concentration of 0.05 - 0.5%. However, this results in darker colors. There are already standard solutions for black-black and transparent-black welding available. For clear and bright colors, pigments, which are flexible in use, are available. They absorb only within the wavelength range, but do not modify the coloring of the polymer significantly. This coloring influence of the additive can be adjusted by color-matching.

Example: Flat plate design



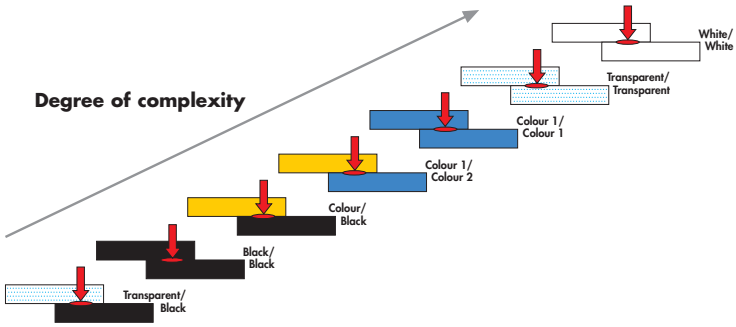
Example: Tube design



EVEN COLORED AND ALSO TRANSPARENT

Black, colored, transparent, white… In this order, the complexity of process requirements for laser welding of polymers increases.
Applications with black material, acting as absorber, are usually easy to realize or already available as a standard solution. For welding of colored polymers, the necessary pigment combinations are customized in laser transparent and laser absorbing form – a typical task for the experienced masterbatcher.
Welding of light-colored or transparent polymers, which is particularly required in the medical device industry, is successfully achieved with CO_2 lasers in the case of welding thin films or more general by using the above mentioned laser absorbing high performance additives. Those have to exhibit high absorption efficiency at the appropriate wavelength and low color impression in the visible range as well as various additional characteristics: the know how of an innovative worldwide operating masterbatcher ensures optimum results.

Titanium dioxide presents particular problems in relation to beam scattering and low transparency and require customized solutions for white-white weldings.



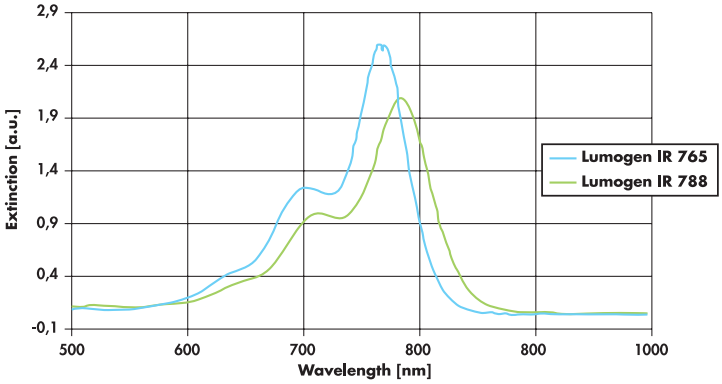
Increasing degree of complexity in overlap welding of polymers. For many applications an experienced partnership between additive producer, masterbatcher and laser manufacturer is of great advantage.

INNOVATIVE GENERATION OF ADDITIVES

The new BASF Lumogen® IR product line is the result of several years of interdisciplinary research and development in the field of additives and pigments: high-quality and highly efficient NIR-absorber (NIR = near infrared) based on proven BASF pigment technology. The first two representatives of this innovative generation of additives, Lumogen® IR 765 and Lumogen® IR 788, provide UV and thermal resistance on a level which has up to now only been reached by inorganic materials. At the same time they can be processed as easily as classical organic polymer additives.

The structural relationship to graphite is manifested in the distinct chemical resitance and low reactivity of this class of substances. In contrast to graphite, however, Lumogen® IR 765 and Lumogen® IR 788 provide excellent solubility in all commonly used transparent or translucent thermoplastic polymers. In addition, the original color can also be maintained even with high NIR absorption efficiency.

Lumogen® IR 765 and 788 - 0.01 percent by weight in polycarbonate



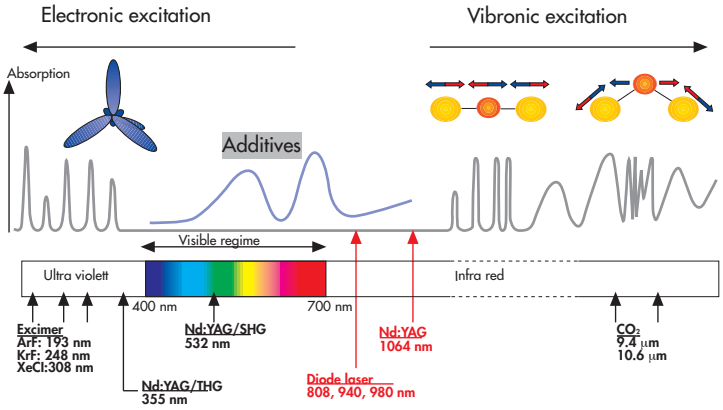
Absorption range of 3 mm thick polycarbonate die-cast plates, mass doped with 100 ppm Lumogen® IR 765 or Lumogen® IR 788 each.

Lumogen® IR 765 and Lumogen® IR 788 are non-ionic, free of halogon and heavy metals and toxicologically harmless: excellent preconditions for the use in the medical device industry and other sensitive requirements.

PIGMENTING: A FACTOR OF SUCCESS

To find the ideal pigmentation formulation, the desired coloring together with perfect laser welding characteristics are the two key factors. For that, it takes a specialist with the knowledge and experience of hundreds of thousands of formulations and with a sophisticated laboratory equipped with modern extrusion and kneading lines. Color samples submitted by the customer are the basis for the creation of masterbatches. The masterbatch is easy to process, optimally dispersing and is identical in color. If requested, the original material can be conditioned, which means it is used as the carrier material for the masterbatch. The characteristics and the authorization of the original material are thus retained to a large extent.

Spectrum:



Most polymers (grey curve) are usually transparent or translucent in the visible and near IR range. By adding pigments (blue curve), suitable absorption of the laser wavelength is achieved.

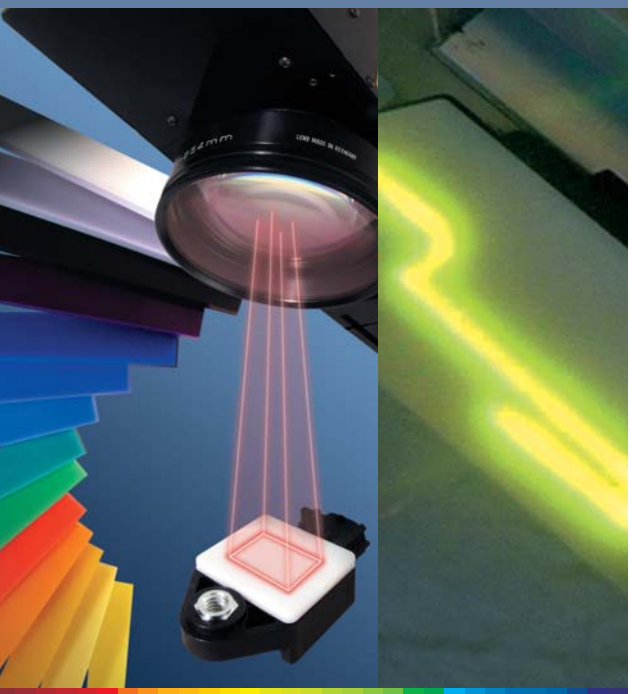
WHICH LASER SOURCE?

The wavelength is the decisive feature in determining which laser is the ideal one for polymer welding: diode lasers, Nd:YAG lasers or CO_2 lasers. Apart from the difference in wavelengths and the absorption behaviour of certain pigments, the following rules apply: Nd:YAG lasers are particularly suitable for welding seam widths below 1 mm and for plane welding geometries with scanner head applications. Diode lasers, however, are preferred for wider welding seams, circular seams and simple spot welds. In most cases the required power ranges from 30 to 300 W, which is achieved by both laser technologies effortlessly and cost-effectively.

INTEGRATED OR STAND-ALONE

Depending on the requirements of the production method, flexibly integrable laser sources and optic kits are available: the StarWeld Diode family comprises diode lasers, diode- and lamp-pumped Nd:YAG lasers with galvo deflection heads or fiber-coupled optics in different power ranges. With 808, 940 and 1064 nm, all common wavelengths for polymer welding are available – either tightly focusable or with high output power.

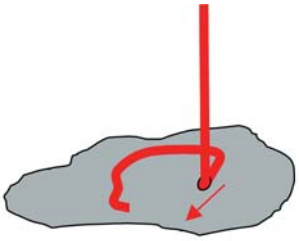
PolyScan is a new turnkey all-in-one solution for contour and quasi-simultaneous welding of polymers. It is particularly suitable for prototype or small batch production. All lasers with galvo scanning heads from the StarWeld family can be integrated, i.e. lamp- or diode-pumped Nd:YAG lasers or diode lasers. The sealed-off CO_2 laser StarShape C is the ideal instrument for welding thin films by direct absorption due to its wide range of output power and its outstanding beam quality.



CONTOUR & QUASI-SIMULTANEOUS WELDING

These two processes show presently the best market presence. With contour welding, the laser beam follows the welding seam, similar to metal welding. The laser beam is often delivered via fiber optic to a robot-controlled focus head. Almost any workpiece size can be welded. The limits for this technique are set by the tolerable gaps. With quasi-simultaneous welding, the laser beam passes over the entire welding contour several times very rapidly. Beam deflection is done using galvo scanning heads and therefore higher beam quality is essential. The entire welding path melts quasi-simultaneously due to heat buffering and allows the layers to move against each other easily. The pressure on both layers and a suitably designed sacrificial region can bridge larger gaps. On the one hand, quasi-simultaneous welding requires higher laser power, on the other hand, it allows even distortion-free energy input.

Contour welding:



Quasi-simultaneous welding:

WHY BASF, TREFFERT AND ROFIN?

Very simple: three experienced specialists for the main factors of success in polymer laser welding – the suitable additive, the right choice of pigments and the right laser – work hand in hand. The performance chemicals section within BASF is engaged in research and development of additives and pigments. The innovative generation of additives Lumogen® allows even transparent / transparent weldings.

A laser application lab (ROFIN / Baasel Lasertech), a color and chemical physical laboratory and the 'Centre d'Innovation, Pole Technique Groupe Treffert' working with two ROFIN PolyScan Lasers in Ste-Marie-aux-Chênes (TREFFERT) are ready for your sampling and feasibility studies. Within a few days you get the polymer solution for your specific application, already tested for laser welding. We look forward to solving your task!

BASF

The Chemical Company

BASF is the world's leading chemical company: The Chemical Company. Its portfolio ranges from chemicals, plastics, performance products, agricultural products and fine chemicals to crude oil and natural gas. As a reliable partner to virtually all industries, BASF's intelligent solutions and high-value products help its customers to be more successful. BASF develops new technologies and uses them to open up additional market opportunities. It combines economic success with environmental protection and social responsibility, thus contributing to a better future. In 2004, BASF had approximately 82,000 employees and posted sales of more than € 37 billion. BASF shares are traded on the stock exchanges in Frankfurt (BAS), London (BFA), New York (BF), Paris (BA) and Zurich (AN). The product range of BASF's Performance Chemicals for Coatings, Plastics and Specialties business unit includes pigments, preparations and dyes, binders and crosslinkers, light stabilizers and process chemicals. The products are manufactured and marketed worldwide. BASF is one of the world's leading suppliers in these fields.

TREFFERT

The TREFFERT-group polymer-technology with plants in France and Germany, develops and produces color systems, additives, compounds and master batches for the polymer industry, which are delivered worldwide. TREFFERT makes developments for the medical, automotive and electronic industries, as for other technical applications. The company delivers batches from the smallest amount as samples up to several tons. Being a specialist in this branch with highest quality standards and over 75 years of tradition, TREFFERT produces just-in-time for specialized markets. The outstanding strength of this company is in fulfilling orders, which require high performance in development and consultation.

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BAASEL LASERTECH

The successful installation of more than 20,000 lasers all over the world has established ROFIN as one of the leading manufacturers of lasers and laser based systems. Macro, Micro and Marking are the three company competence columns which allow ROFIN to cover an extraordinarily wide range of products for industrial material processing. ROFIN's high-performance lasers are used all over the world for precision cutting, welding, microstructuring and marking. More than 1,400 employees in production sites in the US, Germany, Great Britain, Japan and Singapore as well as numerous sales and service branches ambitiously work on future laser technology for the industry.

THREE PARTNERS
ONE SOLUTION

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