Laser Microjoining - Innovative Processes and Applications for Welding, Soldering, Bonding and Polymer Welding

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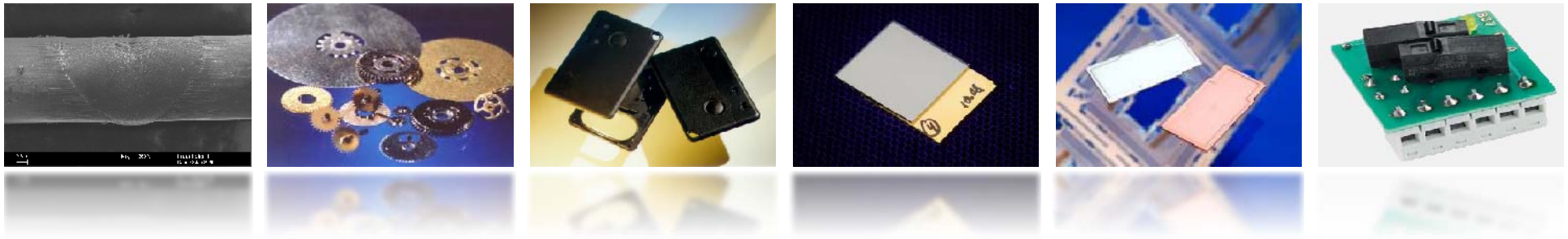

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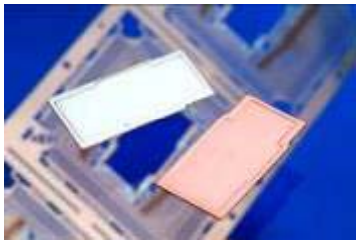
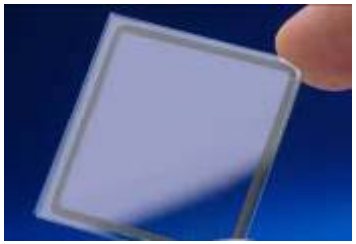
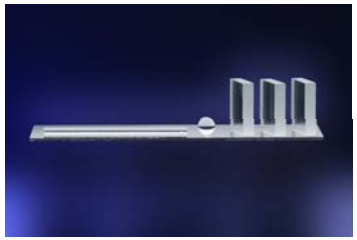
Laser Micro Joining Technologies

Polymers | Metals | Dielectrics | Semiconductors

Welding | Soldering | Bonding

Melting of Joining Partners

Melting of Additional Solder Material

No Melting of Joining Partners

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Laser Micro Welding - Fields of Application

Automotive

- Electric Contacts

Micro Mechanics

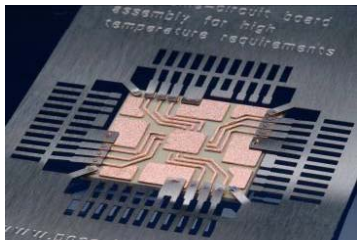
- Mechanical Contacts

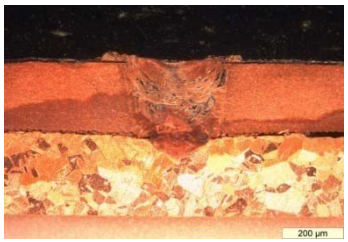
Medical Engineering

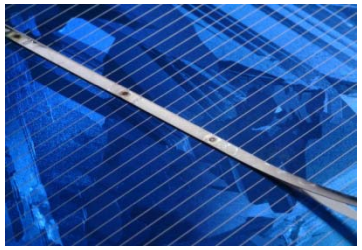
- Electric Contacts, Seals

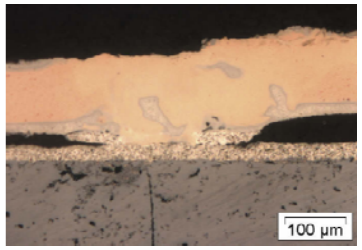
(Consumer-)Electronics

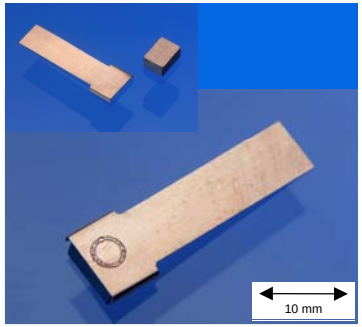
- Electric Contacts

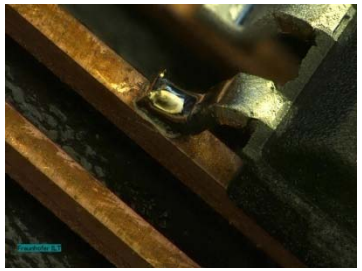












- Overlap- and butt joints
- Wire connections
- Highly reflective materials
- Limited welding depth

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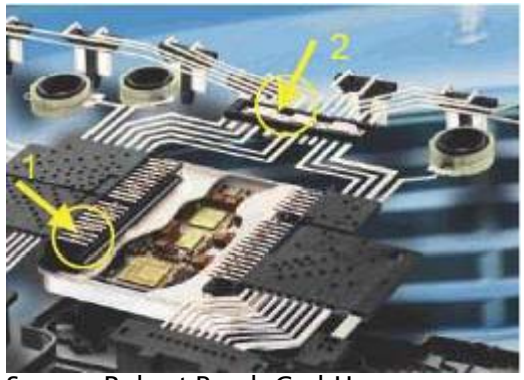
Spot Welding

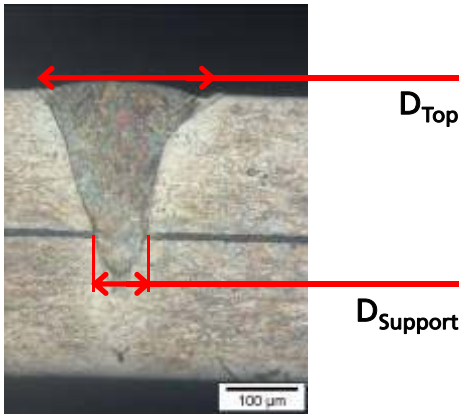
- Electronic Components
- High Throughput
- Controllable Weld Properties

Common Problems with Spot Welding

- Small Supporting Joint Diameter
- Sensitive to Depth Variation
- Porosity due to Melt Pool Overheating



Source: Robert Bosch GmbH



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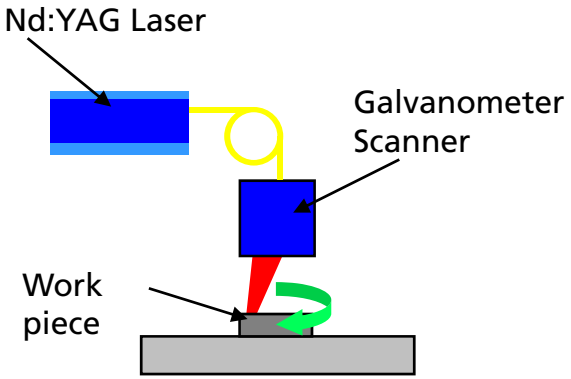
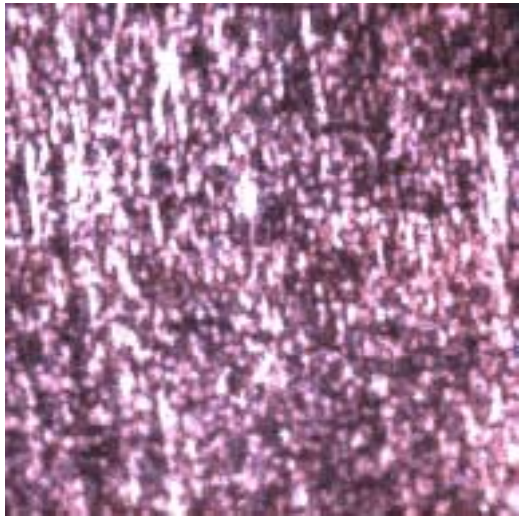
Micro Ring Welding



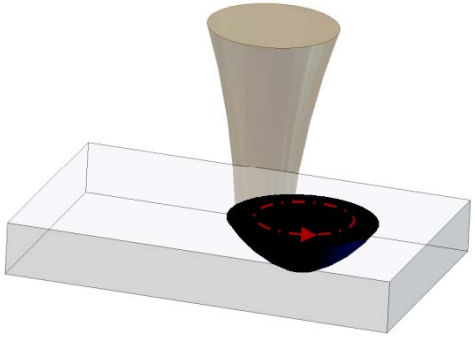
- Multiple Revolutions
- Ring Diameter ~ Beam Diameter
- Overlapping Irradiation Pattern

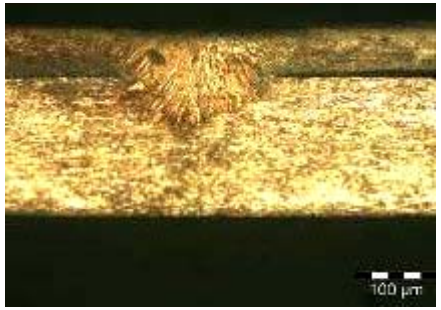


P = 3.75 kW

2w = 400 µm

D_{circle} = 300 µm





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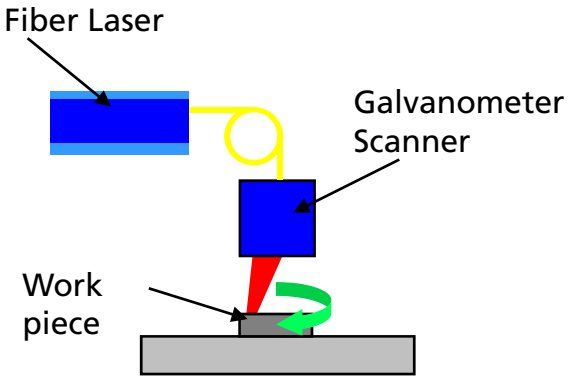
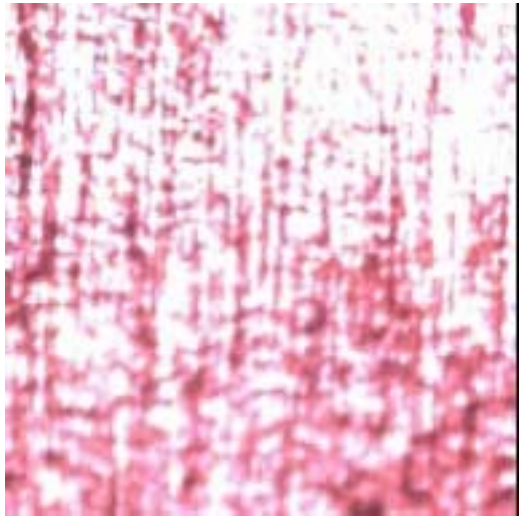
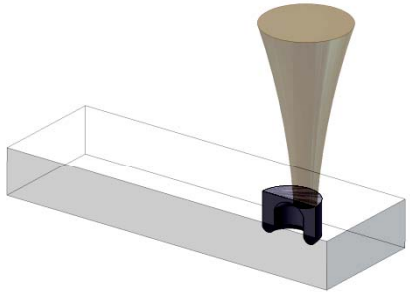
Micro Ring Welding





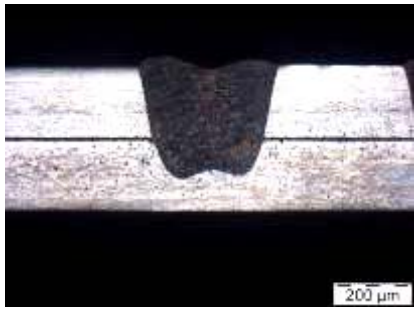


- Multiple Revolutions
- Ring Diameter > Beam Diameter
- Non-Overlapping Irradiation Pattern

P = 100 W

2w = 30 µm

D_{circle} = 500 µm



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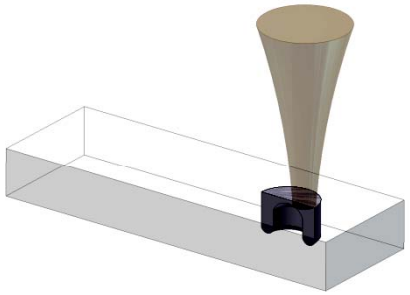
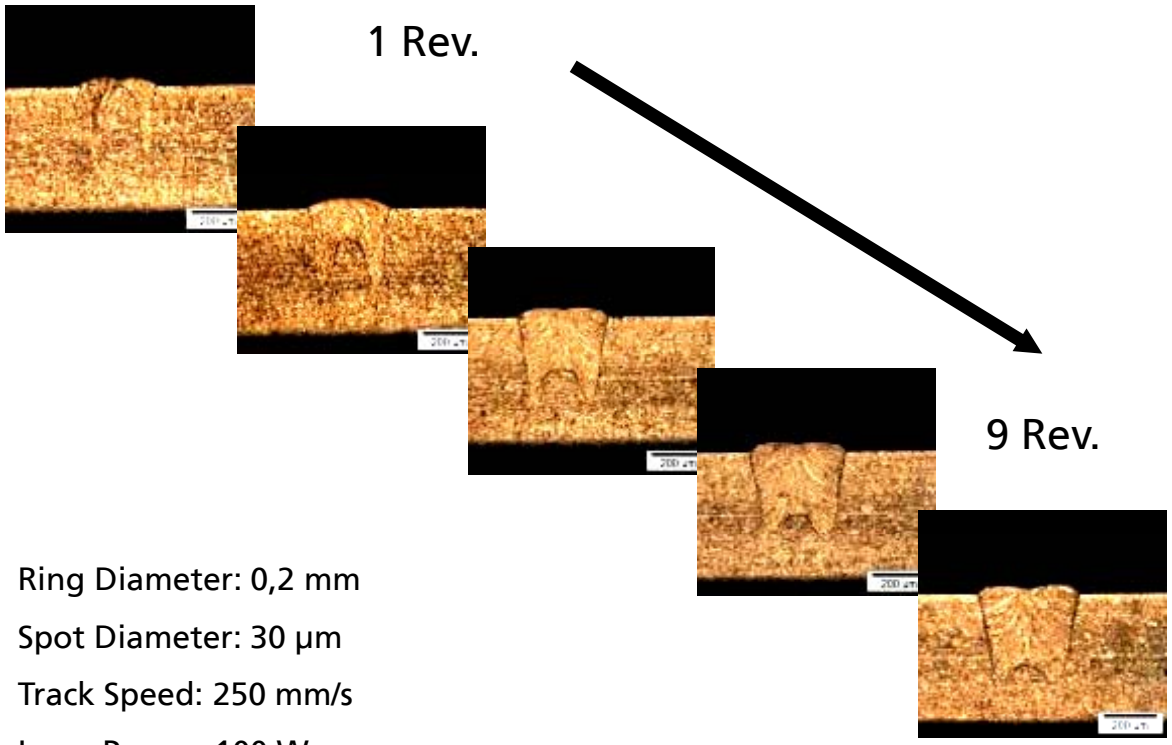
Micro Ring Welding
Melt Pool Formation





- Peripheral Depth: Path of the Laser Beam
- Central Depth: Heat Accumulation

Ring Diameter: 0,2 mm

Spot Diameter: 30 µm

Track Speed: 250 mm/s

Laser Power: 100 W

Material: Stainless Steel, t = 500 µm

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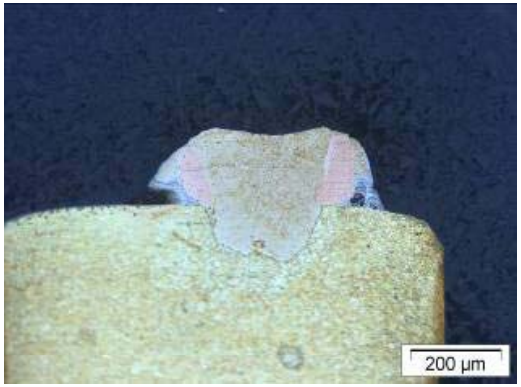
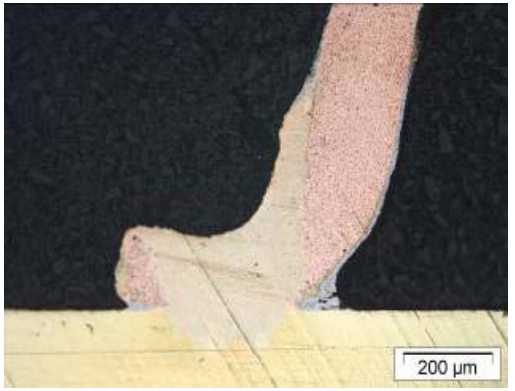
Micro Ring Welding
Welding of Electronic Components





Welding of SMDs

- Contact size: 0,5 mm²
- Material thickness: t = 0,2 mm
- Ring Diameter: 0,3 mm

- No porosity
- Cylindrical melt pool
- High supporting joint diameter

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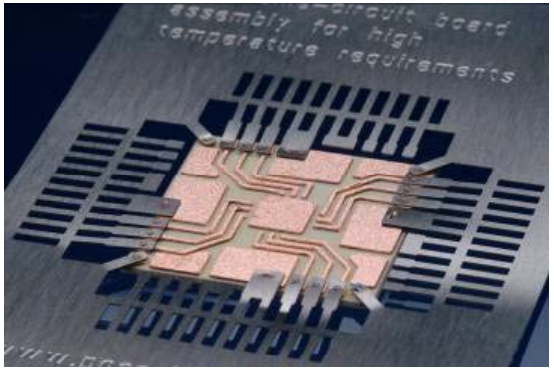
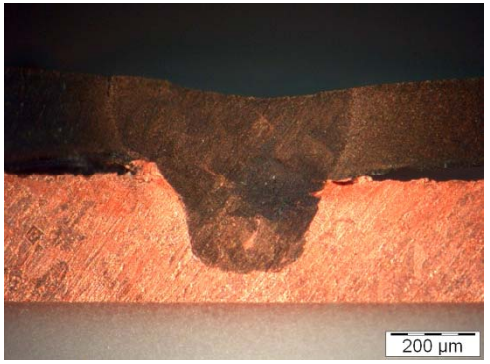
Micro Ring Welding
Welding of Metal Coated Ceramic Substrates





Welding of DCBs

- Contact size: 1 mm²
- Leadframe: t = 0,2 mm
- Cladding: t = 0,3 mm

Spot welding

- 2w = 180 µm
- P = 1,3 – 2,5 kW (Peak)
- T_h = 5 – 10 ms
- E_p = 5 – 10 J

Ring welding

- 2w = 20 µm
- P = 320 W
- T_h = 18 ms
- E_p = 5,8 J

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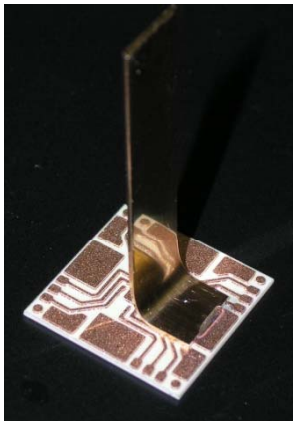
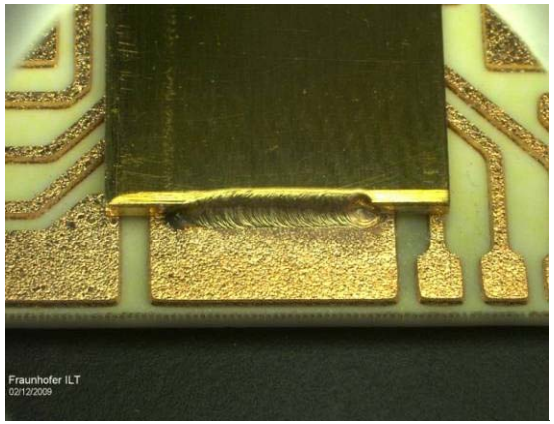
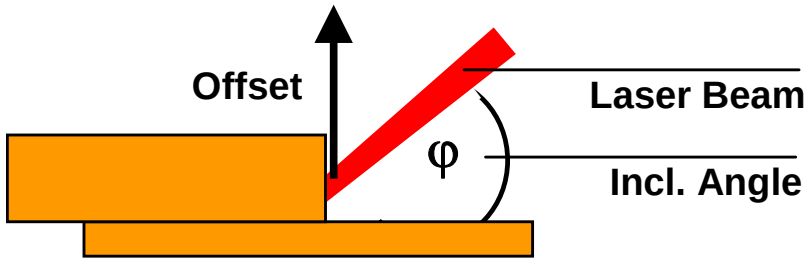
Micro Ring Welding
Fillet Welds with Moving Rings







Sample:

- DCB: Cu-Clading t = 0,3 mm
- Contact Fin: CuSn6, t = 0,8 mm
- Overlap Weld not reliable due to material thickness
- Fillet Weld by Spatial Power Modulation

Parameters:

P = 500 - 700 W

S = 0.2 – 0.6 mm

V_f = 30 mm/s

A = 0,3 mm

f = 1 000 Hz

α = 20 °

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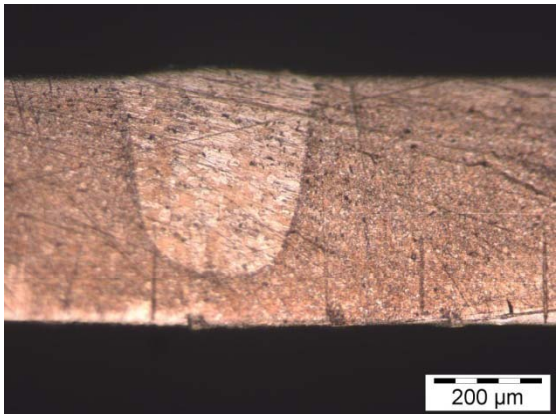
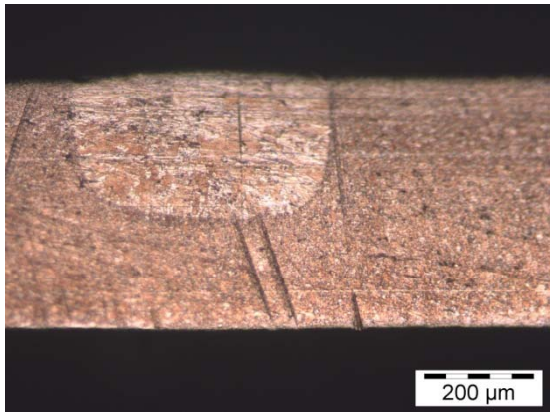
Laser Beam Micro Welding with Superposed Oscillation

Rectangular weld shape

- High supporting joint diameter even at the bottom
- Not sensitive to variation of the welding depth
- Welding geometry depending on preset amplitude
- Transition between deep penetration and heat conduction welding at amplitudes of 0.15 mm



- CuSn6
- Laser power 200 W
- Velocity 30 mm/ s
- Frequency 1 kHz
- Amplitude 0.1 mm



- CuSn6
- Laser power 200 W
- Velocity 30 mm/ s
- Frequency 1 kHz
- Amplitude 0.3 mm

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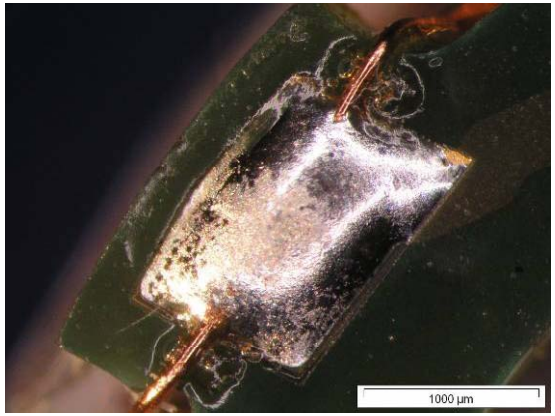
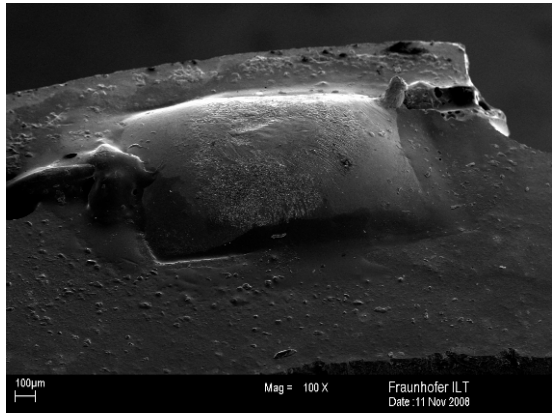
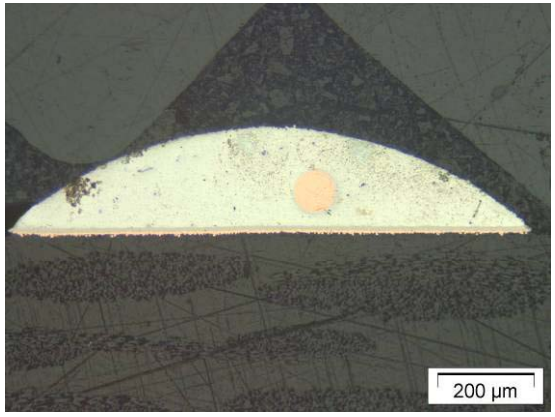
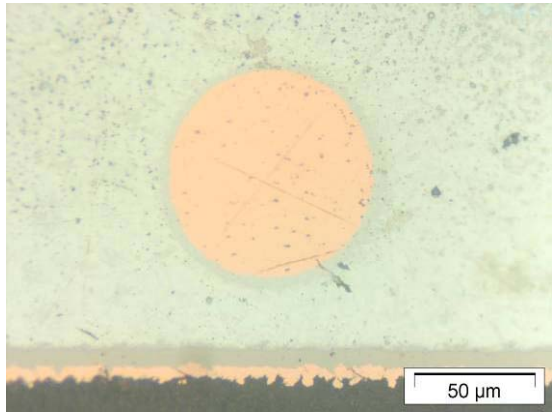
Laser soldering in electronics
Soldering of enamelled Cu wires

- Thin Cu wire with isolation coating
- Stripping and soldering in one step
- Height of the solder joints:
  200 µm
- Full wetting of the entire pad area
- No polymer residues visible in the cross section









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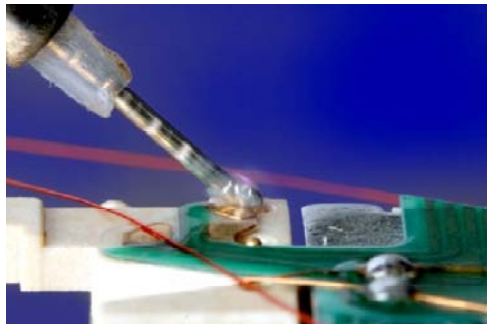
Laser soldering in electronics
Soldering of enamelled Cu wires



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Laser Processes for Photovoltaics

From Solar Cell to Photovoltaic Module

Quality control and handling of solar cells

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Soldering

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String handling and interconnection

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Assembly

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Lamination

↓

Assembly terminal box

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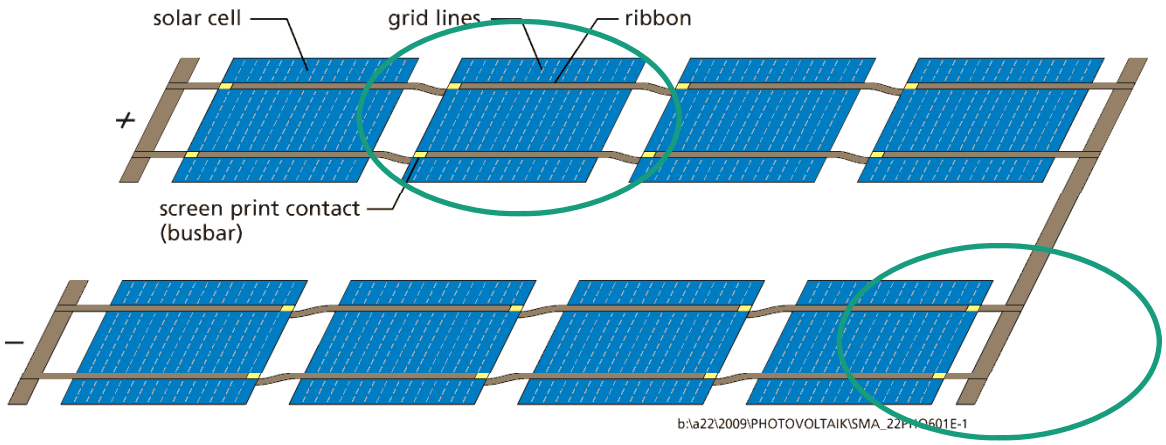
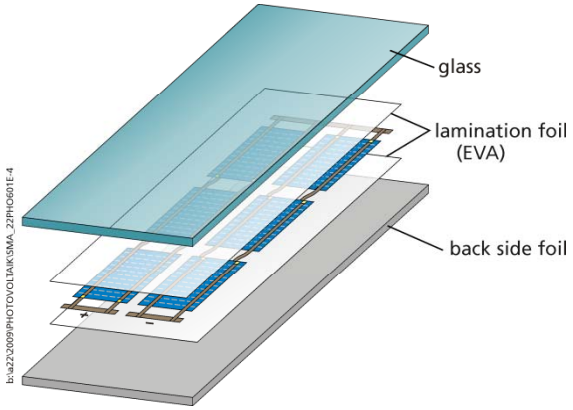
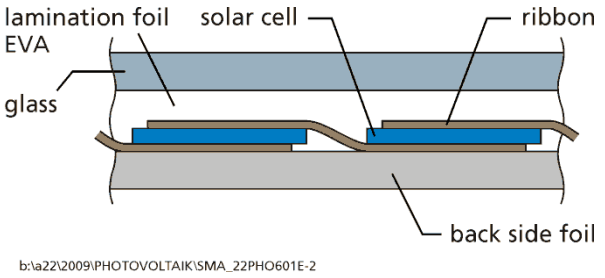
Framing

↓

End control







SOLASYS

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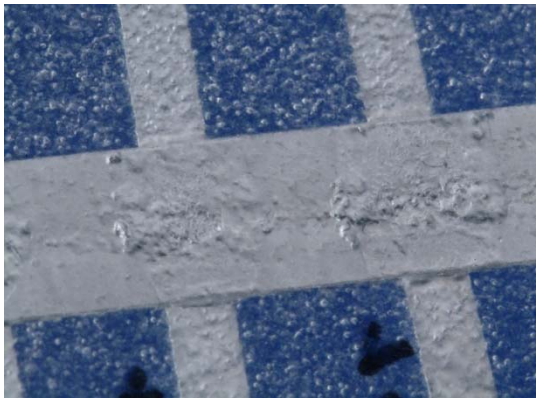
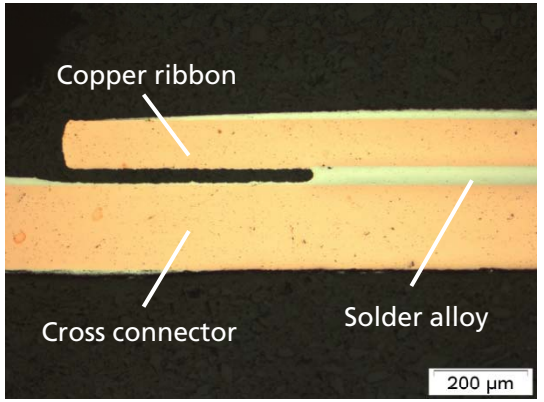
Laser Soldering for Interconnection to Cross Connector

Top-view of soldered connection

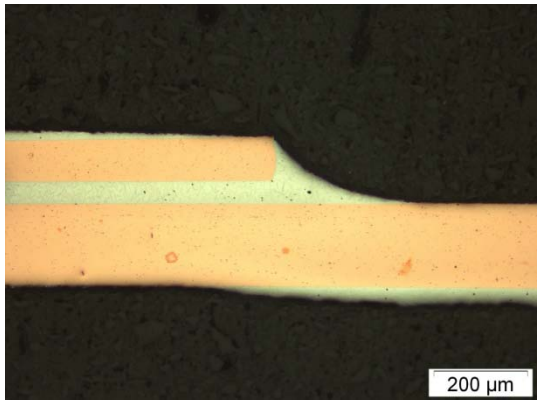


Bottom-view of soldered connection

- Joining of copper ribbon and cross connector
- Damageless process without deterioration of EVA can be achieved
- Diode laser with 120 – 160 W, process duration 0,5 s
- Good wetting angle for higher laser power
- EVA adheres to cross connector



t_H = 0,5 s, P = 120 W



t_H = 0,5 s, P = 160 W

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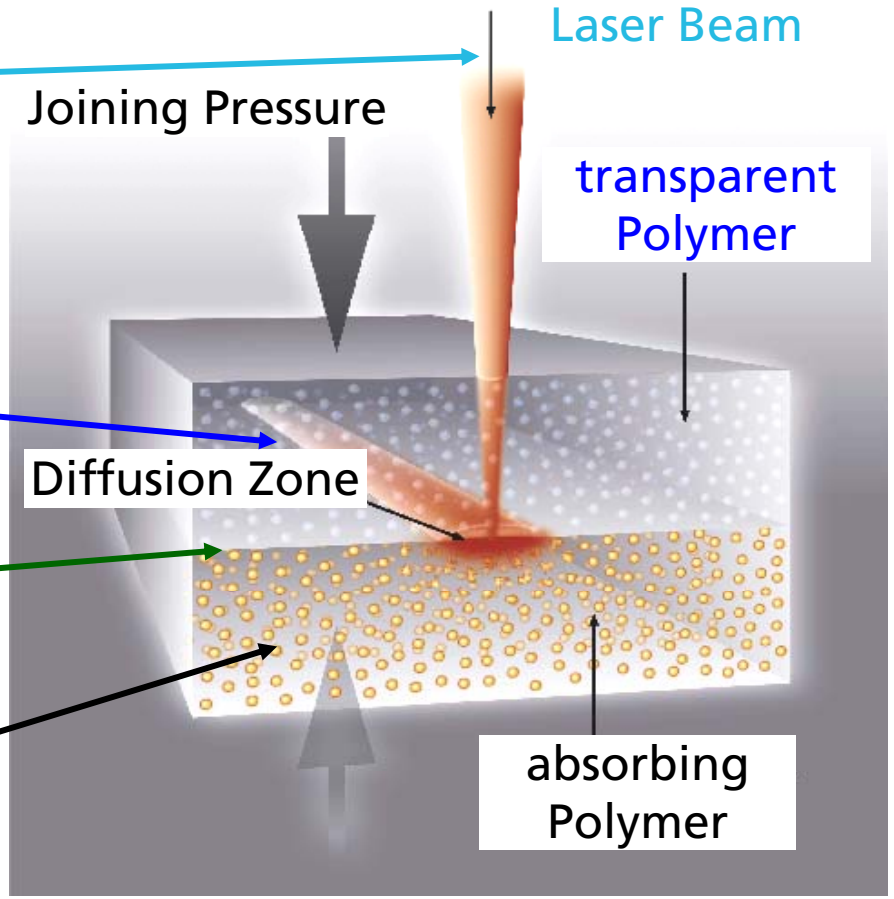
Polymer Welding
Process Technical Basics – Overlap Welding

Wavelength
Intensity Distribution
Beam Quality

Degree of Transmission
Degree of Reflection
Scattering
Material Thickness

Polymer Compatibility
Surface Contact

Degree of Absorption
optical Penetration Depth
thermal Properties



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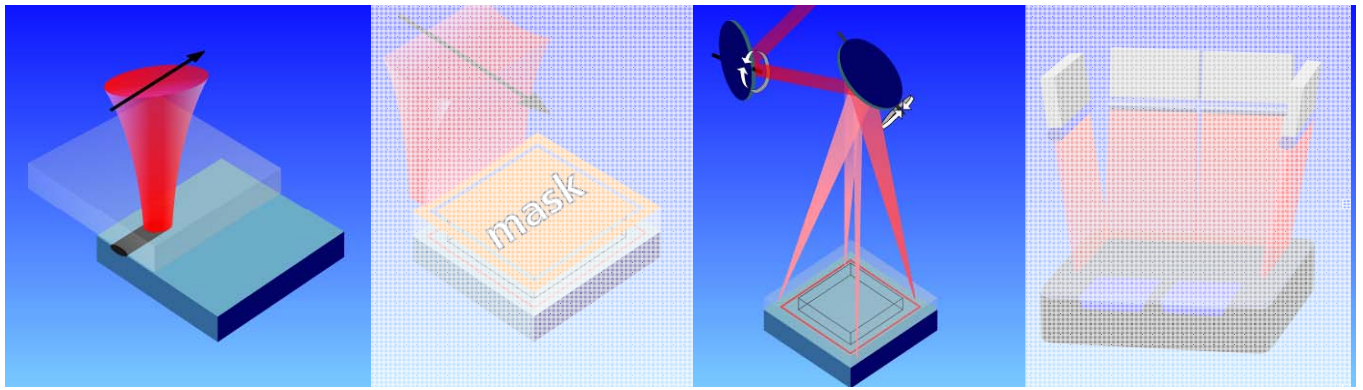
Polymer Welding
Laser Sources and Welding Techniques



	Contour	Mask	Quasi-simultaneous	Simultaneous
Laser source	HPDL / Nd:YAG/Fiber	HLDL	HPDL / Nd:YAG / Fiber Laser	HPDL
Spot diameter [µm]	> 200 / 20 / 10	50 x 40000	> 200 / 20 / 10	-
Laser power[W]	< 200	< 300	> 200	> 200
Feed rate [m/min]	< 25	< 10		-
Interaction time [ms]	> 1	> 2,5	> 0,002	> 50

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TWIST® – A New Welding Process

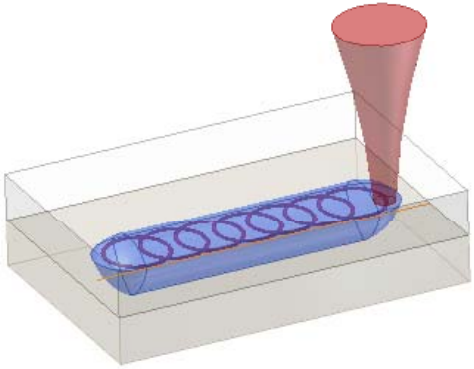
Transmission

Welding

Incremental

Scanning

Technique



$$\begin{cases} x(t) = v \cdot t + r \cdot \cos(2 \cdot \pi \cdot f \cdot t) \\ y(t) = r \cdot \sin(2 \cdot \pi \cdot f \cdot t) \end{cases}$$

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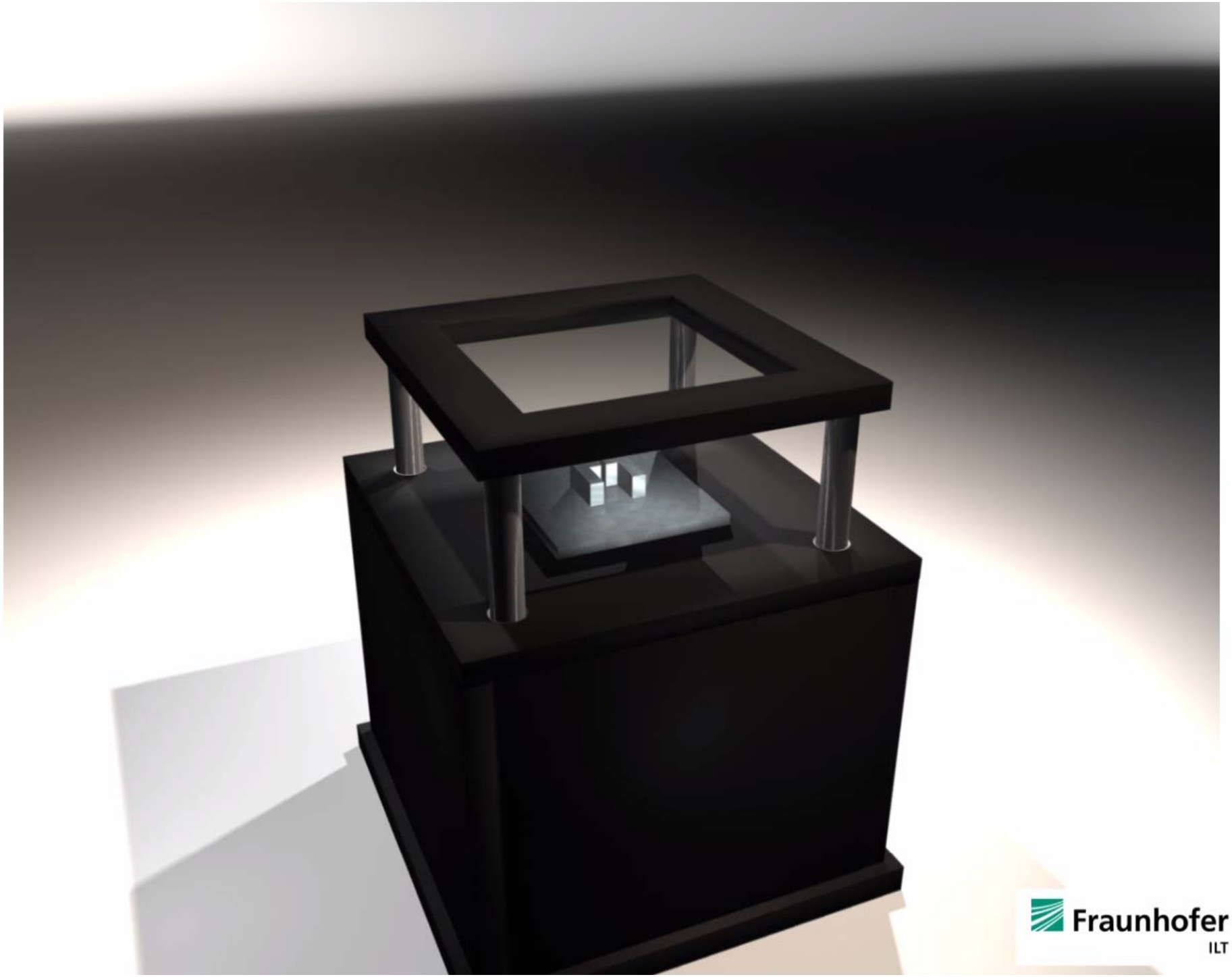

Fraunhofer
ILT

Cross Sections of the Seams

- Welding of Polypropylene (PP) plates

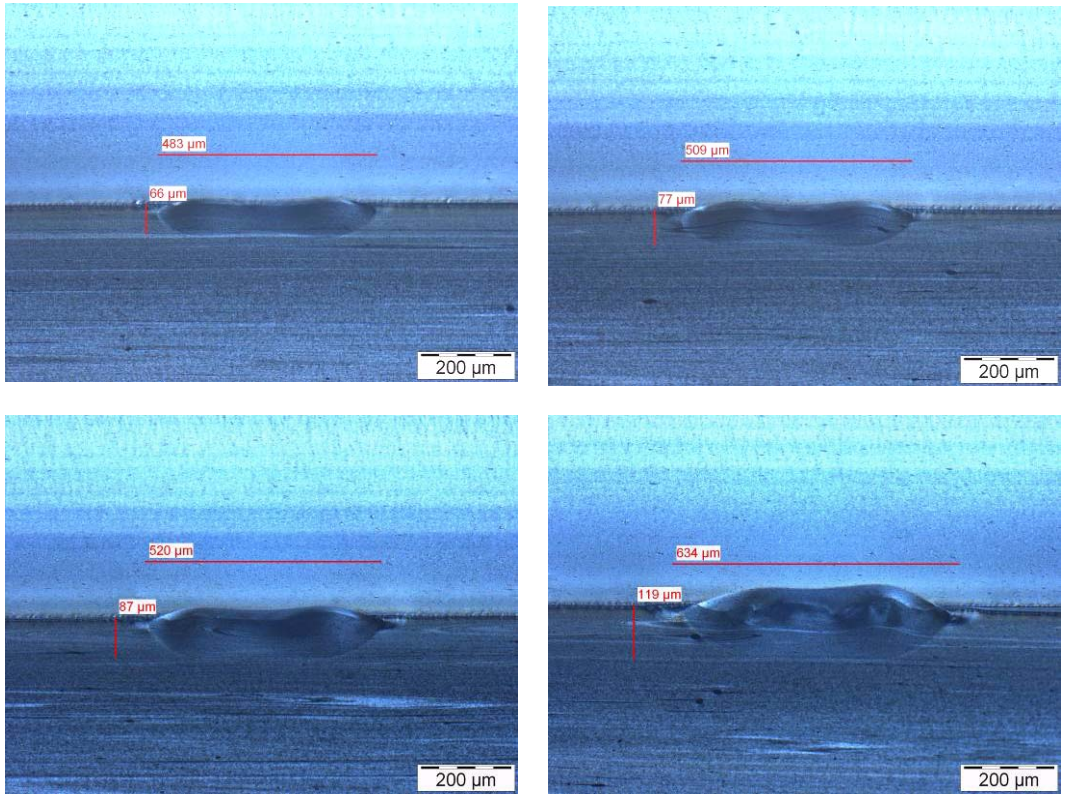
Material properties:

- Thickness d= 1 mm
- 0,5 wt% carbon black

Process parameters

P= 2,5 – 5 W
v= 50 mm/s
r= 0,225 mm
f= 1800 Hz

Weld seam width – 500 µm



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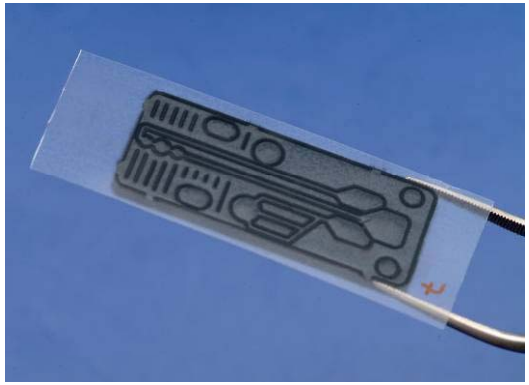
Application for TWIST®

Micro fluidic device
- PMMA or PP

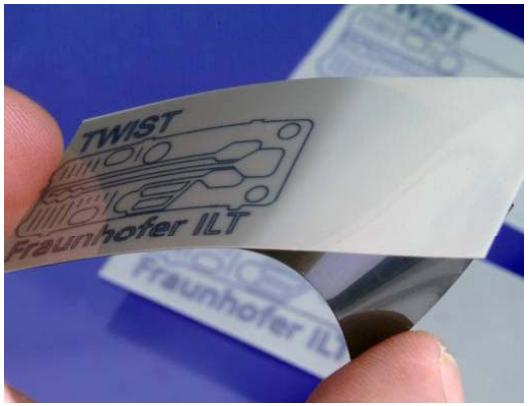
Cover (75 µm)
-PMMA or PP

P= 1,4 - 6,6 W
v= 50 - 300 mm/s
d_0= 70 µm
d_{weld}= 100 to 500 µm



Thin foils
- Polypropylen (PP)
transparent and black
thickness 100 µm

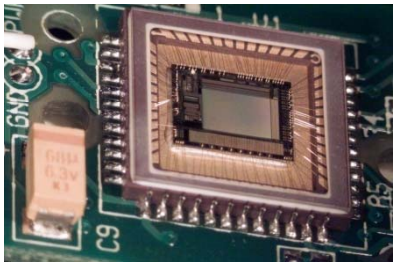
P= 1,4 – 5,9 W
v= 50 to 250 mm/s
d_0= 70 µm
d_{weld}= 150 to 500 µm



Fraunhofer ILT

Laser Based Glass Frit Bonding
Motivation

- Need for hermetic seals in various applications
- Low thermal load for the components
- Fast process
- High flexibility
- No gluing acceptable



www.ieec.binghamton.edu

www.osram.de

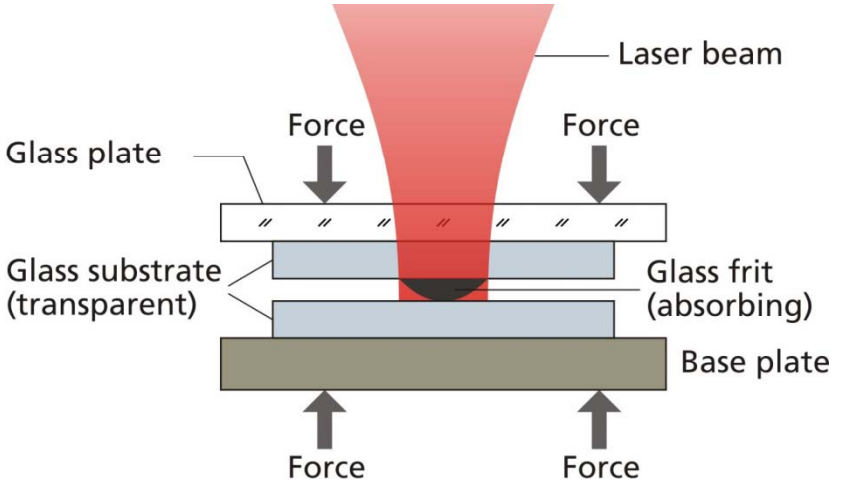
www.teknaseal.com

www.epfl.ch

Fraunhofer ILT

Laser Based Glass Frit Bonding
Process Principles

- Locally selective energy deposition
  - Reduction of the total warming of the joining parts
- Energy deposition based on laser beam absorption in the solder material
- Process prerequisites:
  - At least one transparent or translucent joining partner
  - Contact between solder material and second joining partner for sufficient wetting



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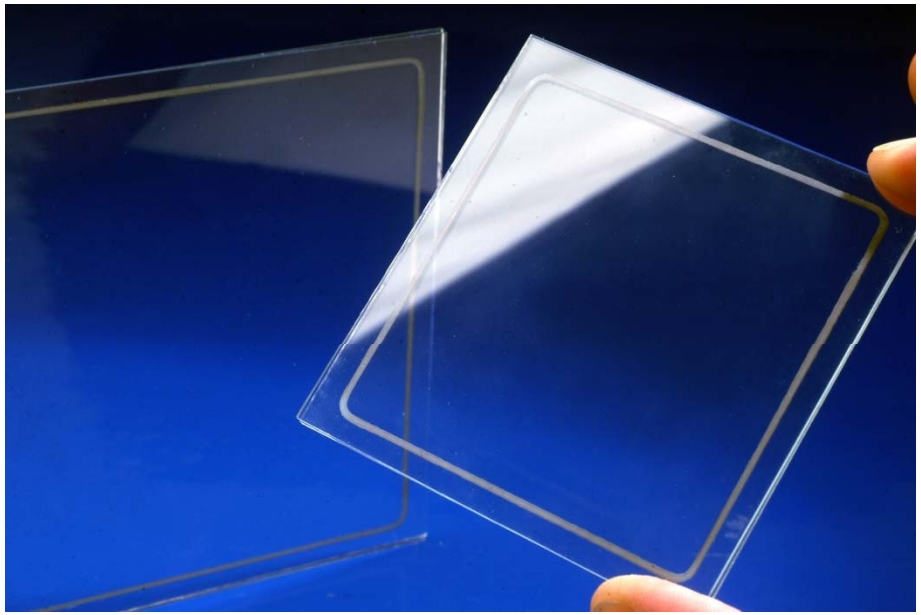
Soldering of Large Glass Substrates

- Material
  - Sodalime glass
  - Substrate size:
    80 x 80 mm²
- Solder material
  - Ferro FX 11-036
  - Solder height: 75 µm
  - Solder width: 700 µm



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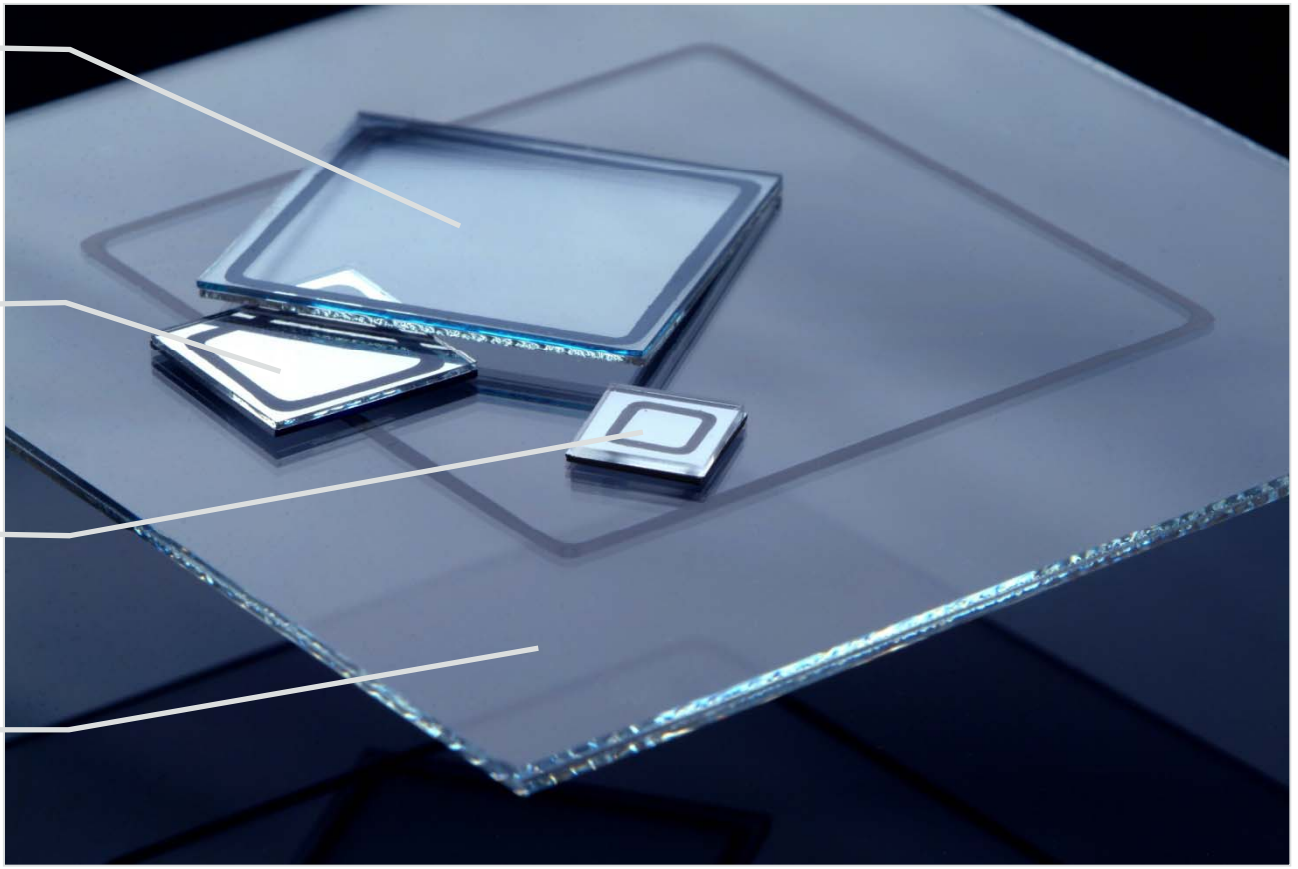
Laser based glass soldering of different material combinations

Sodalime glass /
Sodalime glass
ITO coated

Sodalime glass /
Sodalime glass
MAM coated

Sodalime glass /
Silicon

Sodalime glass /
Sodalime glass
Large substrate



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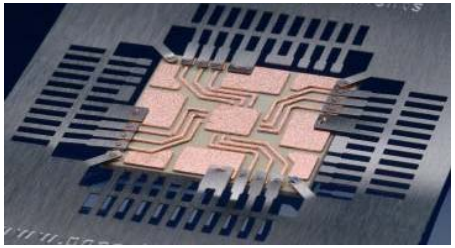
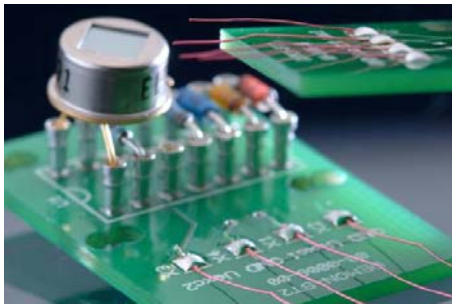
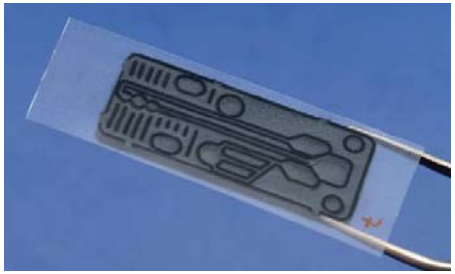
Summary
Laser in Microjoining







- New processes with high reproducibility and stability
  - SHADOW® Micro Ring Welding
  - Laser soldering in PV and electronics
  - TWIST® – Ultrafine welding of Polymers
  - Laser based glass frit bonding
- High brilliance for best focusability
- Temporal and spatial modulation of the laser power to improve the processes
- Best controllability in various applications
- Industrial tool with growing market share

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Thank you for your attention

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