
LASER-BASED JOINING PROCESSES FOR POWER ELECTRONICS AND ELECTROMOBILITY APPLICATIONS

20.02.2019, André Häusler, M.Sc.



Quelle: enbw.com

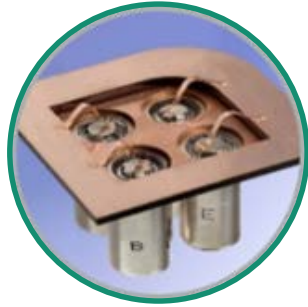


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OUTLINE



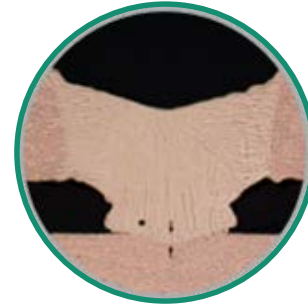
Laser Micro
Welding



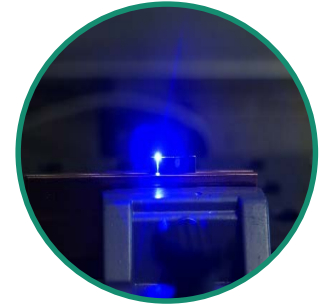
Joining
Technology
for Battery
Systems



Laserbonder



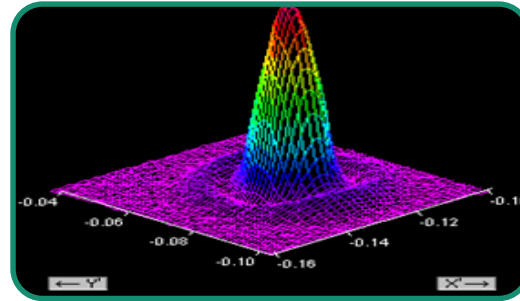
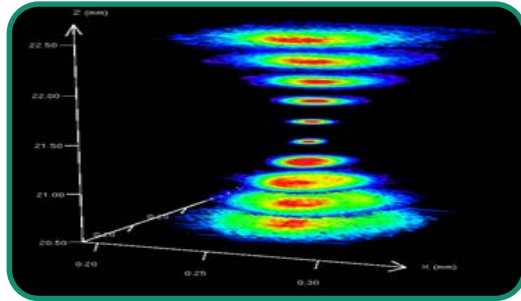
Limbo



New
Approaches

Laser Micro Welding

Micro Joining with Fiber Lasers



Deep penetration welding of copper by using laser beams require high intensities

Small spot diameters ($\leq 40 \mu\text{m}$) can be reached with the usage of lasers with a high beam quality ($M^2 \approx 1$)

Small diameters lead to adverse small joining width

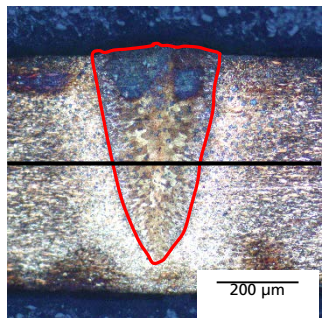
With the usage of spatial power modulation, joining width and process stability increase

Laser Micro Welding

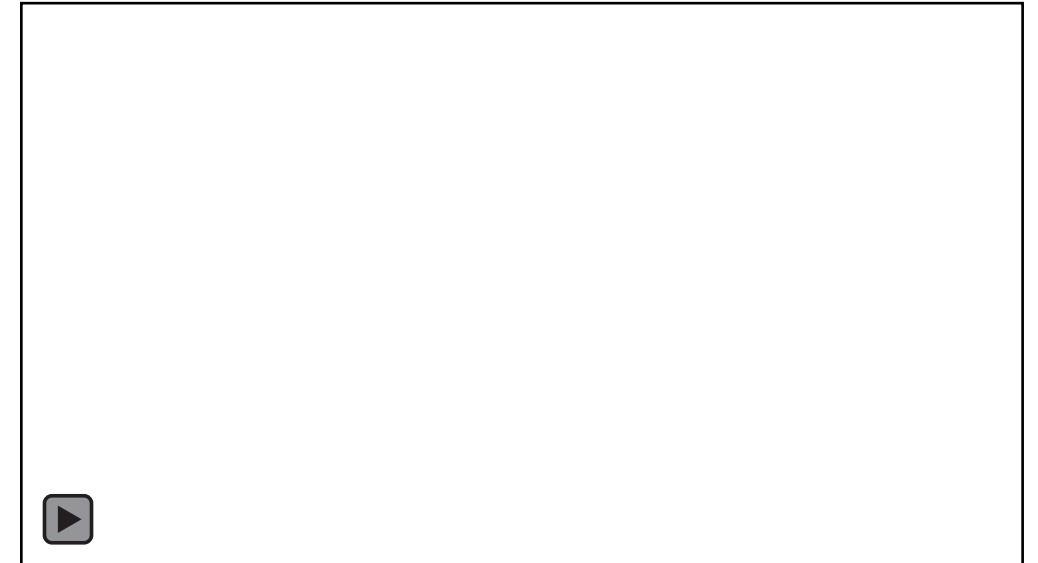
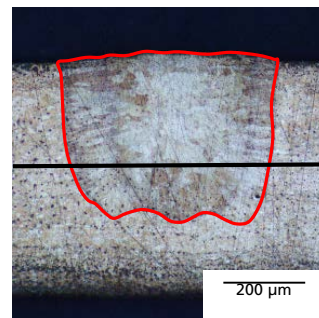
Spatial Power Modulation



- a linear feed with superposed circular motion
- shaping of weld seam geometry
- increase of molten pool area
- additional parameters:
 - oscillation frequency
 - oscillation amplitude



increase of the
connection area

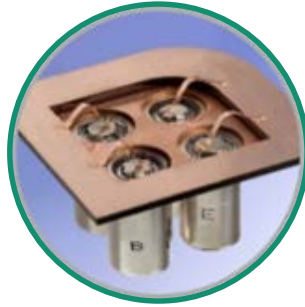


- Precise control of the weld depth possible
- Larger connection area
- Control of the process stability for a better surface roughness

OUTLINE



Laser Micro
Welding



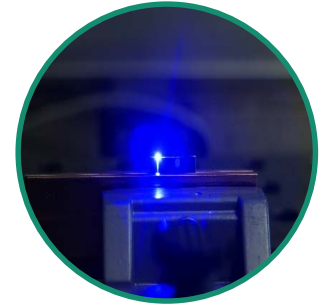
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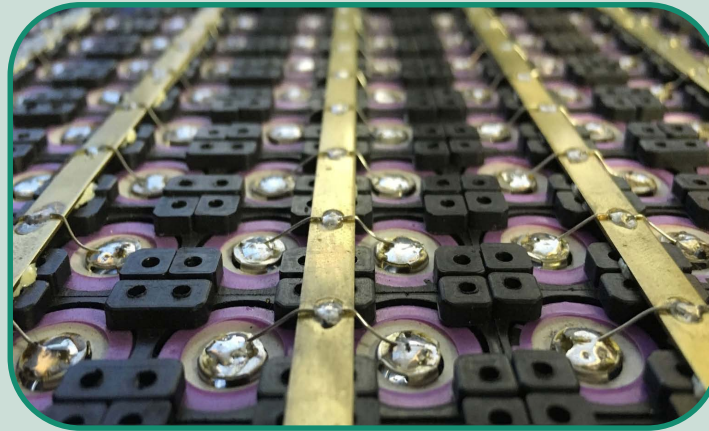
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New
Approaches

Motivation and Introduction

Joining Technology for Battery Systems

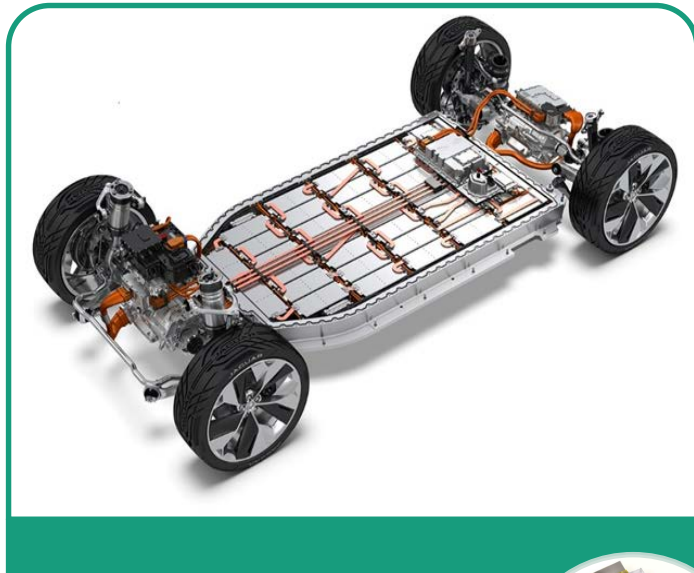


Reddit



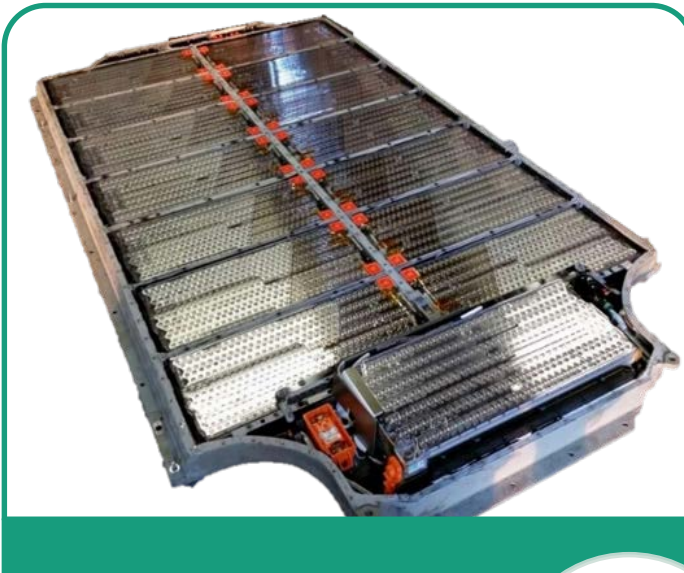
Grabcad

Different Battery Types in Electric Cars



I-Pace

Autocar, Alibaba



Model S

Panasonic, Insideevs



E-Golf

Autophorie, Panasonic

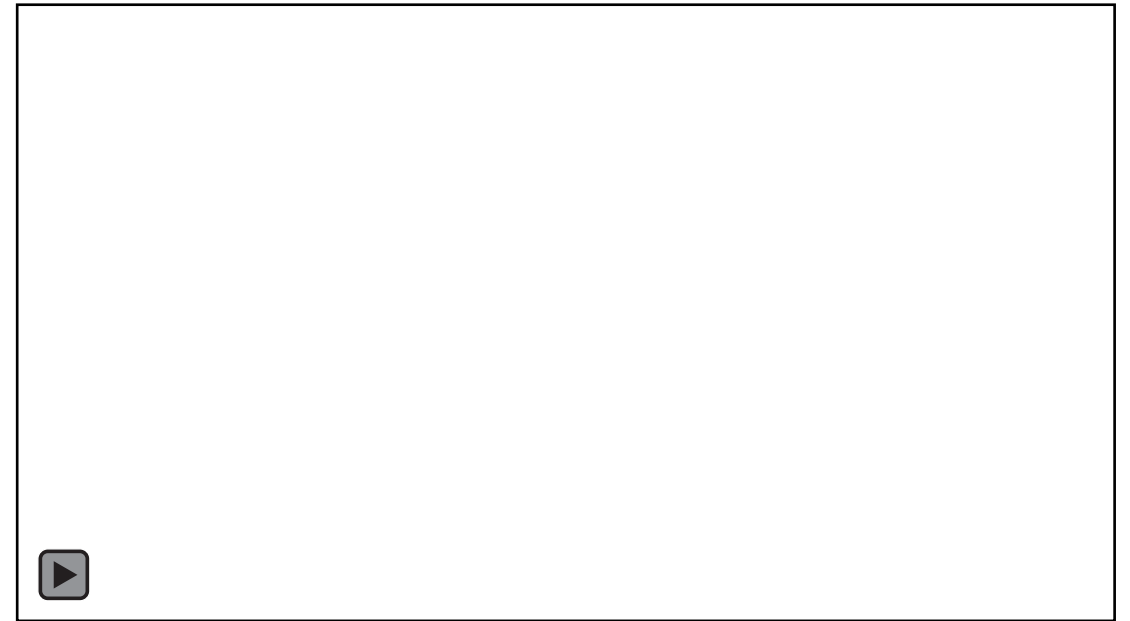
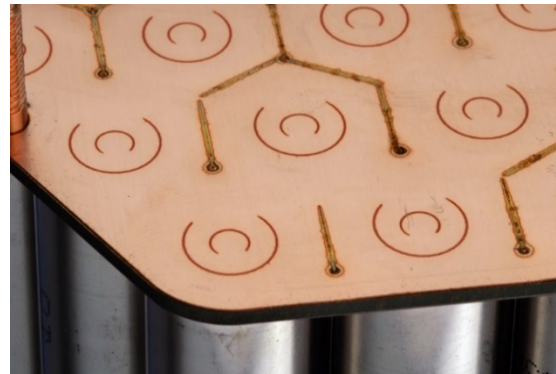




Joining Technology for Battery Systems

18650 Battery Cells

- Challenge: Connection of negative Terminal
- Welding of negative terminal on the bottom side
- Design of a suitable clamping device to realize a minimum gap
- Spatial power modulation for a defined welding depth and connection area

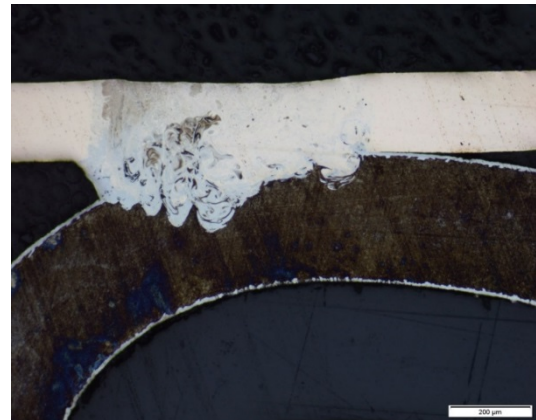
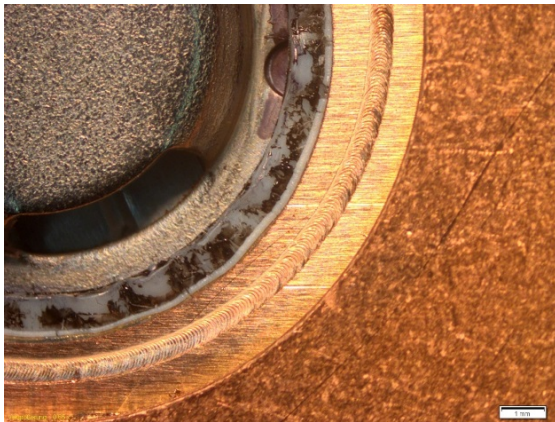


Joining Technology for Battery Systems

18650 Battery Cells



- Connection of negative terminal on the top side (beaded rim)
- Welding along the entire circumference
- Liquid tight weld seam possible
- Challenge: alignment of the weld seam

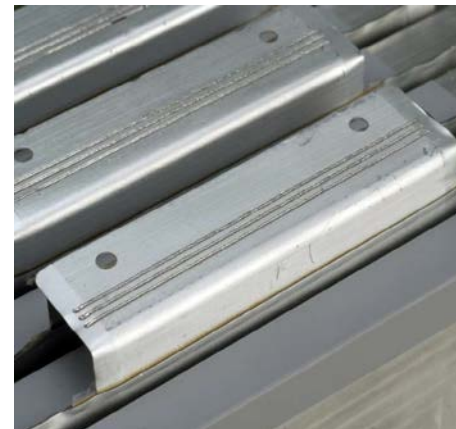
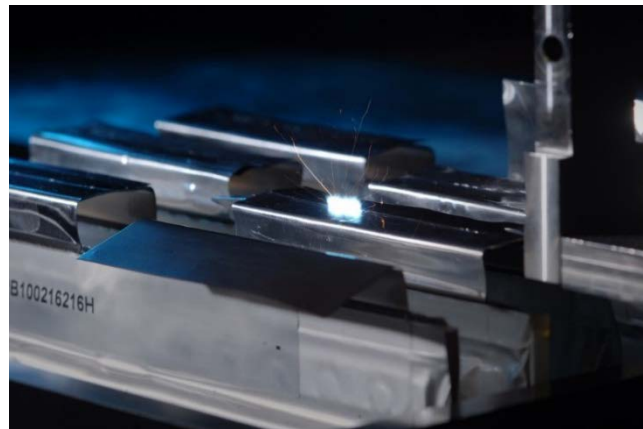
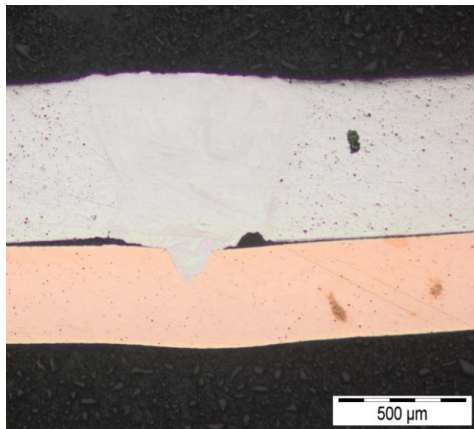


Joining Technology for Battery Systems

Pouch Cells



- Defined bending and clamping of the terminals
- Welding of dissimilar materials (Al/Cu)
- Thin terminals (0,2 mm)
- Short process time – low energy input

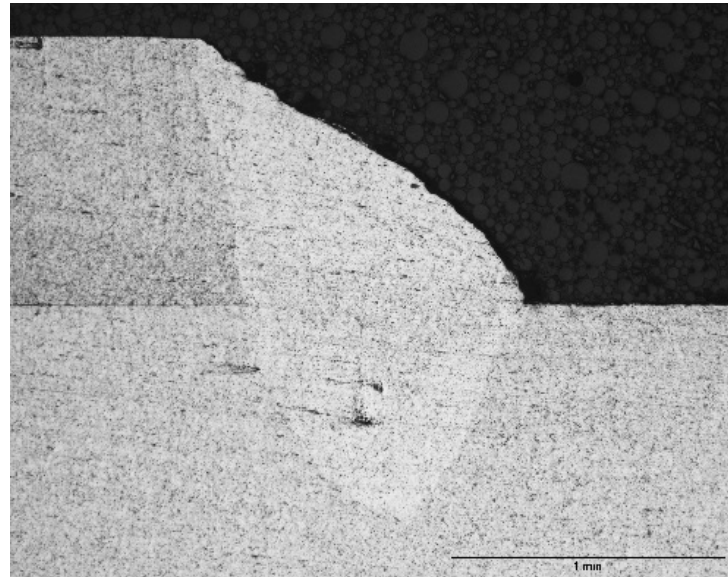


Joining Technology for Battery Systems

Prismatic Cells



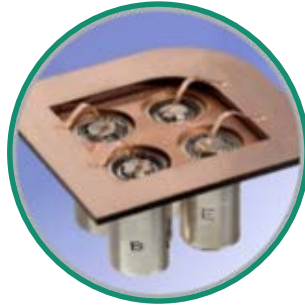
- Welding of bended Al-sheets to the terminal of a prismatic battery cell
- Different welding configurations
- Overlap, fillet weld
- Welding using spatial power modulation
- Reduction of the process time
- Minimum energy input into the terminal
- Control of the welding depth and connection area



OUTLINE



Laser Micro
Welding



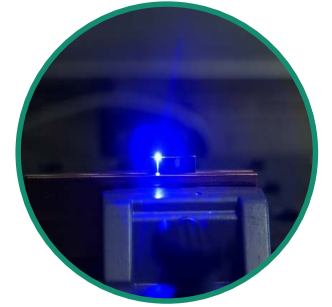
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Systems



Laserbonder



Limbo

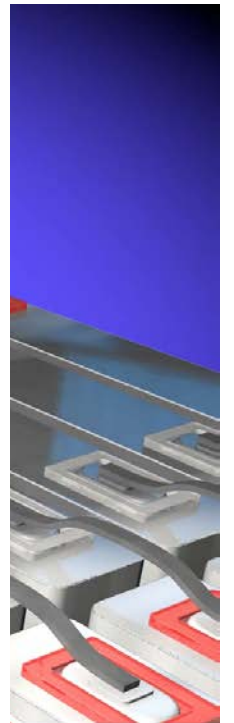


New
Approaches

Laserbonder

Design and Specifications

- Conventional wire bonder has been equipped with an optical head
- Automated ribbon supply
- Laser micro welding process with an automated ribbon supply
- Integrated cutter
- Single mode fiber laser
- Focal diameter: 40 μm



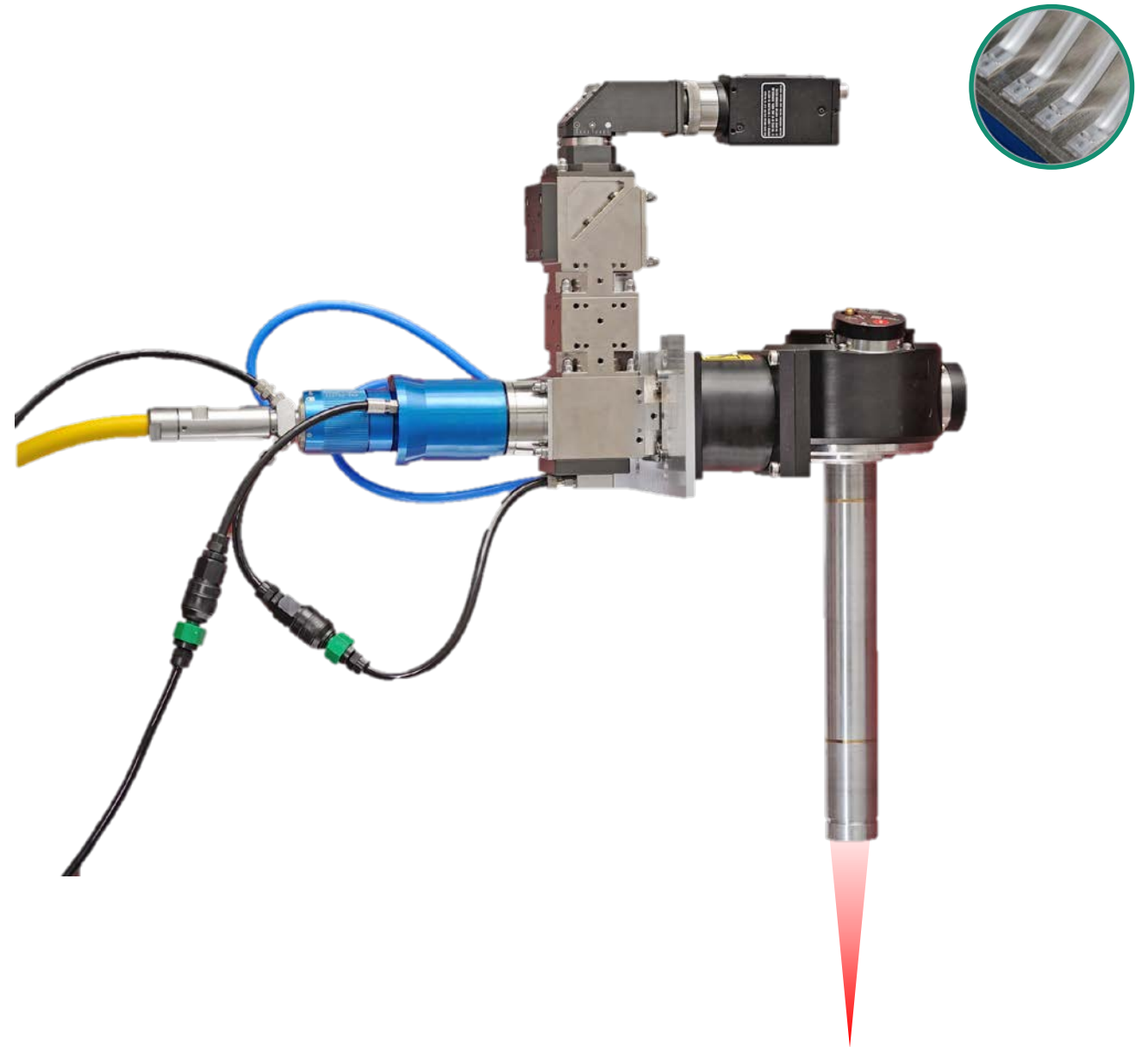
unhofer
ILT

Courtesy of F&K Delvotec

Realization in a Laserbonder

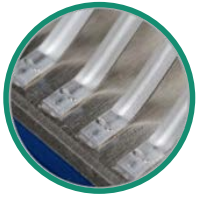
Optical Configuration

- coaxial observation
- including process monitoring (infrared, visible and back reflexion)
- Scanner area of 10 x 10 mm²
- Focal shifter (realize a changeable working distance of 20 mm)
- High power applications (max. 1 kW single mode)



Laserbonder

Laser Beam Joining of Battery Cells



submodule



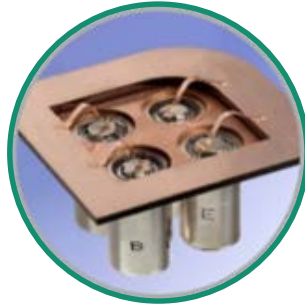
module



OUTLINE



Laser Micro
Welding



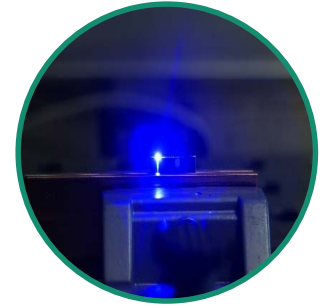
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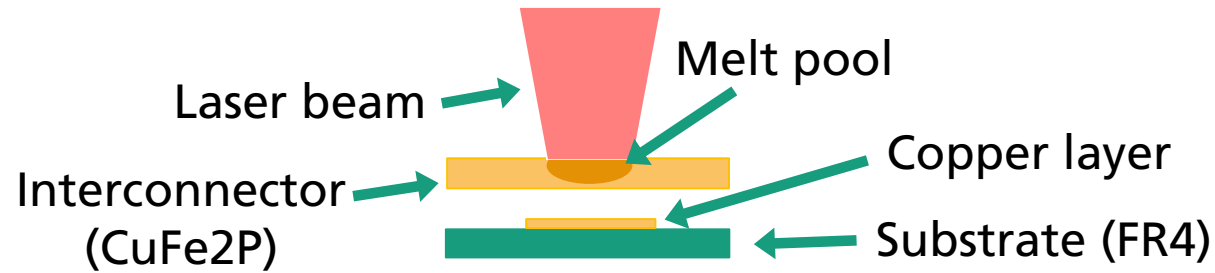
New
Approaches



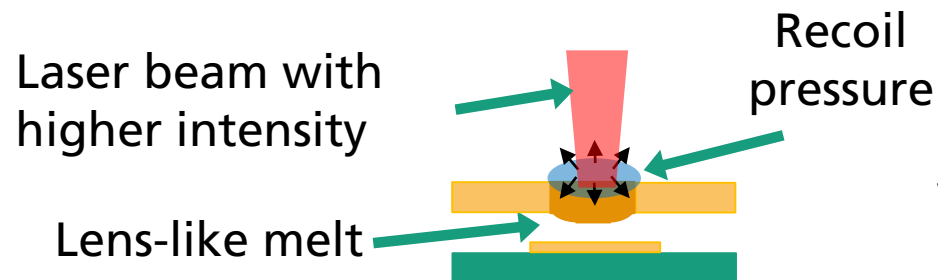
LIMBO

Innovative approach for joining on thin layers

1. Pre heating



2. Melt deflection



3. Joining

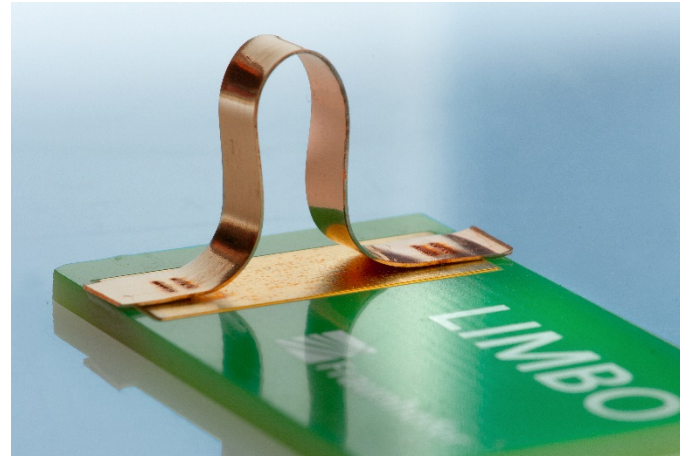


- Fiber Laser $\lambda = 1070 \text{ nm}$
- Gap distance: $h = 100 \text{ }\mu\text{m}$
- Thickness of interconnector $d_V = 200 \text{ }\mu\text{m}$
- Thickness of copper layer $d_K = 100 \text{ }\mu\text{m}$
- Weld joint area $d_A \approx 200 \text{ }\mu\text{m}$
- Process duration: $20 \text{ ms} < t < 80 \text{ ms}$

LIMBO

Micro welding for power electronic devices

- Expanded weld joint for LIMBO
 - Overlap welding of each LIMBO weld joints
 - Larger weld joint area
 - Enhancement of mechanical properties
 - Reduction of electrical resistance
- Reproducible welding procedure for thin layer on substrate with massive interconnector

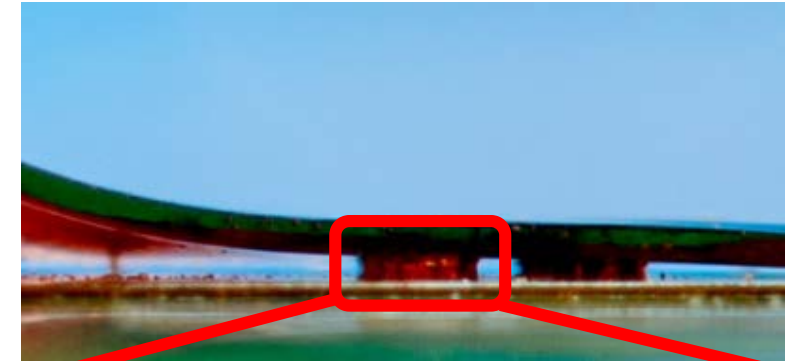
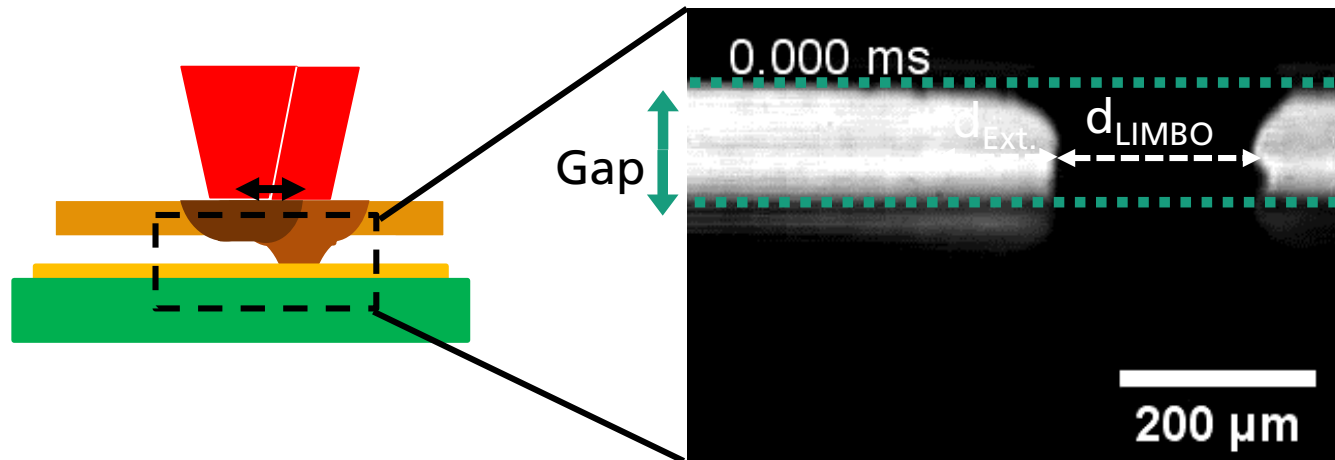


LIMBO

Future Prospects for new Applications



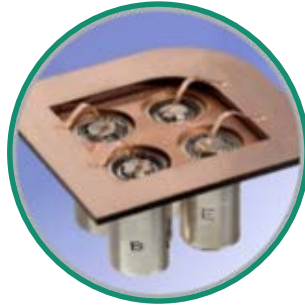
- Side view into 100 μm gap between joining partners
 - Shadow videography for overlap welding



OUTLINE



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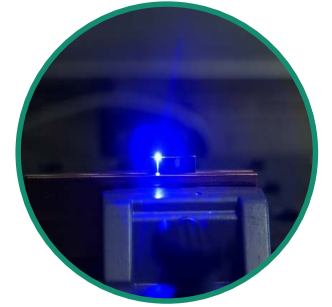
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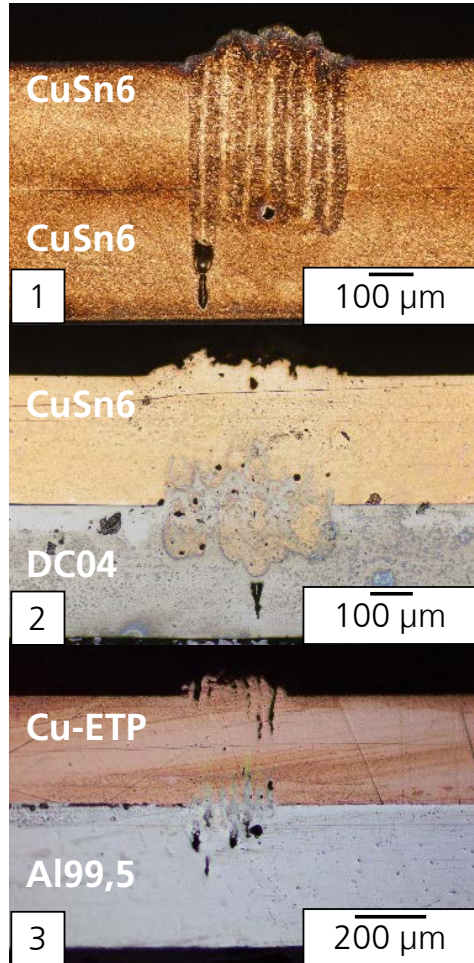
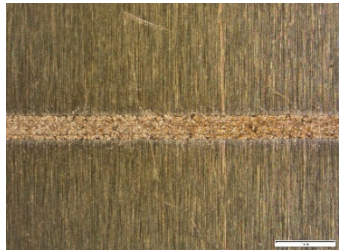
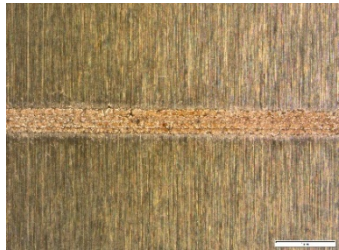
Limbo



New
Approaches

New Approches

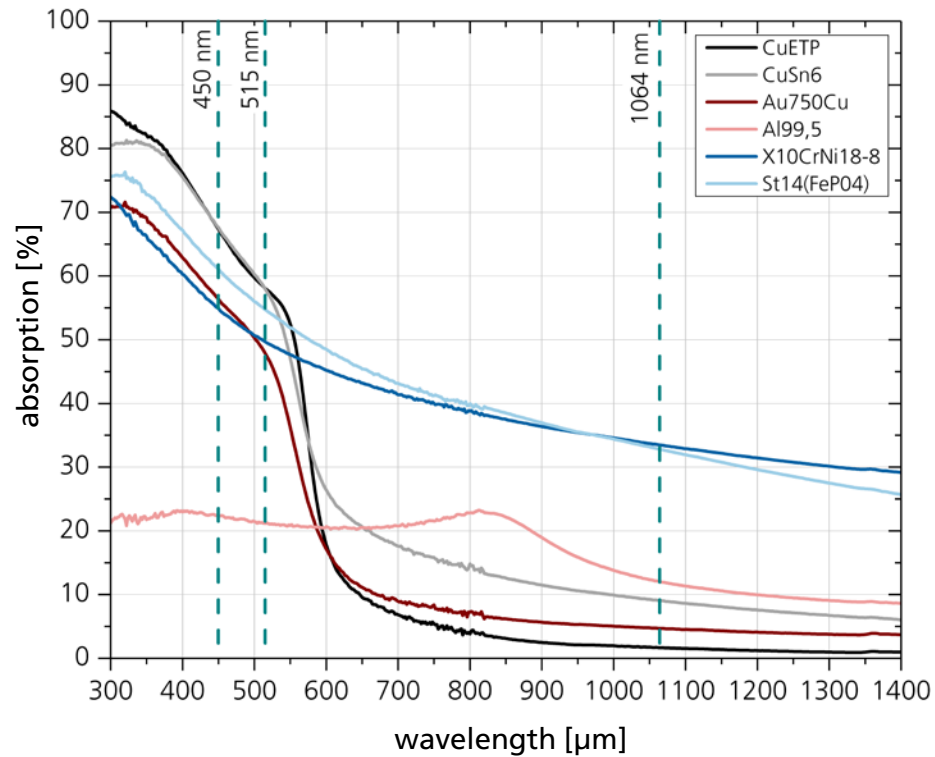
Welding with ns-Pulses



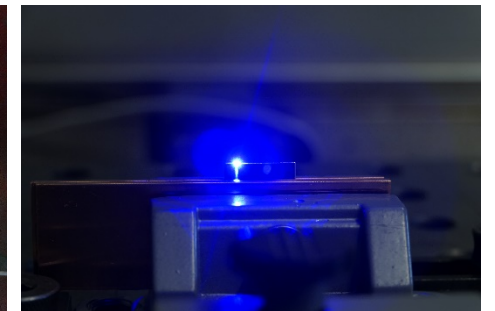
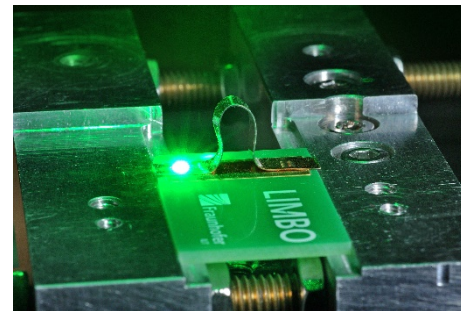
- Welding with ns-pulses ($t_p \leq 1 \mu\text{s}$)
- $P_m = 260 \text{ W}$; $v = 60 \text{ mm/s}$
- Reduction of energy input
- Control of mixing in the case of species-unidentical compounds
- Strength values and contact resistances identical to the cw welding process

New Approches

Welding with Visible Wavelength



- green wavelength $\lambda = 515/532$ nm
- blue wavelength $\lambda = 450$ nm
- changed process regime in comparison to conventional welding
- intensity insufficient to produce a keyhole
- heat conduction welding process
- new application possibilities and welding configurations possible



THANK YOU FOR YOUR ATTENTION!



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SAVE THE DATE

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LASERSYMPIOSIUM
ELEKTROMOBILITÄT**

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