Modular Solutions for Laser Plastic Welding

precise & concise
clean & green

Turnkey modular ready-to-use machines

Plastic parts for welding show a large variety of forms and geometries. To cope with this variety and to meet a wide diversity of customer preferences, our machines are designed in a strictly modular way. The Turnkey machines are configured in our modular design framework according to your requirements. Therefore they are precisely adaptable to the processing of your plastic parts.

All lasers, optics, clamping units, and motion systems from our Modula product portfolio (see page 5-7) are available in the Turnkey systems.

A drawer or rotary table can be selected for the part handling in and out of the machine. With some customer-specific modifications also conveyor systems can be integrated to the Turnkey machines. Our Turnkey machines are delivered fully ready to use. They only need to be connected to an electric power source, and depending on configuration, to compressed air.

Turnkey S

The Turnkey S is the smallest version of the Turnkey machines. It can be set up on a normal work table. Despite its compact design, it is built up in a modular way and can be equipped for all different plastic welding processes with the Modula components. Control system, laser, and cooling are placed in the cabinet on the back side. No separate laser unit is needed.

The welding process can be set up and observed on the touchscreen user interface. Keyboard and mouse can optionally be connected to USB ports on the front of the machine. At the backside, an HDMI port allows the connection of a larger monitor.

For the welding process a small lifting door is opened. For setting up the welding process and for maintenance the complete front cover can be raised providing good access to all components. The drawer for part handling as well as the lifting door can be actuated manually, pneumatically, or electrically. A rotary table is available in both manual or electrical versions.

The Turnkey S can be connected to a local computer network by an Ethernet interface on the backside of the machine. Process data and welding recipes can be both uploaded and downloaded as needed by the user. A secure internet connection can be established for remote services and maintenance.

Configuration shown
- scanner optics
- laser power 200 W
- rotary table
- pneumatic clamping
- pneumatic lifting door

Technical data

Welding area	axes 150 x 100 mm scanner 100 x 100 mm
Laser power	40-200 W
Wavelength	about 980 nm
Laser class	1 (red pilot laser 2)
Clamping force	2300 N
Stroke distance	20 mm, extendable on request
Drawer	manual, pneumatic, or electrical
Rotary table	diameter 300 mm, manual or electrical
Lifting door	300 x 140 mm, manual, pneumatic, or electrical
Cooling	air (IP20, filter mat)
Ambient temperature	35/40 °C – depending on laser power and duty cycle
Electrical supply	100-240 V, 50/60 Hz, <10 A
Dimensions	520 x 700 x 565 mm, with lamp tower 780 mm
Weight	60-75 kg depending on configuration

Configuration shown
- radial optics
- laser power 40 W
- manual drawer
- pneumatic movement radial optics
- pneumatic lifting door

Configuration shown
- spot optics advanced with pyrometer
- xy axes
- laser power 80 W
- pneumatic clamping
- pneumatic drawer & lifting door

Turnkey M

The Turnkey M is a ready-to-use machine for larger components (up to half a meter). It is designed as a workstation that can be operated standing or sitting position. Like the Turnkey S, it has a modular design and can be configured in different versions to suit the workpieces to be welded as well as the customer's requirements.

The laser and the control system are located in the lower part of the Turnkey M, so that in the upper part the welding area with clamping unit, motion system, and optics can be optimally accessed. For setting up the welding area can be reached from the large side doors or from the rear door. All the doors are monitored for safety. The electrical cabinet at the rear side of the lower part of Turnkey M is accessible with two small wing doors and is laser-safe seperated from the welding area. The laser itself in the lower part of the machine is accessible through the lower side doors on the left and right. For welding, only the lifting door at the front is opened and closed.

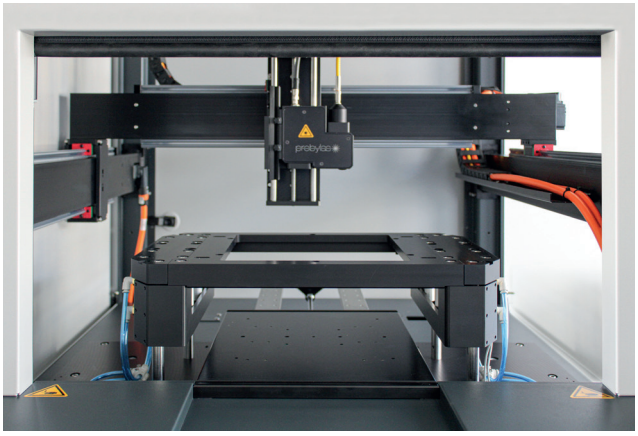
The welding process is set up on the touch screen, which can be tilted according to the height of the operator. A keyboard and mouse can optionally be connected via the USB ports in the operating table.

The drawer for the workpieces and the lifting door can be operated either manually, pneumatically or electrically. The rotary indexing table is available in manual and electric versions.

For connection to a local area network (LAN), the Ethernet interface on the back of the Turnkey M can be used to transfer process data to a server or for remote maintenance via the Internet.

Configuration shown

- spot optics advanced with pyrometer
- laser power 80 W
- xyz axes
- pneumatic clamping
- pneumatic drawer & lifting door



Large welding area up to maximal 500 x 400 mm with axes system including vertical z-axis and large clamping unit.

Electrical cabinet at the back of Turnkey M cooled by air and with two wing doors. Electrical and pneumatic supplies are situated at bottom below electrical cabinet.

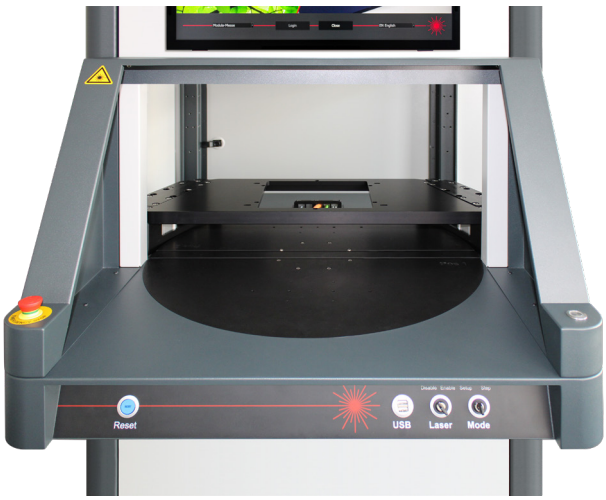
Technical data	
Welding area	axes 500 x 400 mm, scanner 350 x 350 mm
Laser power	40-200 W
Wavelength	about 980 nm
Laser class	1 (red pilot laser 2)
Clamping force	up to 7000 N
Drawer	manual, pneumatic, or electrical
Rotary table	diameter 650 mm, manual or electrical
Lifting door	650 x 400 mm manual, pneumatic, or electrical
Cooling	air (IP20, filter mat)
Ambient temperature	35/40 °C – depending on laser power and duty cycle
Electrical supply	100-240 V, 50/60 Hz, <10 A
Dimensions	880 x 1200 x 1950 mm with drawer 880 x 1250 x 1950 mm with rotary table with lamp tower 2170 mm
Weight	about 300 kg depending on configuration

USB ports for memory stick or additional peripherals like mouse or keyboard.

Configuration shown

- scanner optics
- laser power 200 W
- pneumatic clamping
- rotary table
- pneumatic lifting door

Good accessibility to welding area with clamping unit, optics, and motion system by the large side doors.



Large rotary table with wide opened lifting door and clamping unit in the inside position of the rotary table.

For integration in special-purpose machines we offer the same modules separately as you can find in our Turnkey machines. We also provide the necessary support for your internal machine building department or for an external specialist. Laser units and optics are required for any integration. Additionally, we supply clamping units and motion systems. With all relevant modules coming from ProByLas, they can seamlessy work together of an optimal welding process. The machine building department or an external special machine builder only needs to ensure sufficient enclosure including safety and part handling both in and out of the machine.

Laser

The laser unit is the central component of the Modula product family. Besides the laser itself, it also comprises the system control, interfaces, and control elements.

On the touch-screen, the welding process is set up and observed during operation. Optionally a keyboard and mouse can be connected to the USB ports as well as a larger screen to the HDMI port on the backside.

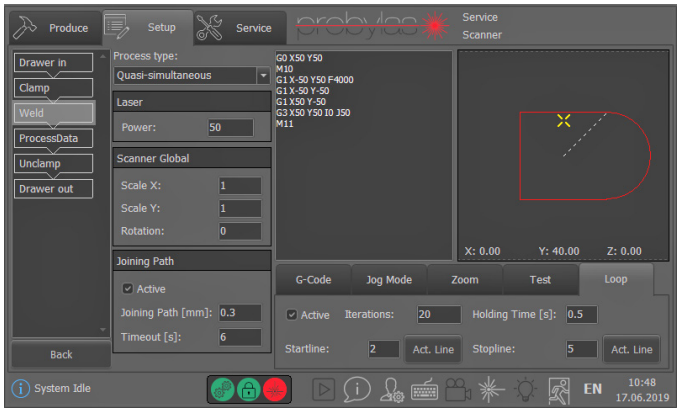
The connections for other Modula components as well as the interface for automation carried out by digital and analog inputs and outputs are located on the backside of the laser unit. The safety controls for emergency stop and two-channel interlock can be configured in different ways allowing integration up to the highest Performance Level e according to EN13849 standard.

Technical data

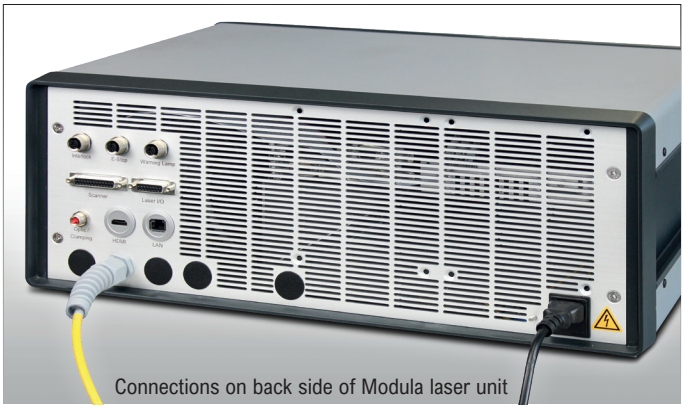
Laser power	40-200 W (wavelength about 980 nm)
Laser class	4 (red pilot laser 2)
Air cooling	Protection class IP20 or IP30, optionally with filter mat
Ambient temperature	35/40 °C – depending on laser power, type of air cooling, and duty cycle
Electrical supply	100-240 V, 50/60 Hz, <10 A
Connectivity	Ethernet RJ45 on back side
Dimensions	520 x 430/530 x 215 mm depth depending on configuration

Front view with air vent slots IP20

Front view with air vent slots IP30 and pivoting legs

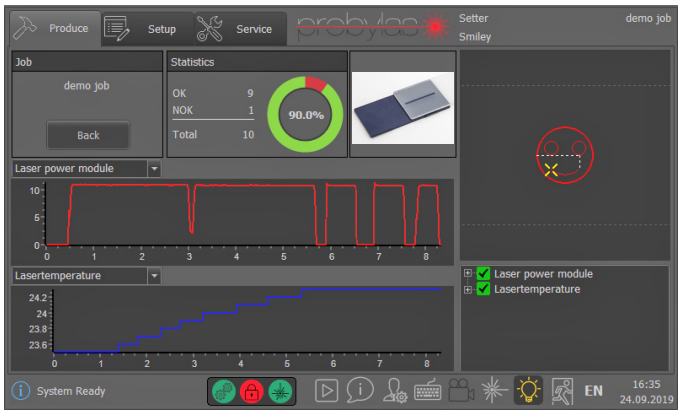


Setup of welding contour and motion parameters with G-code



Connections on back side of Modula laser unit

Selection and presentation of process data and analysis functions



View for operator in serial production

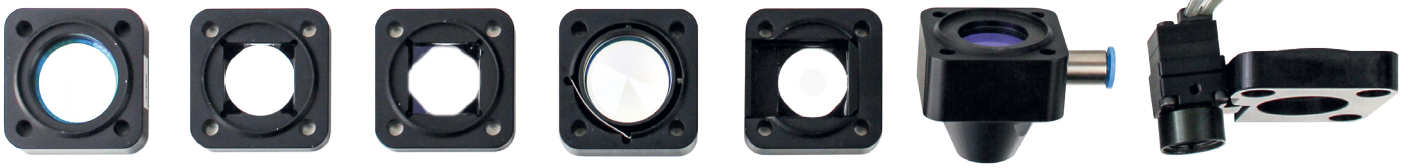
Optics

The optics are designed modular as well. Besides the primary employed spot optics, other optics for specific process types can be utilized for special applications. The fiber connector module with collimation lens and the beam shaping elements are connected to the base body from the top and bottom.

Fiber connector & collimation
Depending on the type of laser different fiber connections are needed.
The collimation lens shapes a parallel beam. With different focal lengths of the lens, various diameters of the laser beam are possible.

Optics base body
For the base body of the optics, a simple version and an advanced version with monitoring of the laser power are available.
The advanced optics can also be equipped with a pyrometer for a temperature reading (100-400 °C).

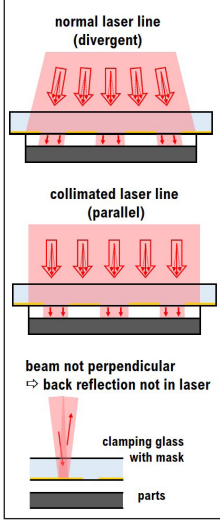
Beam shaping



Spot diameter 0.5-3.0 mm	Line length 12-60 mm	Filled square or rectangle	Ring <50 mm	DOE for any contour	Ball - spot with clamping	Camera module side-mounted on optics for setup and monitoring of welding process

Special optics versions

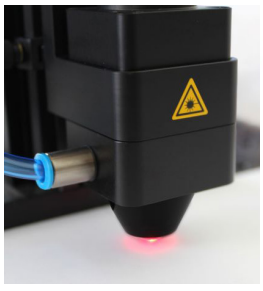
Collimated line optics
The collimated line is a special version of the line optics for mask welding. The laser line is not diverging along the direction of propagation, but remains the same length because the beams run parallel. The geometry of the shadow from the mask onto the workpiece is retained even at larger distances, so that the distortion from mask to welding plane does not have to be precorrected.

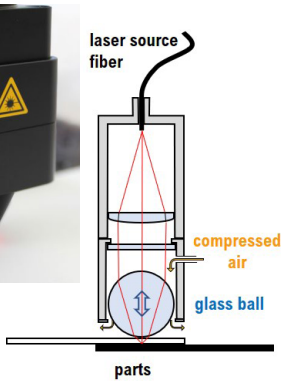


Radial optics
Radial optics allow cylindrical workpieces to be welded simultaneously on the circumference as an alternative to rotating the workpieces underneath a spot optic. It is based on a ring optics and additionally has a cone mirror, which reflects the laser beam from the outside to the inside. Instead of a clamping unit, a press fit contact must be ensured between the workpieces.

Radial optics open lab version with sketched laser beam. Standard radial optics is closed on sides.

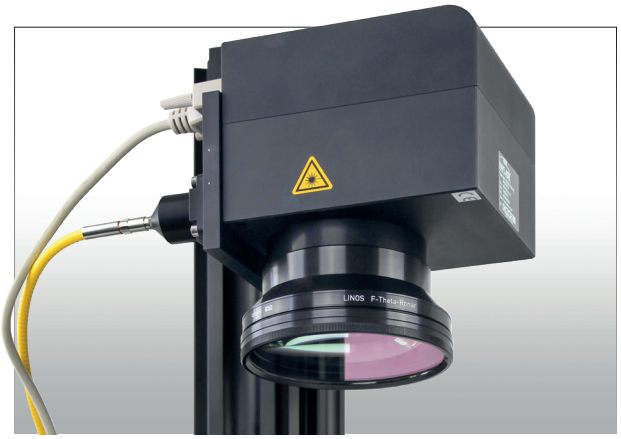
Ball optics
The ball optics allows workpieces to be welded without a clamping unit - typically foils or technical textiles.
The glass ball focuses the laser beam on one hand and presses the workpieces together by the compressed air behind the ball on the other. The ball moves freely in the cylindrical shaft and can thus roll over the workpieces with the movement of the ball optics. If the ball is lifted off from the workpieces, the ball closes the opening at the bottom of the shaft and no compressed air is consumed anymore.

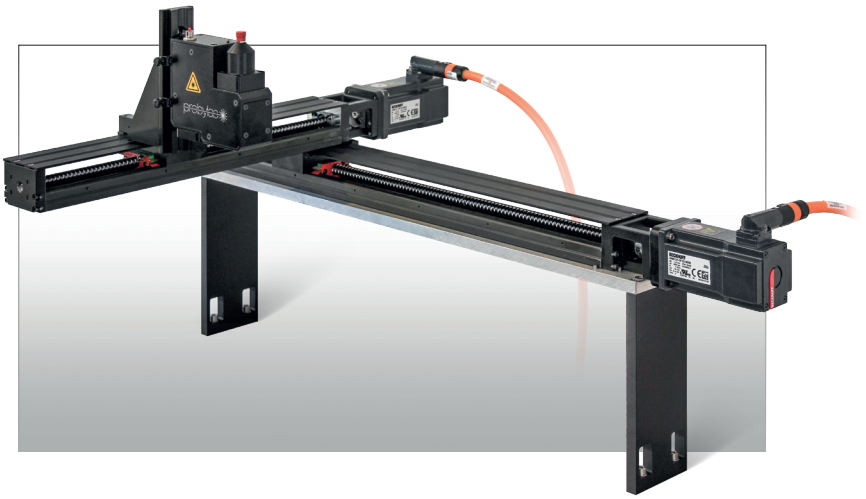




Motion

In order to track the weld contour with the laser beam there are different options. They are closely related to the type of welding process.





Scanner
The scanner is a combination of optics and motion system. Two pivoting mirrors deflect the laser beam in x- and y-direction. With the small mass and inertia of the moving mirrors, high speeds of several meters per second are possible enabling a quasi-simultaneous process type with multiple contour cylces per second.
The final focusing lens (f-theta) determines the size of the working area, which can measure 100 x 100 mm, 240 x 240 mm, or 350 x 350 mm.

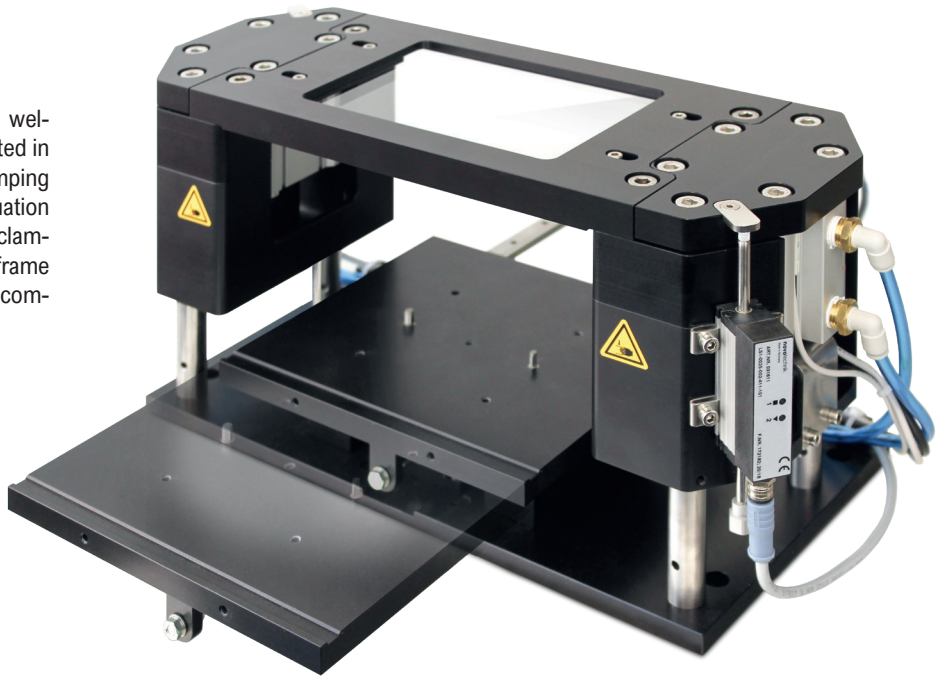
xyz-axes
The optics above can be mounted on an axes system driven by servo motors. Depending on the geometry of the parts and on the welding contour, a single axis may be sufficient or an x-, y-, and z-axis may be combined.
The motion control of the axes (numerical control, NC) is integrated in the laser unit.

Rotation axis
For welding the circumference of a cylindrical part, a single servo motor is employed. It can also be combined with a translational axis e.g. along the length of the cylindrical part.

Clamping unit

The clamping unit presses the workpieces to be welded against one another. The workpieces are inserted in part-specific cavities on the drawer. The upper clamping plate moves down by pneumatic or electric actuation and presses the workpieces together. The upper clamping tool can be a transparent glass plate, a metal frame with part-specific cutouts for the laser beam, or a combination of both.

For process and quality control the clamping unit can be equipped with travel or force sensors. The clamping travel can be monitored with the distance measurement. In the simultaneous or quasi-simultaneous process type also the travel during welding can be measured, analyzed or used for direct process control.



Technical data	small clamping unit	large clamping unit
Size welding contour	150 x 100 mm	240 x 240 mm
Maximal width of workpiece	210 mm	300 mm
Maximal clamping force	2300 N	7000 N
Maximal clamping stroke	20 mm (extendable on request)	
Height workpiece/tooling	55 mm, extendable in steps of 20 mm	
Motion drawer	manual, pneumatic, or electrical	
Actuation clamping	pneumatic (6 bar) or electrical (servo motors)	

The Modula Assemblies are predefined compilations of Modula components that already serve specific purposes. They require less integration effort than individual Modula components. Modula Assemblies can even be operated independently as individual assemblies without integration into an overall system.

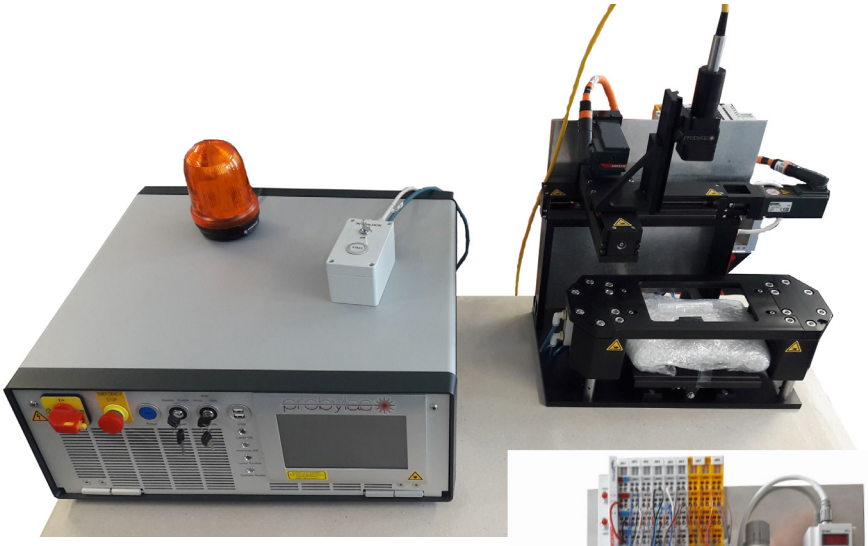
Modula Assembly Lab

The Modula Assembly Lab is a combination of a laser unit and a base plate with clamping unit, motion system and optics, suitable for laboratory operation.

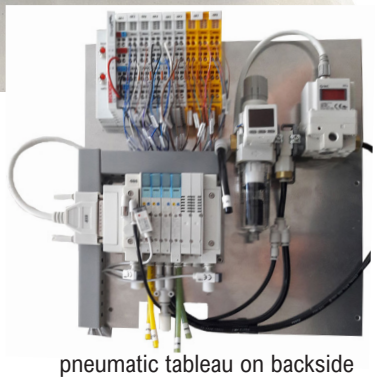
It is a ready-to-use combination like a Turnkey S or M. Because of the missing housing it has to be operated with laser safety goggles (laser class 4). Furthermore, it has to be ensured as well that the operator does not intervene in the clamping unit or into the moving axis system. This can be done by additional safety equipment or appropriately trained specialist personnel.

Potential applications of Modula Assembly Labs are:

- Contour welding in plastics development laboratory with xy axes and pneumatic clamping unit.
- Mask welding with line optics on x-axis and pneumatic clamping unit for small series production of microfluidic chips.
- Radial optics for circumferential welding of e.g. tube connectors with laser-tight tooling closing gaps to radial optics (no safety goggles needed).



Configuration shown
- line optics: laser line 40 mm long
- laser power 200 W
- xy axes
- pneumatic drawer
- pneumatic clamping



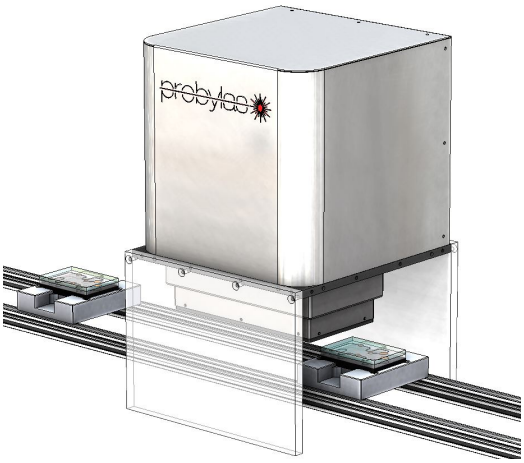
pneumatic tableau on backside

Modula Assembly Inline

The Modula Assembly Inline is a specific combination of a laser unit, a scanner optics, a special clamping unit and a housing for integration onto a transfer system or a larger rotary table. The clamping unit presses on the workpiece carrier and closes it in a laser safe manner, so that the Modula Assembly Inline can be operated without additional laser protection measures.

For the integration there are only additionally required:

- Substructure for the processing unit fitting the employed conveyer system or rotary table, mechanically rigid enough for the employed clamping forces.
- Workpiece carrier or tooling, which closes laser safe to the upper tooling at the clamping platform of the Modula Assembly Inline.
- Interface connection for start trigger and emergency stop signals.



Technical data	
Welding area	100 x 100 mm
Laser power	40-200 W (wavelength 980 nm)
Laser class	4 (red pilot laser 2)
Clamping force	up to 2300 N
Maximal stroke	20 mm (extendable customer-specific)
Cooling	air (IP20 filter mat)
Ambient temperature	35/40 °C depending on laser power
Electrical supply	100-240 V, 50/60 Hz, <10 A
Dimensions	Processing unit 330 x 330 x 410 mm Modula laser unit 520 x 430 x 215 mm

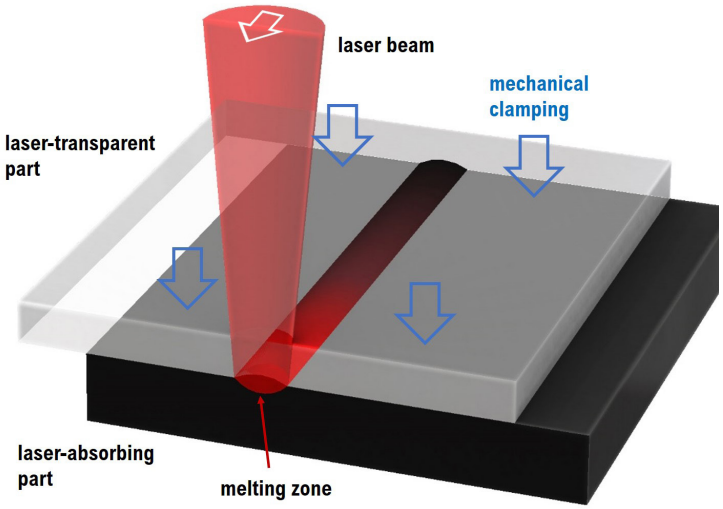
In the welding process the surfaces of two or more plastic parts are melted and pressed together so that the liquid plastic melts mix. When cooling down, the plastic melt solidifies to yield a strong bond. For welding, the plastics must melt when exposed to heat (thermo-plast). Plastics which do not melt when heated, but degrade or disintegrate, cannot be welded (thermo-set plastics).

Process of laser welding

In laser plastic welding the heat to melt the plastic is introduced by a laser directly at the weld seam. The workpieces are already pre-mounted in the final position. The upper workpiece is transparent for the laser, so that at least some part of the laser beam can propagate to the surface of the lower workpiece. This lower part absorbs the laser at the surface, heats up and melts. Due to mechanical clamping pressure, the workpieces are in contact with one another. Both the upper surface of the lower workpiece as well as the lower surface of the upper workpiece plasticize and melt. The two melts mix to yield a strong and solid bond after cooling down.

Advantages

- precisely localized
- shallow melting zone
- little energy needed
- low material strain
- no particles
- no vibrations
- no emissions
- no solvents



Industries

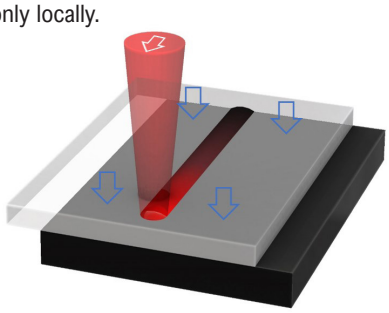
Based on its technical advantages, laser plastic welding is primarily applied in industries with high quality requirements such as

- Medical
- Automotive
- Electronics
- Consumber goods
- Technical textiles

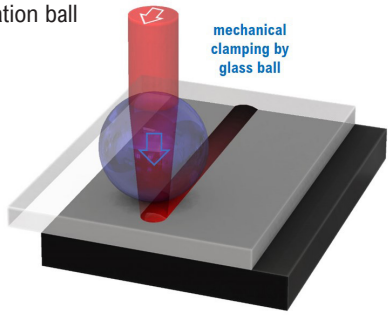
Types of welding process

Contour process

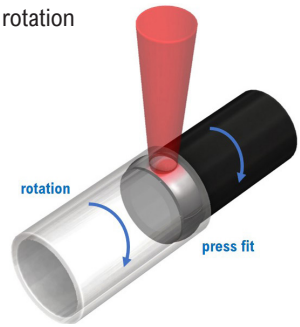
The laser tracks the weld contour once. The plastic melts only locally.



Variation ball

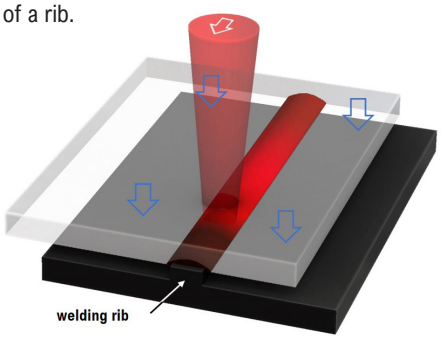


Variation rotation



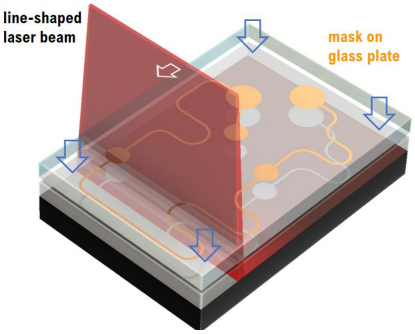
Quasi-simultaneous process

The laser tracks the weld contour several times per second and melts the plastic along the complete weld seam at the same time enabling the melt off of a rib.



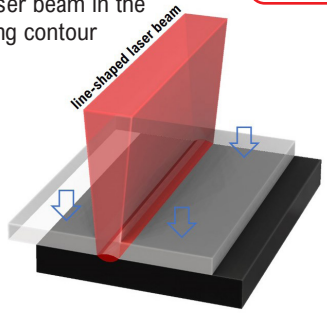
Mask process

The mask shadows the line-shaped laser beam locally, so that only welding takes place where the laser shines through the mask.

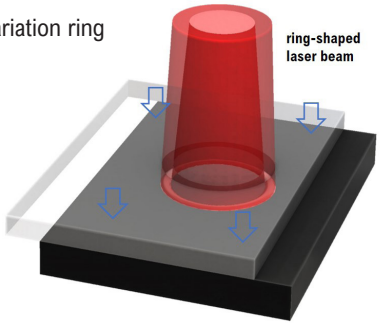


Simultaneous process

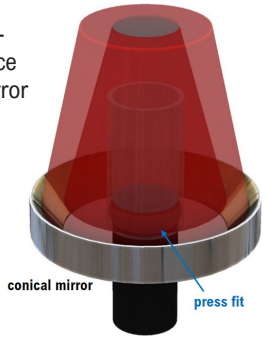
A special optics shapes the laser beam in the welding contour



Variation ring

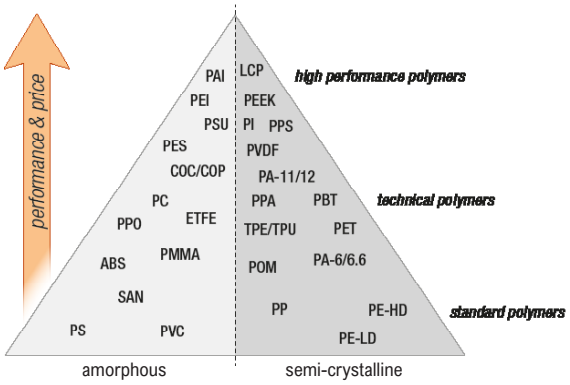


Variation radial - on circumference with conical mirror



Plastics

In general, all thermo-plastic polymers can be welded. Ideally both parts to be welded consist of the same type of polymer. Combinations of similar polymers can be welded if the melting temperatures are in the same range and if the polymer melt mix well.

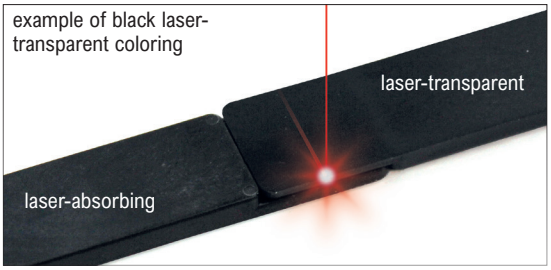


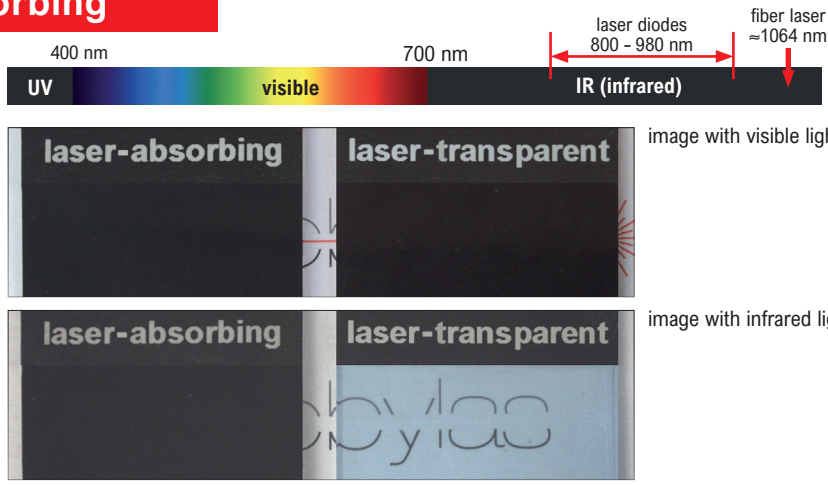
lower part	upper part	PE	PP	EP(D)M	COP	COC	PS	ABS	ASA	SAN	SB	TPU	PVC	PA6	PA6.6	PA11	PA12	PC	PET	PBT	PMMA	POM	PES	PSU	PI	PEI	PAI	PTFE	ETFE	PVDF	PEK	PEEK	LCP
Polyolefins	PE-LD/HD	■	■	■																													
	PP	■	■	■																			■	■									
	EP(D)M	■	■	■																			■	■									
Cycloolefins	COP				■	■																											
	COC				■	■																											
Polystyrene and copolymers	PS						■	■			■	■	■							■	■												
	(M)ABS						■	■	■	■	■	■	■					■	■	■	■		■	■									
	ASA						■	■	■	■	■	■	■					■	■	■	■		■	■									
	SAN						■	■	■	■	■	■	■					■	■	■	■		■	■									
	SB						■	■	■	■	■	■	■	■	■			■	■	■	■												
Polyurethanes	TPU						■	■	■	■	■	■	■	■	■			■	■	■	■												
Polyvinylchlorids	PVC						■	■	■	■	■	■	■	■	■			■	■	■	■												
Polyamides	PA6										■	■	■	■	■																		
	PA6.6										■	■	■	■	■																		
	PA11															■	■																
	PA12															■	■																
Polyesters	PC						■	■	■	■	■	■	■					■	■	■	■												
	PET						■	■	■	■	■	■	■					■	■	■	■												
	PBT						■	■	■	■	■	■	■					■	■	■	■												
Polyacrylates	PMMA						■	■	■	■	■	■	■					■	■	■	■												
Polyacetals	POM								■	■		■								■	■	■	■										
Polysulfones	PES				■				■	■														■	■								
	PSU				■				■	■														■	■								
Polyimides	PI																								■	■							
	PEI																								■	■	■						
	PAI																									■	■						
Fluoropolymers	PTFE																											■	■	■			
	ETFE																											■	■	■			
	PVDF																											■	■	■			
Polyetherketones	PEK																														■	■	
	PEEK																														■	■	
Liquid crystal polymers	LCP																																■

■ good welding ■ possible – tests necessary ■ only in exceptional cases

Laser-transparent and laser-absorbing

Laser plastic welding uses lasers with wavelengths in the near infrared range (800-1100 nm). Therefore the transparency and the absorption of the plastics for the human eye and for the laser can be adjusted independently from one another by means of suitable colorants.



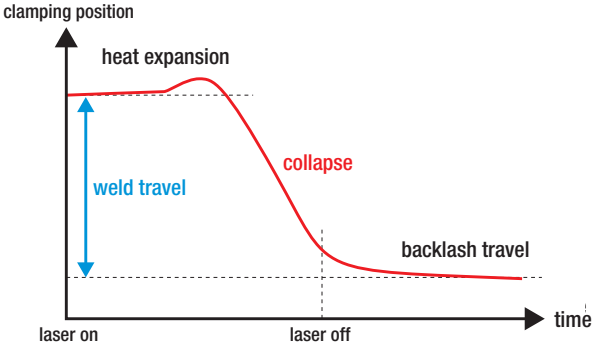


Process and quality control

Before, during, and after the welding process, various data can be measured and analyzed for a quality assessment. Besides the laser power measurement, pyrometry for the contour process and weld collapse for simultaneous and quasi-simultaneous processes are frequently applied during welding.

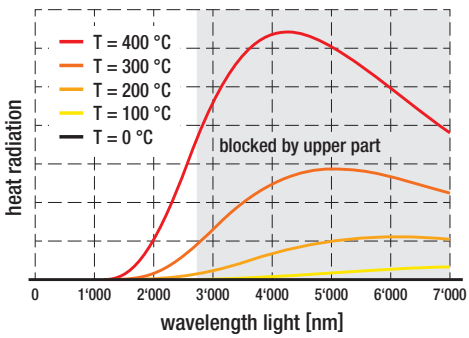
Weld collapse

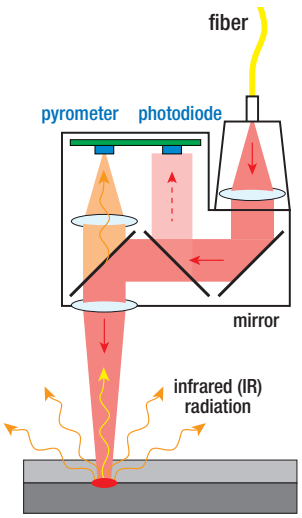
Depending on the plastic used, a small expansion can be observed before the plastic melts and the collapse of a melt rib starts. After switching off the laser, the travel does not stop immediately as the melt has to cool down and solidify first before the collapse ends.



Pyrometry

A pyrometer detects the heat radiation from the weld seam. As the upper workpiece blocks some part of the heat radiation only a relative temperature signal can be retrieved not an absolute temperature value.





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- Sample parts up to small series
- Installation and training
- Maintenance and troubleshooting
- Upgrade of machines