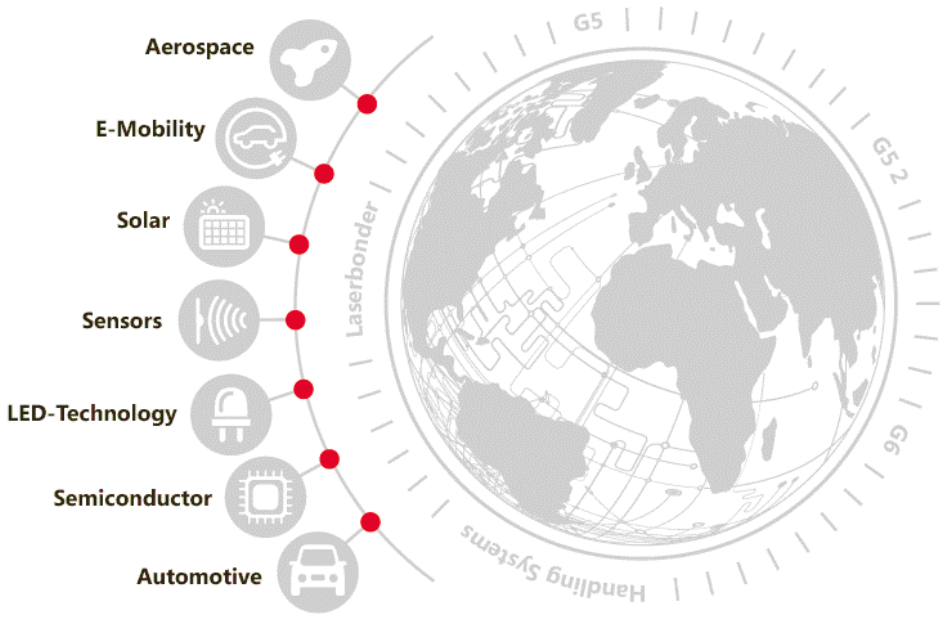

TECHNICAL INFORMATION LASER BONDING

Abstract

The Delvotec Laserbonder M17 LSB is used for welding metallic ribbons onto metallic or metallized surfaces by way of laser radiation or for welding components onto each other without the need for additional clamping of the weld partners. This latter method is known as Laser-TAB.

The integrated camera system supports the identification of the component's geometric characteristics and the automatic adaptation of the weld process to them. The M17 LSB can be used as a single workstation or as part of a production line. The central element of every laser bonder is the bond head with the bond tool which is able to move on 4 axes.

The use of M17 laser bonders for battery & power electronic technologies are just two examples of several fields of application in active production. The highly flexible Laser-welding technology with ribbons or pre-placed connectors (Laser TAB opens a future perspective for working with an unlimited range of materials exploiting all welding processes the bonder offers.

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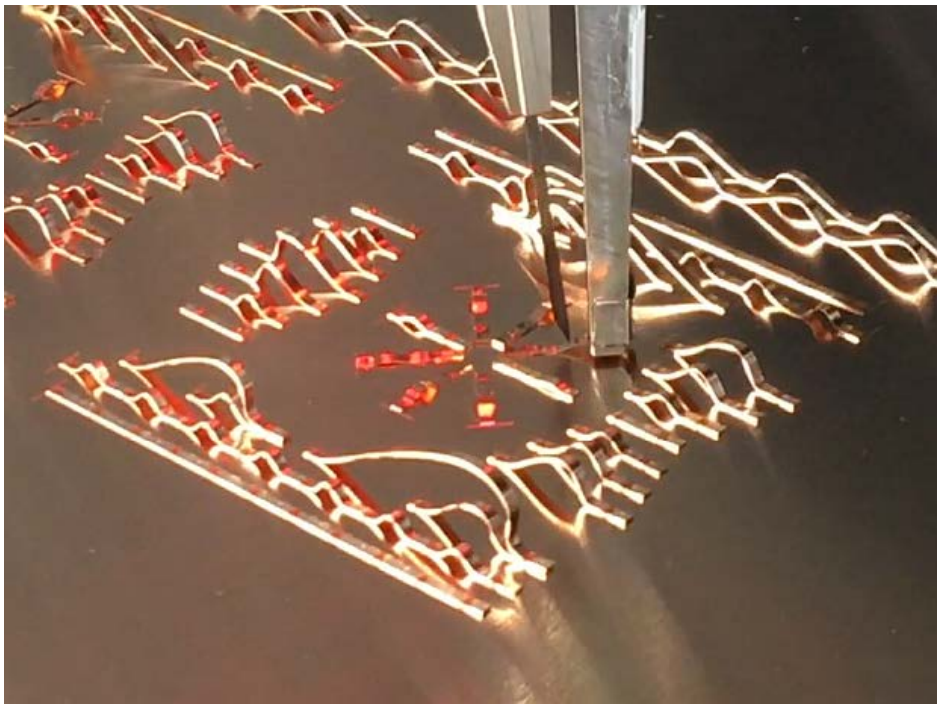


Samples of laser bonds

MODEL 2017 / LASERBONDER (M17 LSB): APPLICATION AND FUNCTIONALITY

The main area of application for the M17 LSB is welding of metallic ribbons (usually copper, aluminum or other materials with good conductive properties) by way of laser radiation onto metallic or metallized surfaces in a laser microjoining process. The goal is to create electric bonds between two or more components. To this end, the ribbon is carried along inside the bond head, positioned with the help of a special tool, welded onto the surface and then guided to the next bonding position. This process can be repeated until the ribbon is finally cut off.

A secondary field of application for the M17 LSB is the welding of two or more metallic components onto each other *without* the use of a ribbon. This method is called Laser-TAB. In this case, the M17 LSB acts like a laser-welding automat that uses a local, automated clamping device.

The components are pressed together by the bond tool and then welded locally in the area where the tool is in contact with the component's surface.

To allow for fully automated operation, the M17 LSB includes a camera system (PRU) for recognition of geometric component characteristics. This facilitates automatic positioning of the ribbon on the component on the fly.

The M17LSB can be operated as a single workstation or, if equipped with the appropriate material handling, as part of a production line.

The M17LSB is classified as a class 1 Laser system according to DIN EN ISO 60825-1:2014. Employing the machine outside the framework of its designated use, or modifying the machine (e.g. removal of safety devices) may result in a higher safety level (class 4).

STRUCTURE OF THE M17 LSB

The Laser bond head of the M17 LSB includes an X/Y/Z axis system for positioning the tool, guiding the ribbon, onto the component. With an additional rotational axis (P-axis) the ribbon is aligned by the tool in the direction of the desired connection.

This allows complete 360° freedom in bonding direction.

The optical system shapes, guides and finally focuses the laser beam onto the surface. As the optical system of the laser is mounted and moves with the tool along the Z axis, the laser focus and clamping tool are inherently aligned and guarantee ideal optical welding conditions.

The source of the laser radiation needed for the welding is a fiber laser. The specified maximum output power of the laser source is 1 kW (cw), although optionally, lasers with different maximum output powers can be installed. The wavelength of the laser radiation being used is in the range of 1000 nm to 1200 nm.

BOUNDARY CONDITIONS AND SCOPE OF APPLICATION

Laser bonder: Boundary conditions and primary fields of application

The laser bonder is designed for joining metallic ribbons or wires to metallic surfaces. The primary focus is on the use of ribbons made of copper (alloys) and aluminum (alloys).

Laser oscillation welding is used as the joining process. This represents the current state of the art in the field of laser microwelding.

The machine is designed for the use of heavy ribbon material (ribbons with thicknesses ≥ 100 µm). The lower limits of the system technology have not yet been determined. The upper limit of the thickness of the ribbons being used is currently 500 µm.

Regarding the metallic surfaces, the application focus is on components with comparatively thick metallic plating or thick material thicknesses (plating or material thickness > 60 µm), since oscillation welding, depending on the ribbon thickness, has process limits in relation to the welding depth or the danger of possible destruction of underlying layers.

LASER BONDING PROCESS SEQUENCE

Bond process overview

Similar to ultrasonic wire bonding, the process steps for creating a ribbon joint are divided as follows:

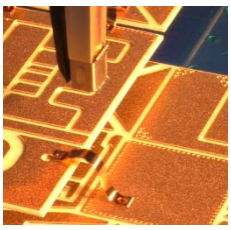
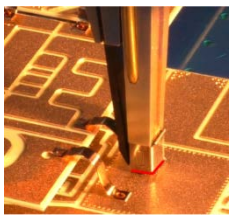
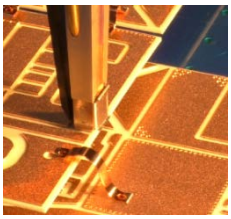
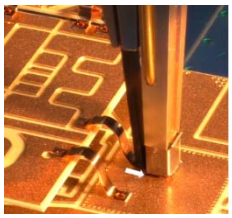
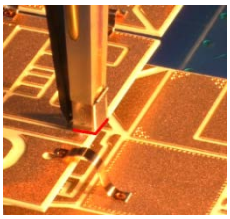
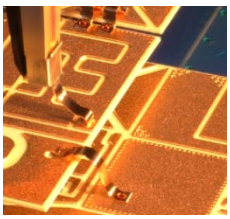
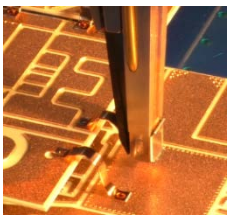
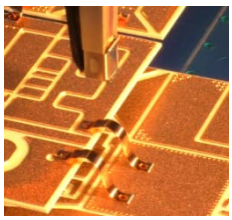
1 	Laser bond head and ribbon guidance (tool) are lowered onto the component.	6 	The metal ribbon is welded onto the component's surface by way of laser radiation. The beam scans the weld area within the tool.
2 	The set parameters for bonding force are applied whilst actively compensating for any substrate deflection.	7 	When the proper welding procedure is finished, the tool performs a small forwards step forwards to position the cutter.
3 	The metal ribbon is welded by way of laser radiation with an agitated beam. The laser beam scans the weld area within the tool.	8 	The welded loop ribbon is cut and thereby separated from the continual spool feed through the tool.
4 	Laser bond head with ribbon guidance (tool) performs the so called reverse loop to ensure a sufficient loop angle.	9 	The metal ribbon is welded onto the substrate. The process is finished.
5 	The ribbon guidance pulls the metal ribbon to the second connection and with the ribbon clamp the desired loop shape is formed.	10 	The tool moves to the next connection – step 1

Fig.1: laser bonding work steps

Regular joining process

The appropriate joining process between the ribbon / wire and the surface beneath the ribbon is laser beam micro welding with a moving beam and a CW weld.

In the case of the moving beam, the laser beam is moved relative to the surface. During this process, a seam instead of a welding point is formed. It has to be differentiated between intermittent seam welding and CW welding. For a spot weld, the laser beam is pulsed during the welding procedure, which results in individual, side-by-side welding points that overlap partly. For a CW weld, the laser is not switched off during the welding procedure (continuous stitch operation = continuous wave, abbr. CW). Thus, a continuous seam is formed. The process of oscillation welding mentioned below is a subordinate variant of CW welding.

Enhanced process with oscillation

Oscillation welding – also known as wobble – is the enhanced joining process and state of the art of laser beam micro welding. Here, the feed motion is superimposed by a circular movement, thus enlarging weldable cross-section with a controlled penetration depth with the same energy input compared to the regular joining process. Fig. 2 illustrates the laser beam path during oscillation welding on the surface.

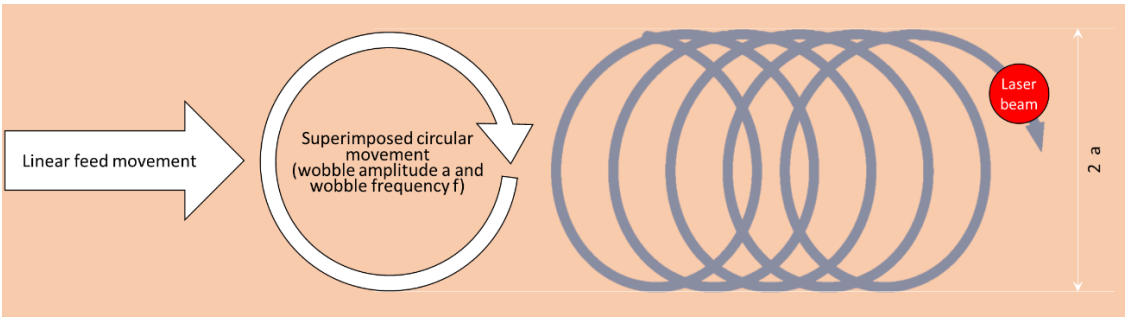


Fig. 2: Line movement in the oscillation welding procedure

The laser bonder comprises system technology that allows users to configure the process in a way that the laser beam is guided over the ribbon and applies local welds. As a result, the ribbon is bonded with the metallic surface underneath by a lap joint.

Joining processes available to users

Users can switch between different parameter sets in the process regimes. In doing so, they can generate a regular cw seam as well as the enhanced oscillation process. -

Laser-TAB bonding

The term “Laser-TAB” originates from the process of Tape automated bonding (TAB) used in the context of semiconductors. For semiconductors, a prefabricated foil equipped with circuit paths is bonded to the semiconductor by way of thermo-

compression bonding. No wire or the like is used. Instead, both components are pre-positioned and connected at single bond points.

Although no wire or ribbon have to be placed an aligned, a tool is still used as a mobile and flexible clamping device, to guarantee a “zero gap” and for correct setting of the laser’s focal position in relation to the surface. Both critical conditions for a successful welding joint.

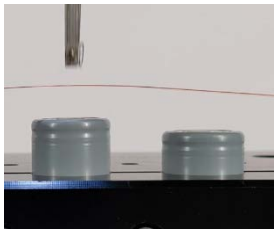
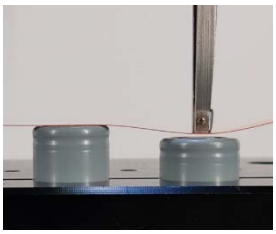
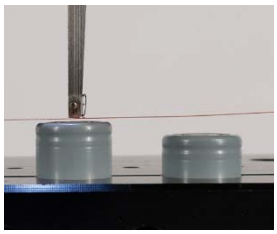
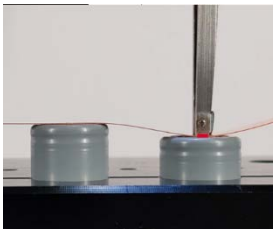
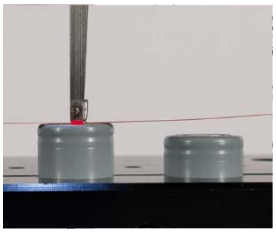
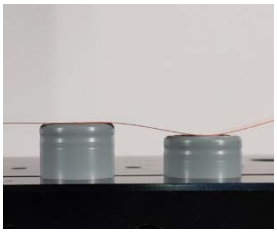
1 	Connector (here: sheet metal) is placed onto the component (in our example, batteries). The tool is positioned above the joining point. There is no ribbon threaded into the tool.	4 	Lifting the tool and forward movement of the bond head to the next joining position and secures zero gap.
2 	The set force and position parameters are controlled in order to achieve zero gap clamping.	5 	The next weld is performed.
3 	With zero gap achieved, the laser beam scans inside the tool and performs the weld.	6 	The Bond head moves to the next joining components and he process is repeated.

Fig. 3: Laser-TAB bonding procedure

Summary of design & manufacture considerations enabled through laser bonding process

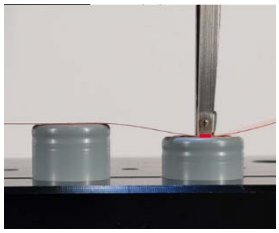
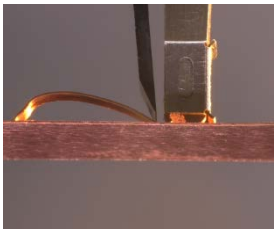
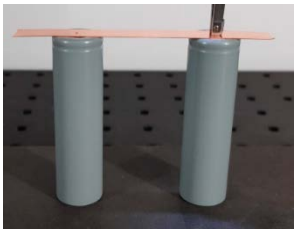
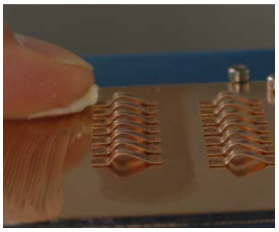
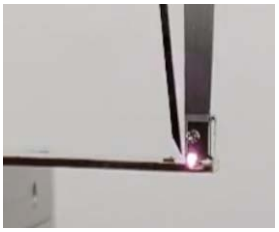
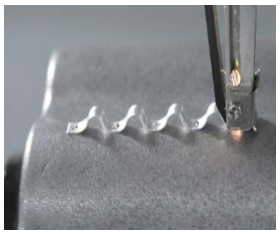
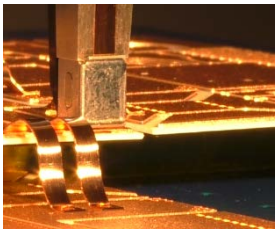
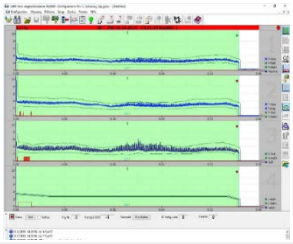
Consideration 1 	Z tolerance robust.	Consideration 5 	Precision welding/penetration depth on thin material
Consideration 2 	No specific assembly clamping	Consideration 6 	Contamination-robust bonding process
Consideration 3 	Bonding on unstable surfaces	Consideration 7 	Bonding on unprepared surfaces such as Al castings
Consideration 4 	High current connections with negligible bonding force	Consideration 8 	Tractability with plasma, temperature, back-reflection process monitoring

Fig. 4: Summary of possibilities of Laser welding process