Overcoming the Challenges in EV Production with Coherent ARM Fiber Lasers

Laser E-Mobility Workshop 10th and 11th 2022

Thomas Hofmeister / BDM Automotive Europe

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Agenda

1. E-Mobility Challenges for Laser Applications
2. Beam Shaping with FL-ARM Laser
3. FL-ARM Applications

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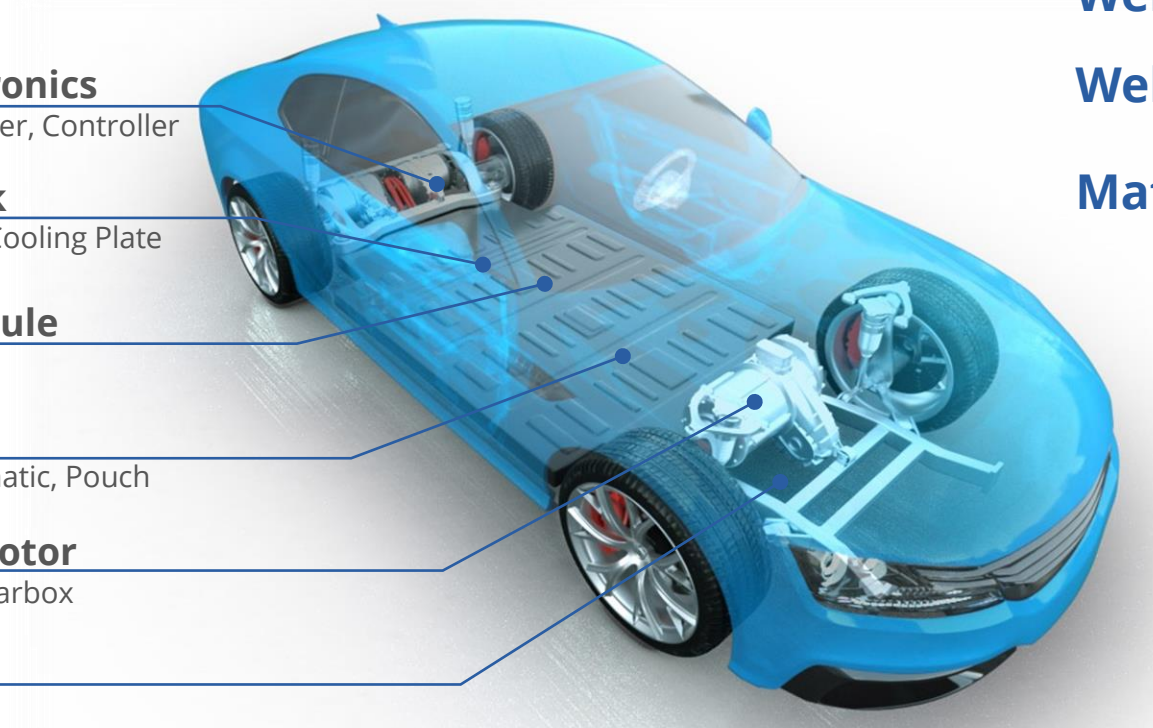
E-Mobility: Requirements Shift

Shift from ICE to E-Powertrain



- **Power Electronics**
  Inverter, Converter, Controller
- **Battery Pack**
  Tray, Structure, Cooling Plate
- **Battery Module**
  Frame, Busbars
- **Battery Cell**
  Cylindrical, Prismatic, Pouch
- **E-Traction Motor**
  Stator, Rotor, Gearbox
- **Fuel Cells**
  Bi-Polar Plates

Shift in Requirements for Welding

Welds per part: ↑

Weld length: ↑

Weld depth: extreme thin ⟷ thick

Material:

- Copper
- Aluminum 3xxx/5xxx/6xxx
- Al extruded + die cast
- Cu + Al combinations
- Stainless Steel
- HSS High Strength Steel

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E-Mobility: Challenges from the Laser Perspective

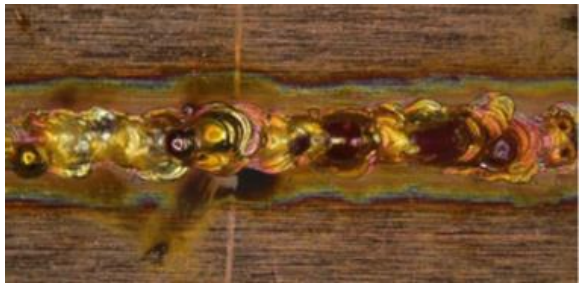
Laser Welding Demands

- Material combinations
- Material unsuitable
- Spatter sensitive parts
- High welding speeds
- Electrical conductivity
- Seam strength
- Thermal sensitivity
- Pressure loads
- Gas tightness
- Weld width and depth

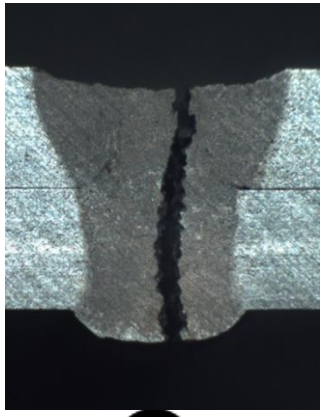
Laser Technology

"Usual" Laser set-up has limitations to deal with this

Copper



Al 6xxx



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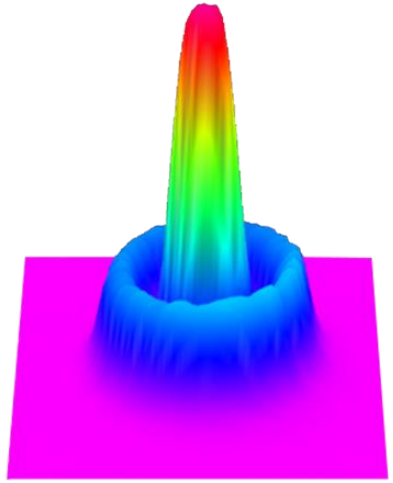
Meet the Challenges with Laser Technology

Laser weld strategies

- Higher Laser Power
- Higher weld speeds
- Scanner optics
- Beam oscillation
- Process analysis / monitoring
- Process strategy
- Wavelength

➢ **Beam Shaping (e. g. ARM)**



YouTube video

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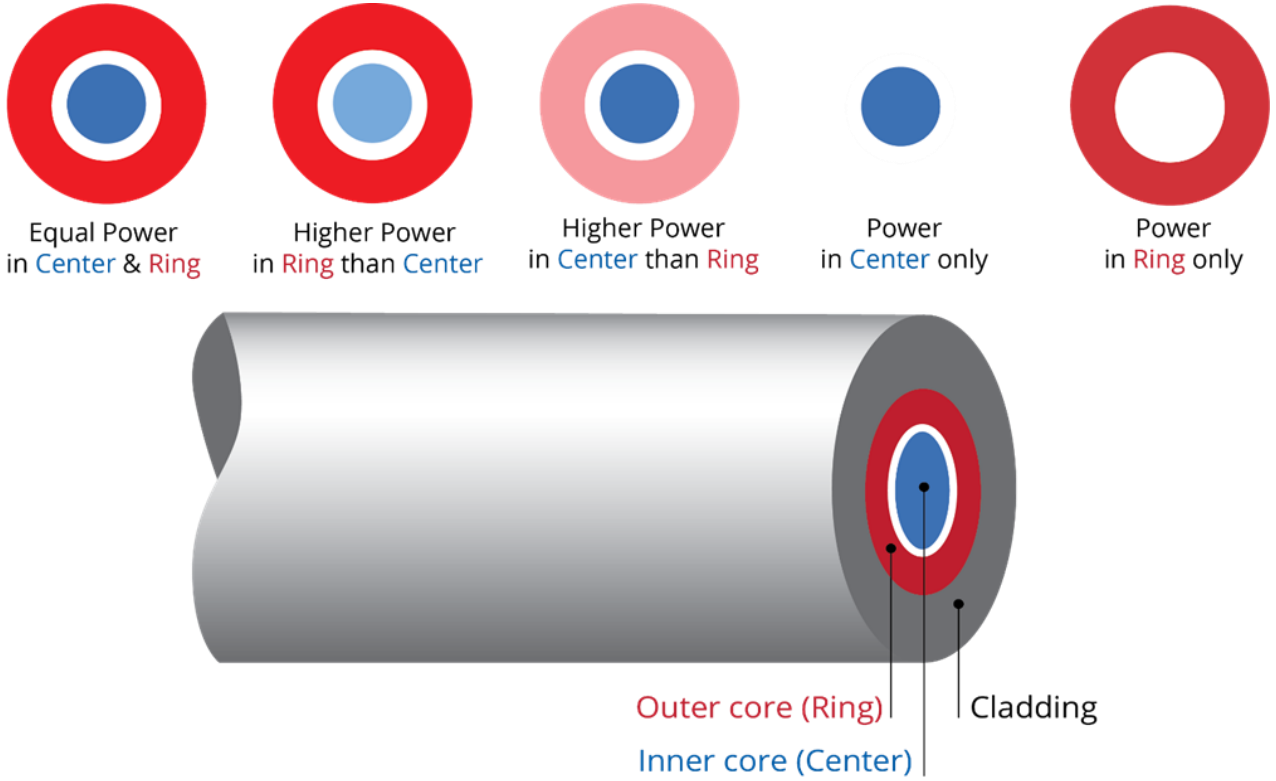
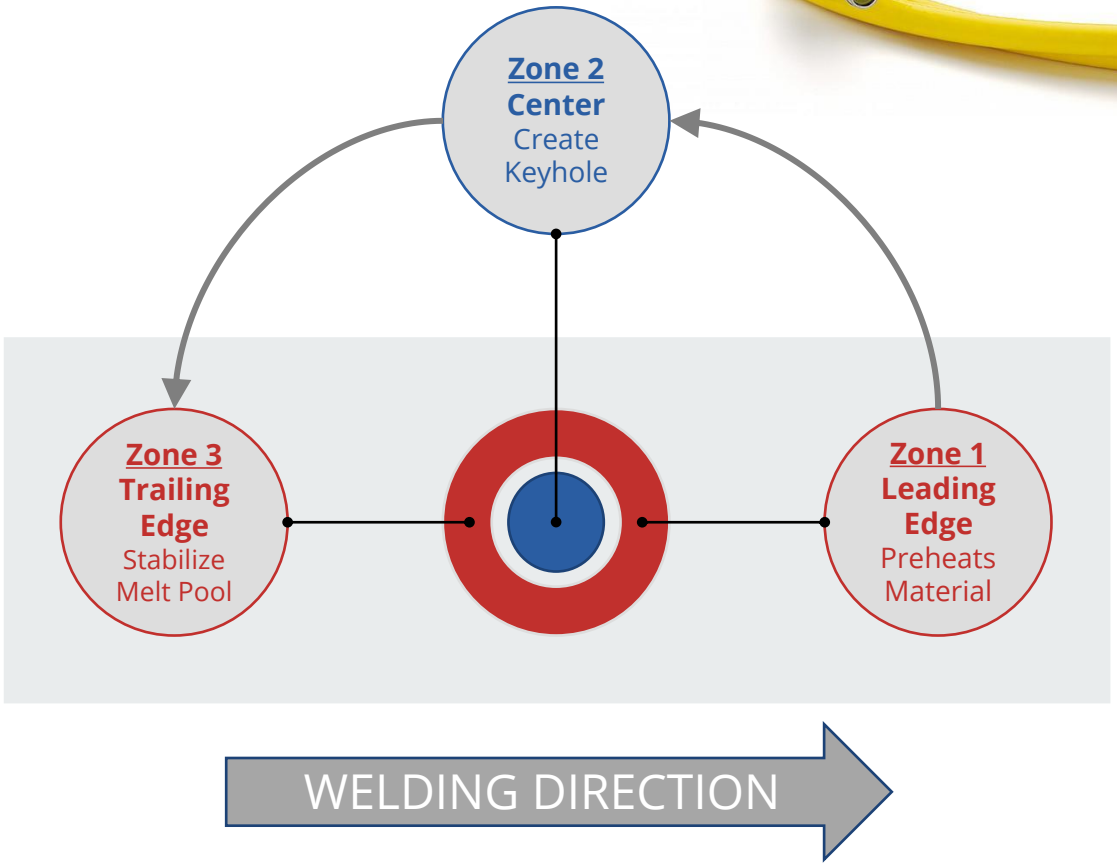
Adjustable Ring Mode (ARM) Fiber Lasers

ARM Process Fiber with two co-axial, independent beams





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HighLight FL-ARM Family

	HighLight FL Max. Power C/R [kW]	Process Fiber D Center/Ring outer	Spliced or FFS/FFC
E-Mobility	CSM-ARM 1,5/2,5	**25/170 µm** (SM/MM)	Spliced
	ARM Compact 6/10*	**50/140 µm**	Spliced
	ARM Compact 7,5/10*	**70/180 µm**	Spliced
E-Mobility	ARM 2/7,5 NEW	**50/200 µm**	FFC FFS
E-Mobility	ARM 7,5/10*	**100/290 µm**	FFC FFS

* 10kW max. combined total power

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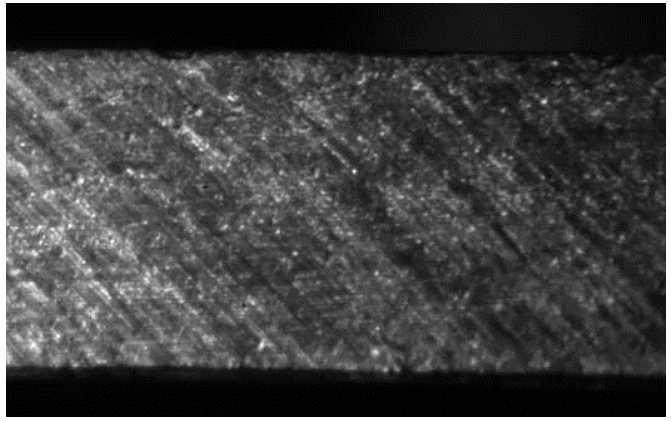
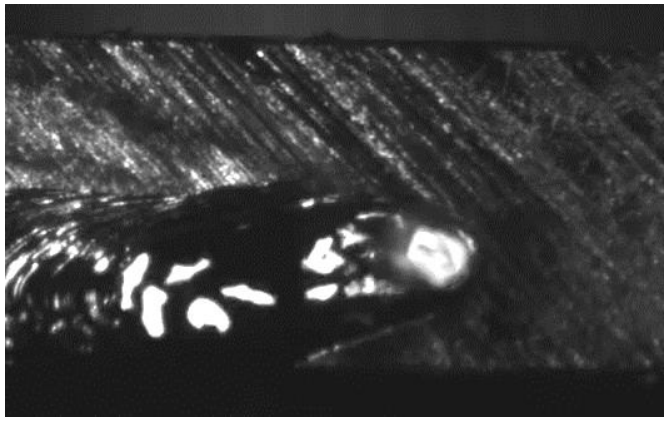
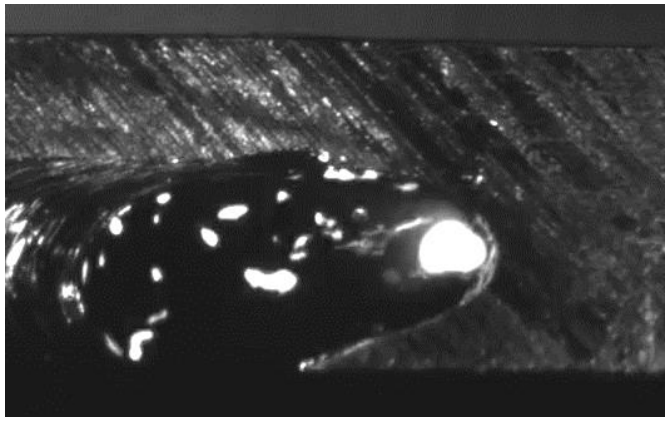
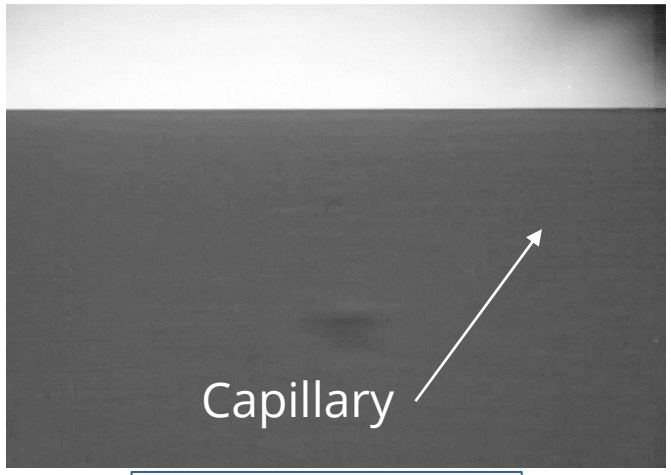
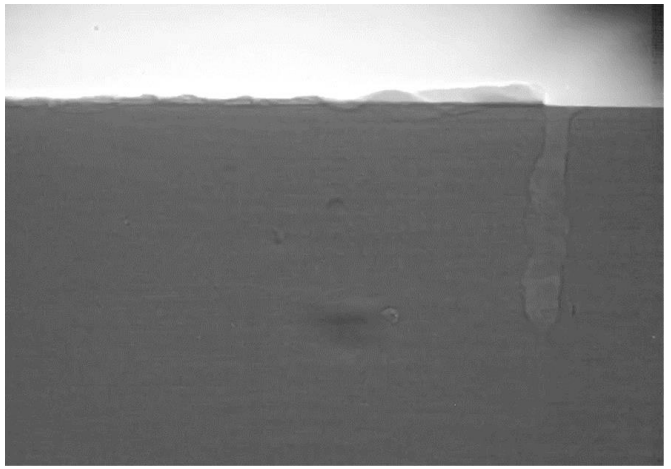
Power distribution between Core and Ring

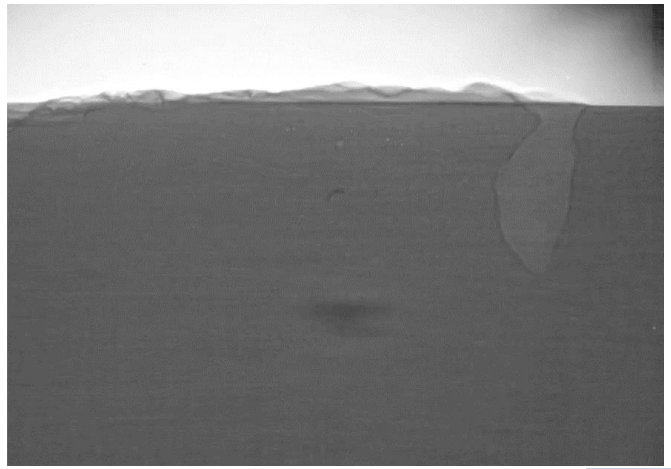












P_{center} = 3 kW
P_{ring} = 0 kW

P_{center} = 1,5 kW
P_{ring} = 1,5 kW

P_{center} = 0 kW
P_{ring} = 3 kW

Cu ETP
t = 2mm

in cooperation with ESRF Beamline 19 and Group of Production Technology

ESRF The European Synchrotron

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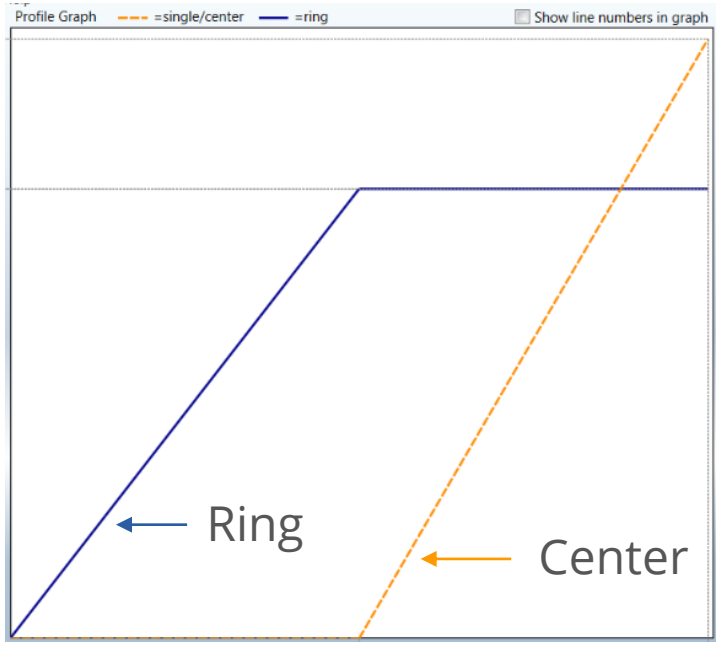
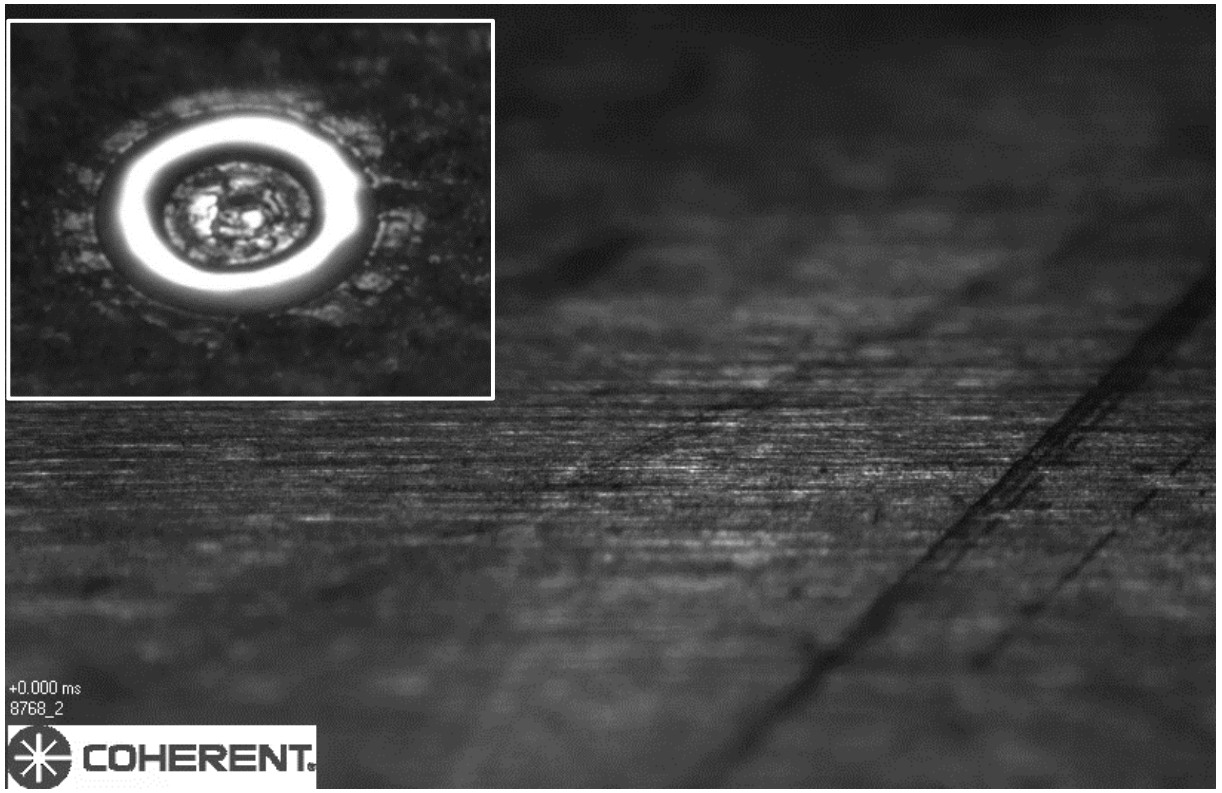
Defined power control with FL-ARM technology





- **Independent power control** of center/ring
- Power modulation up to **5 kHz**

Spatter control and weld preparation by independent ramping of core and ring beam

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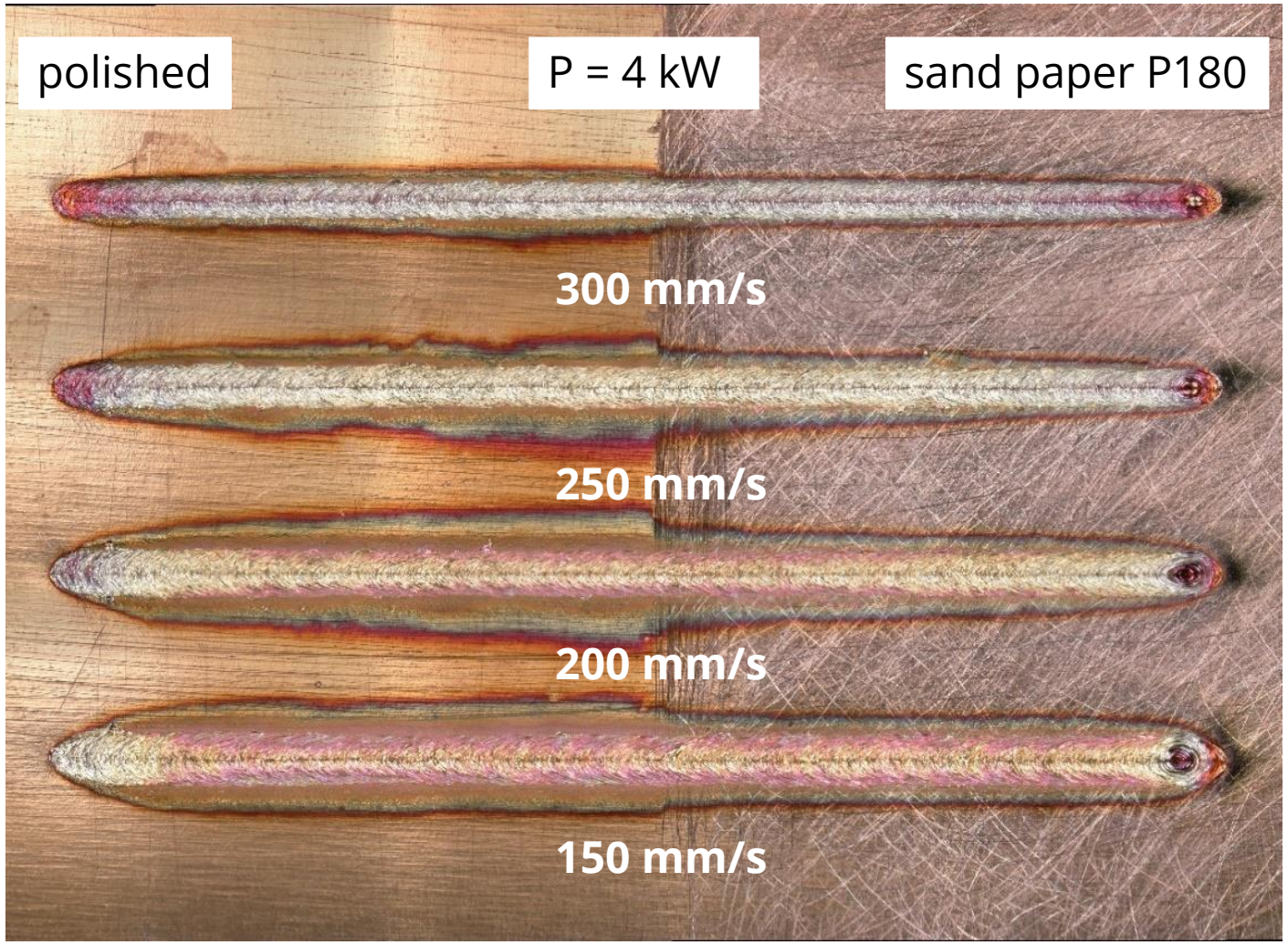
Defined process start / independency from surface finish

v = 300 mm/s

Direct coupling
Reproducible process



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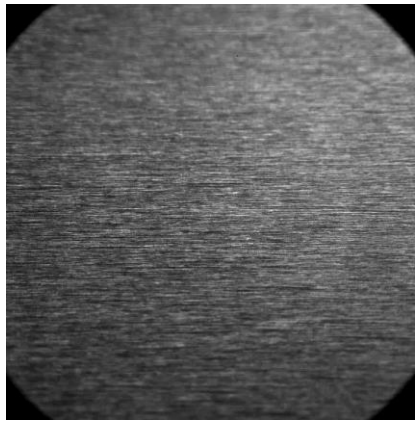
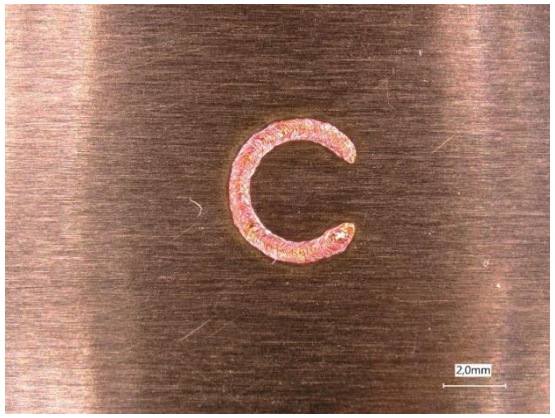
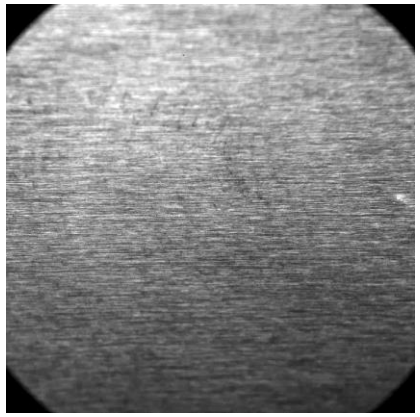
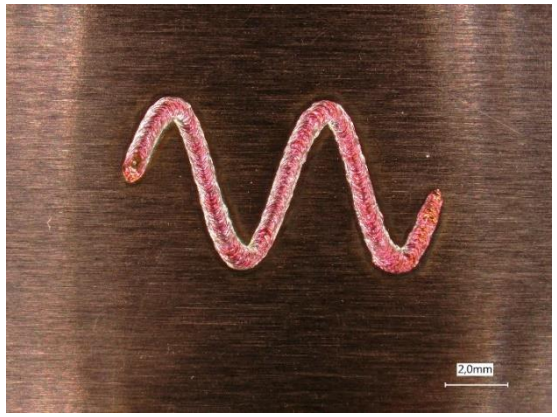
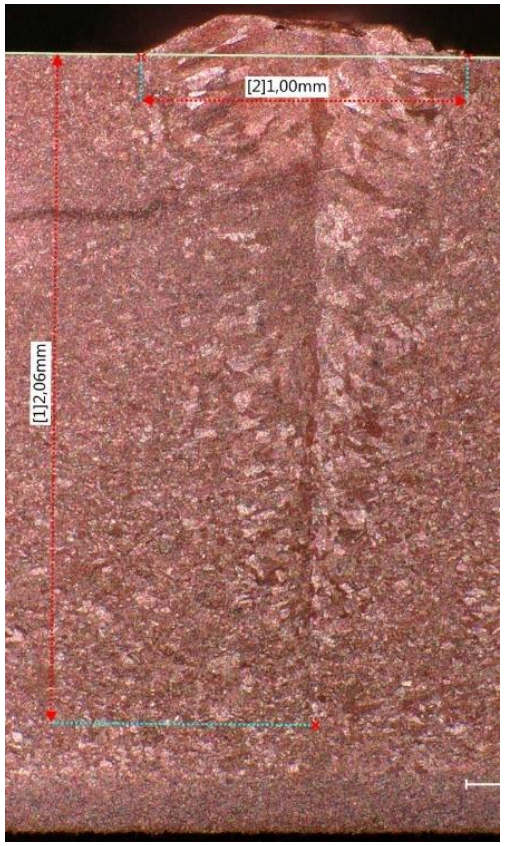
Rotationally symmetrical beam properties

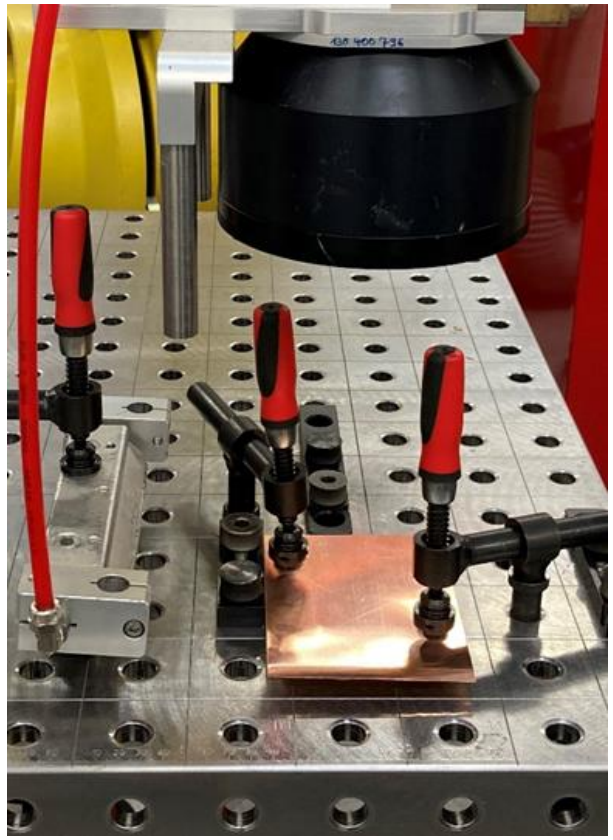












Unidirectional weld patterns with scanners

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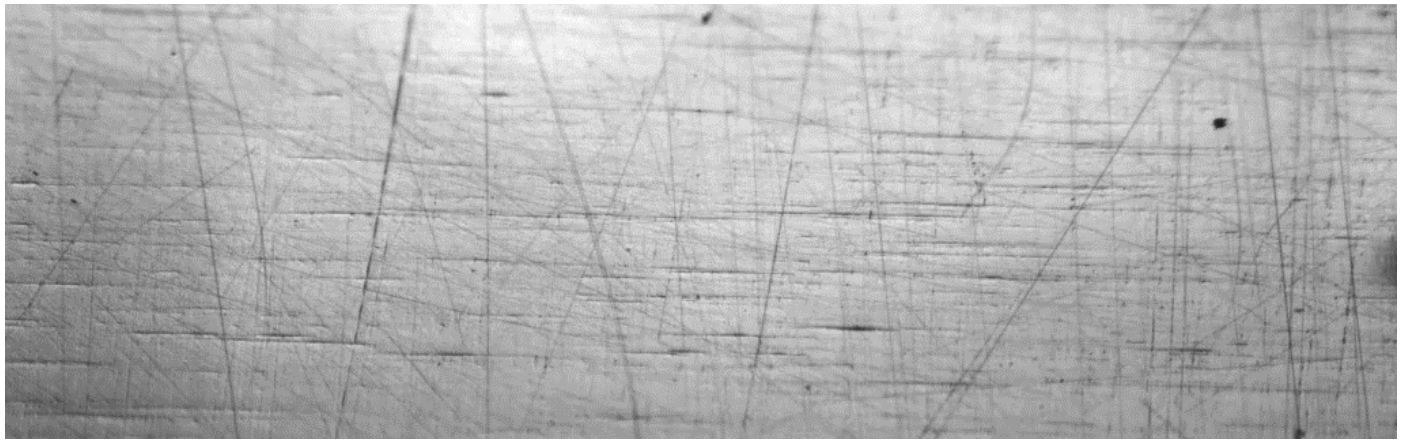
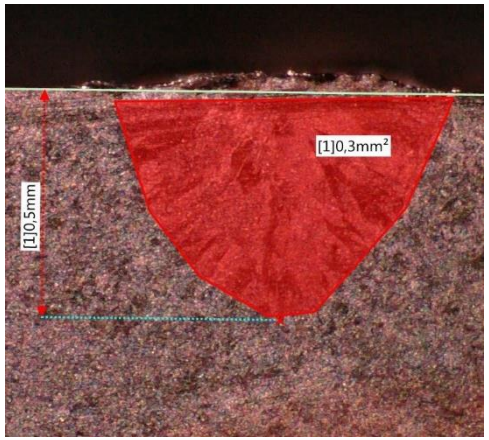
Penetration Consistency / Welding thin Cu



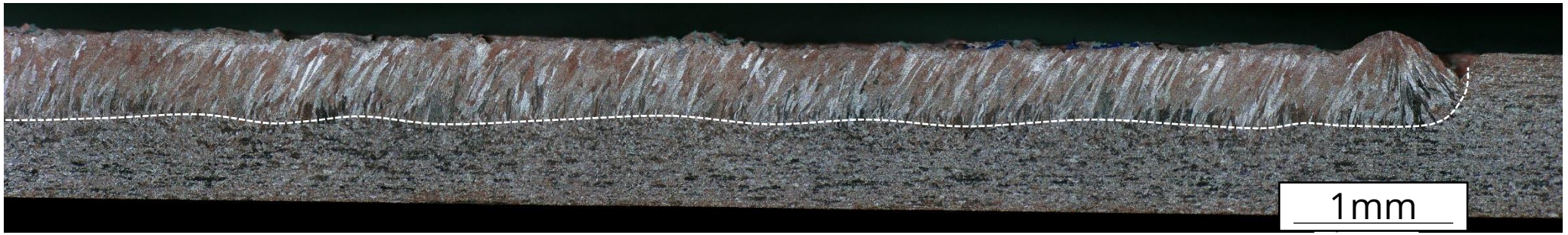
P = 4kW; v = 300mm/s



Cross section

Depth = 0,5 mm

Area = 0,3 mm^2



Longitudinal cross section

Penetration depth stability for IR laser without any process control

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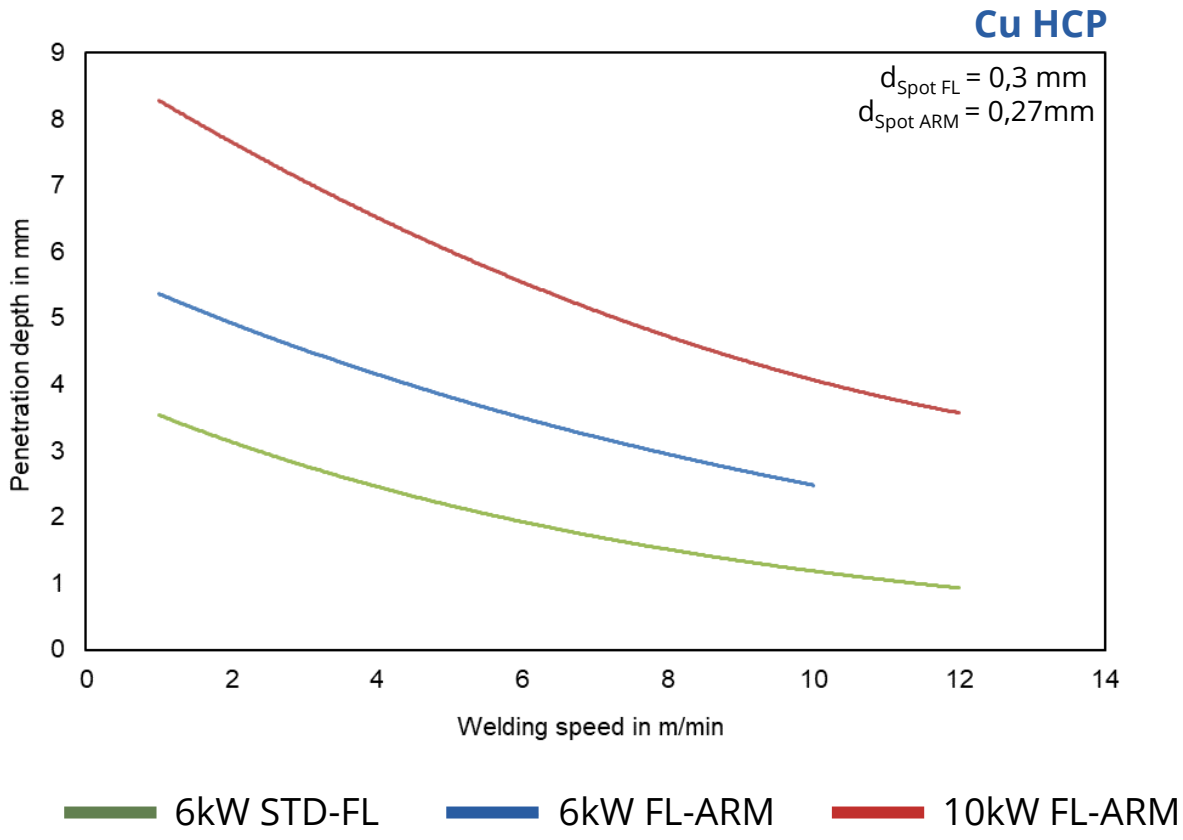
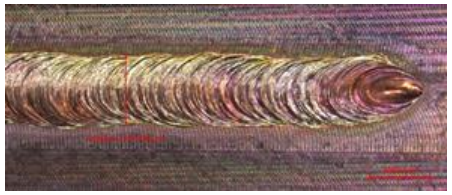
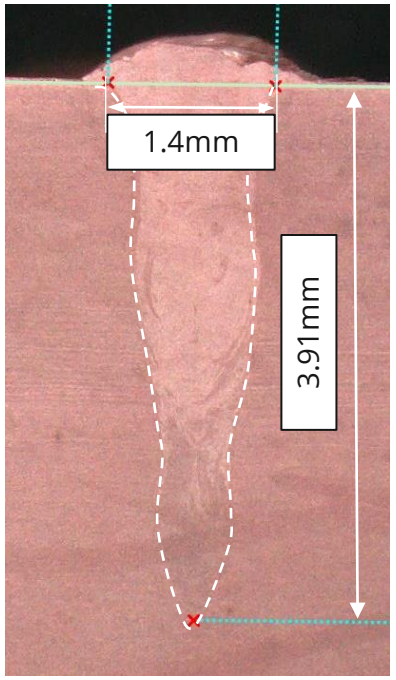
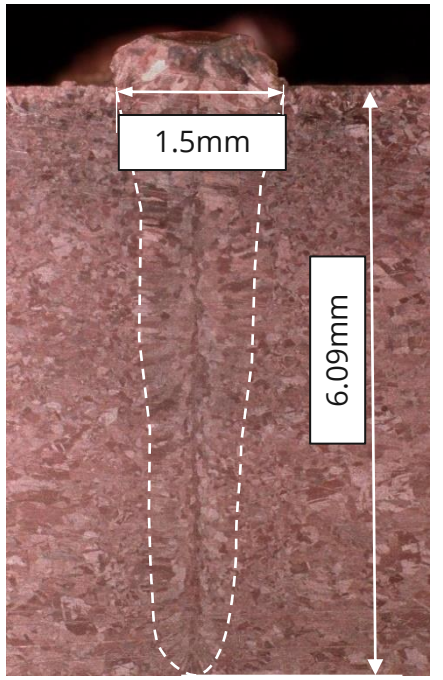
Deep penetration Cu welding









P_{total} = 6 kW
v = 4 m/min

P_{total} = 10 kW
v = 4 m/min

Deep welding only possible with IR wavelength

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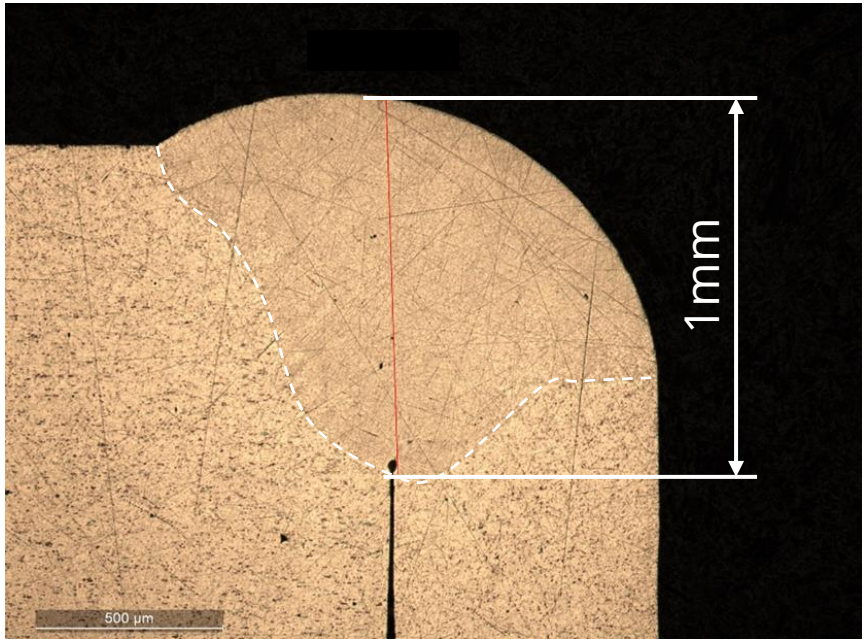
Prismatic Battery Lid Welding with ARM + Scanner

Welding of 3000 series aluminum

- ARM power tuning: width and penetration control
- No pores > 0.05 mm detectable
- Extremely low number of spatter
- Smooth seam surface
- Welding speed up to 350 mm/sec



Reduced pore formation and high process stability

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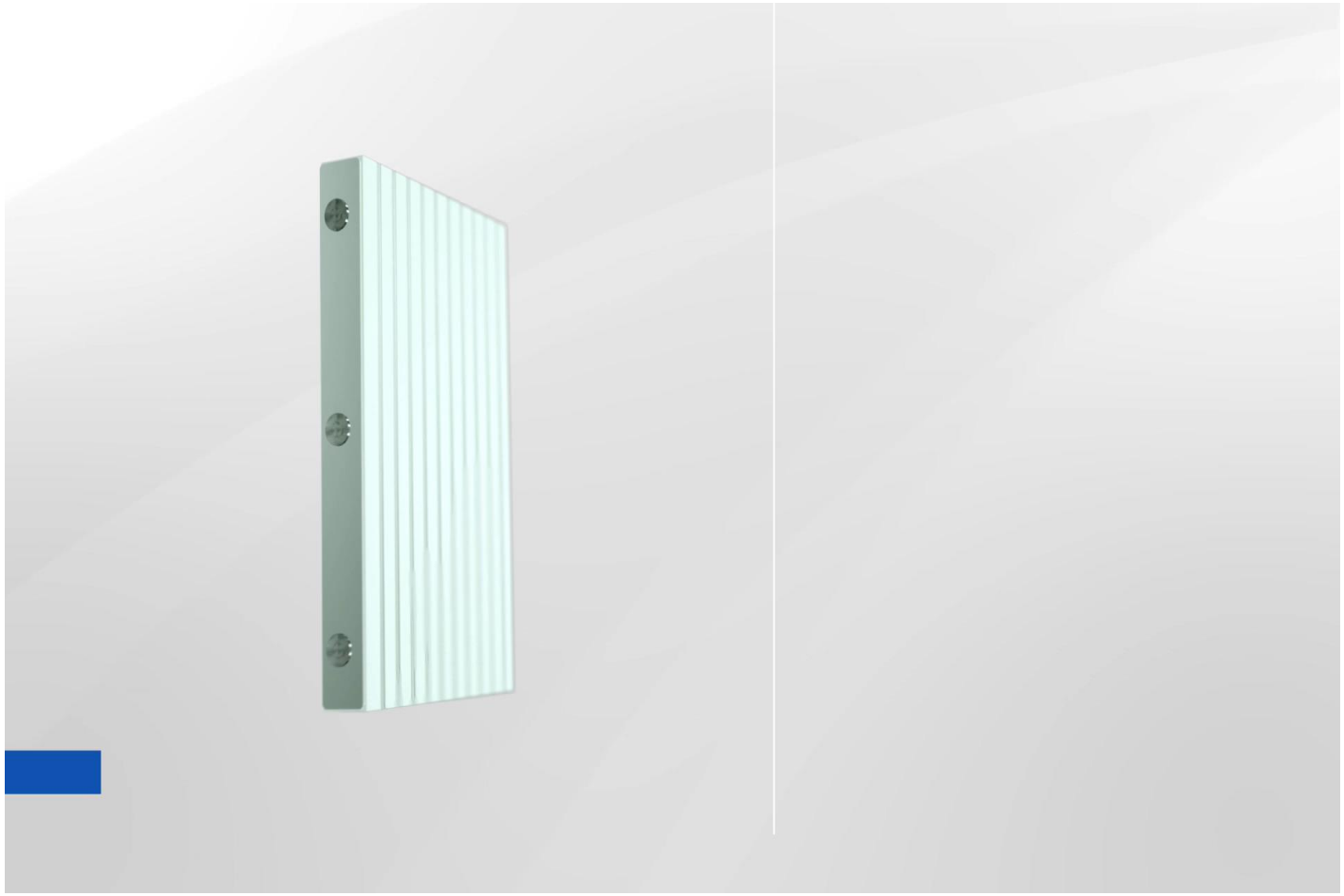
Prismatic Battery Lid Welding with ARM + Scanner



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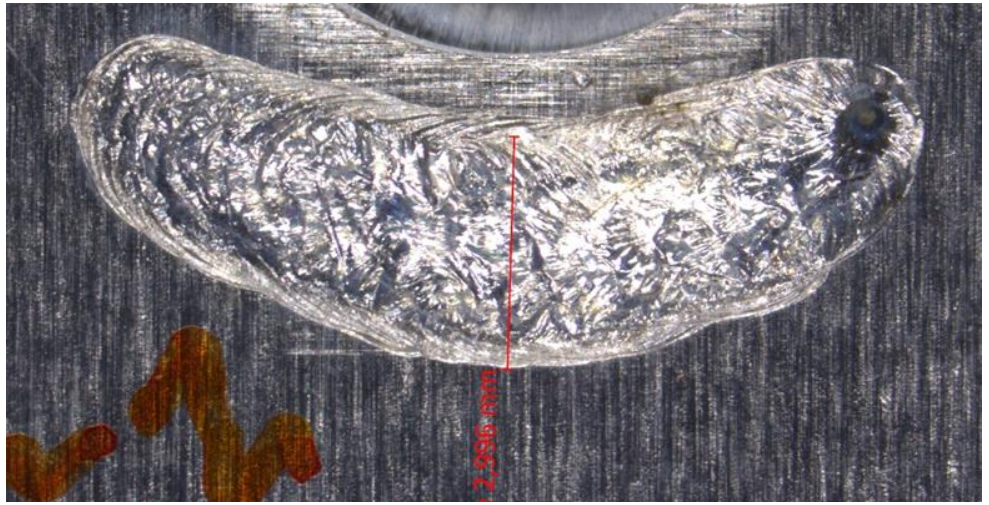
Al Busbar Welding ARM + Scanner

Requirement

- Temperature sensitive plastic component Integrated
- Requiring **< 90 ℃** @ insulator

Achievement

- Penetration control and high-speed process
- Process time: **0.1 sec./seam**
- Temperature: **70 – 80 ℃**



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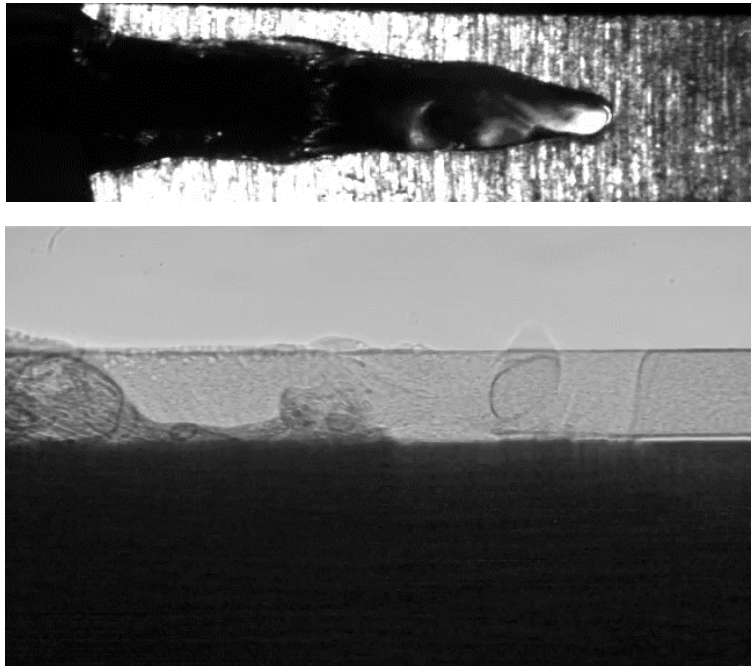
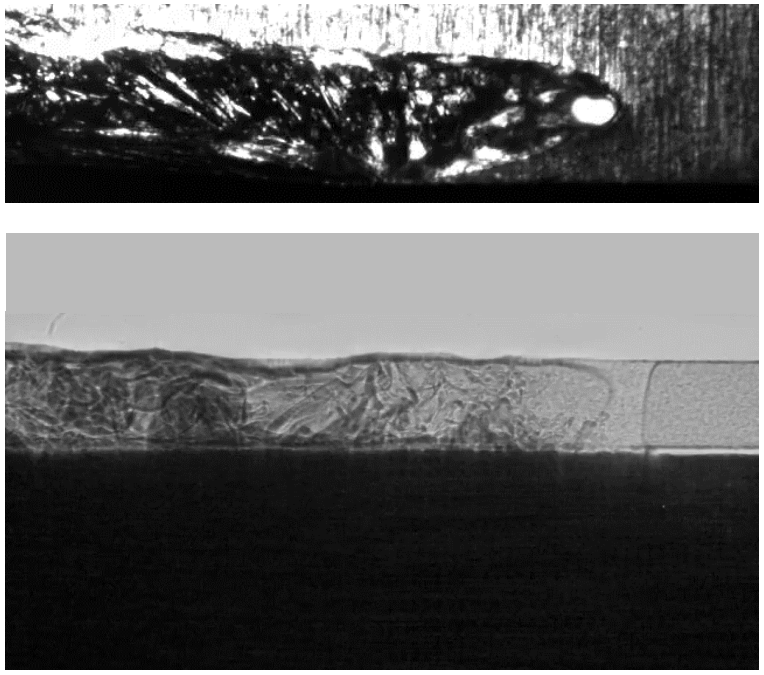
Dissimilar joints of Copper and Aluminum



4,5kW Top Hat



4,5kW adapted power distribution

Al

Cu

Stable process for mixed materials

in cooperation with ESRF Beamline 19 and Group of Production Technology

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E-Traction Motor - Hairpin Welding with Scanner

Production Volume up → Total process time down

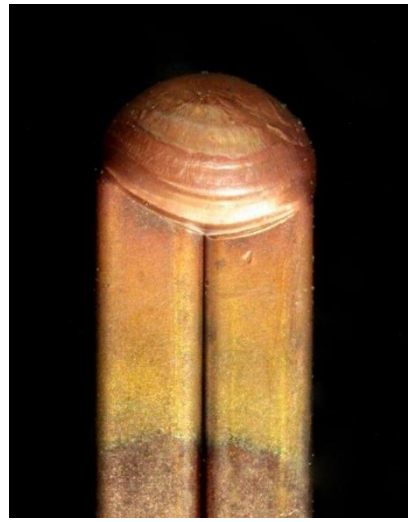
Total Process time
= Placement + Vision + Software + Weld

1. Positioning
2. Image Capturing
3. Detection Hairpin Pair
4. Offset Correction
5. Parameter Set
6. Weld Time

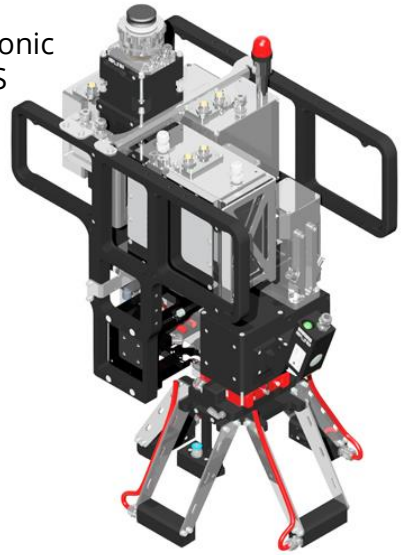
→ Higher Power

PRECITEC
ScanMaster

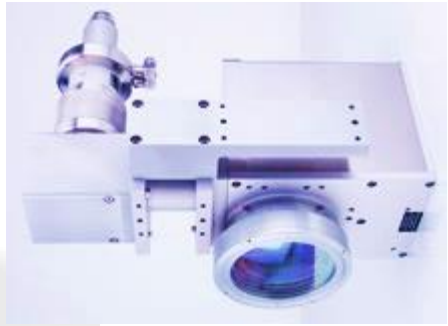
II-VI Highyag
HIGHmotion 2D

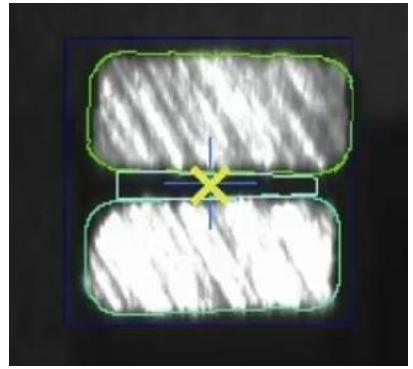


scansonic
RLW-S



Blackbird/*SCANLAB*
intelli*SCAN* FT





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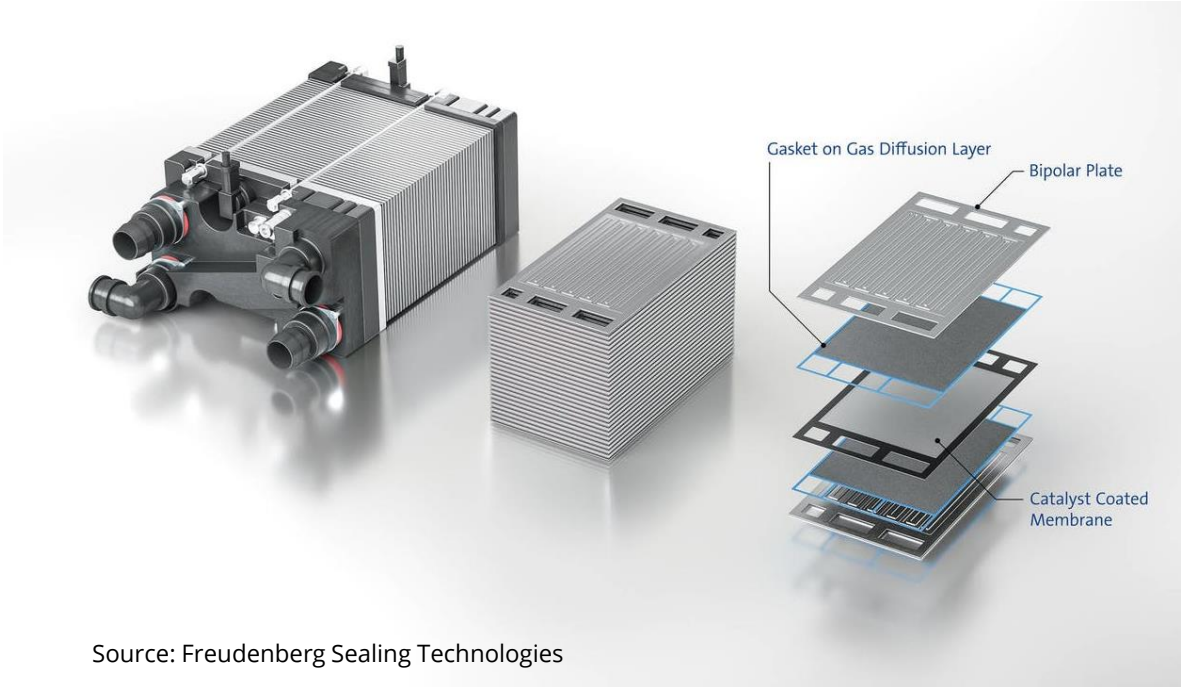
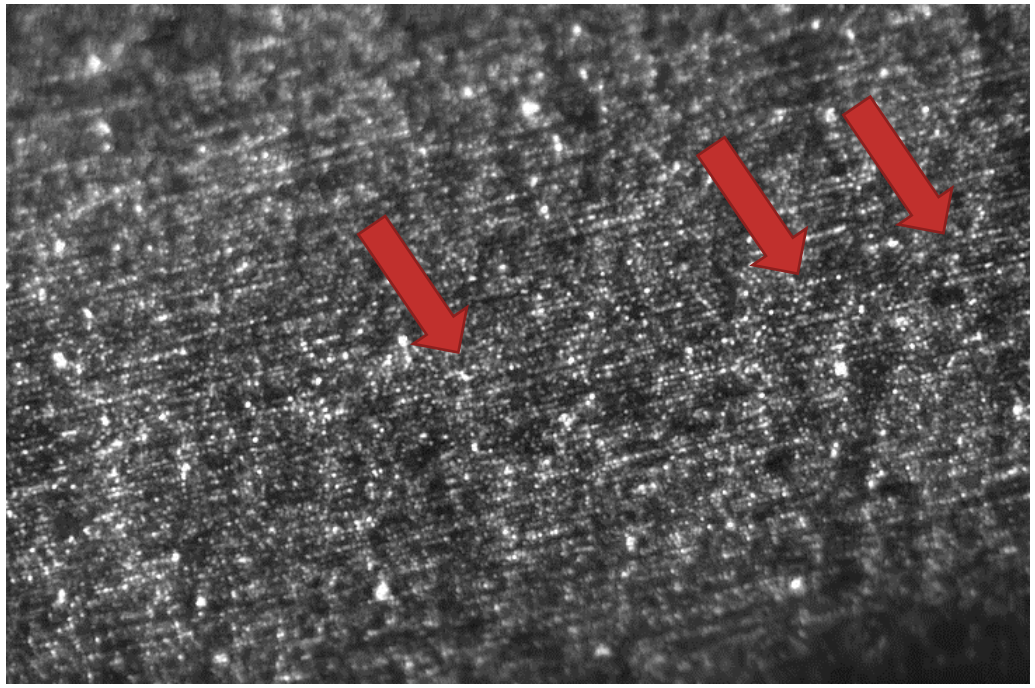
Fuel Cell Bi-Polar Plate: Humping Phenomena



Source: Freudenberg Sealing Technologies

Fuel cell



v = 100 %

Presence of humps using standard SM Lasers → Limitation of process speed

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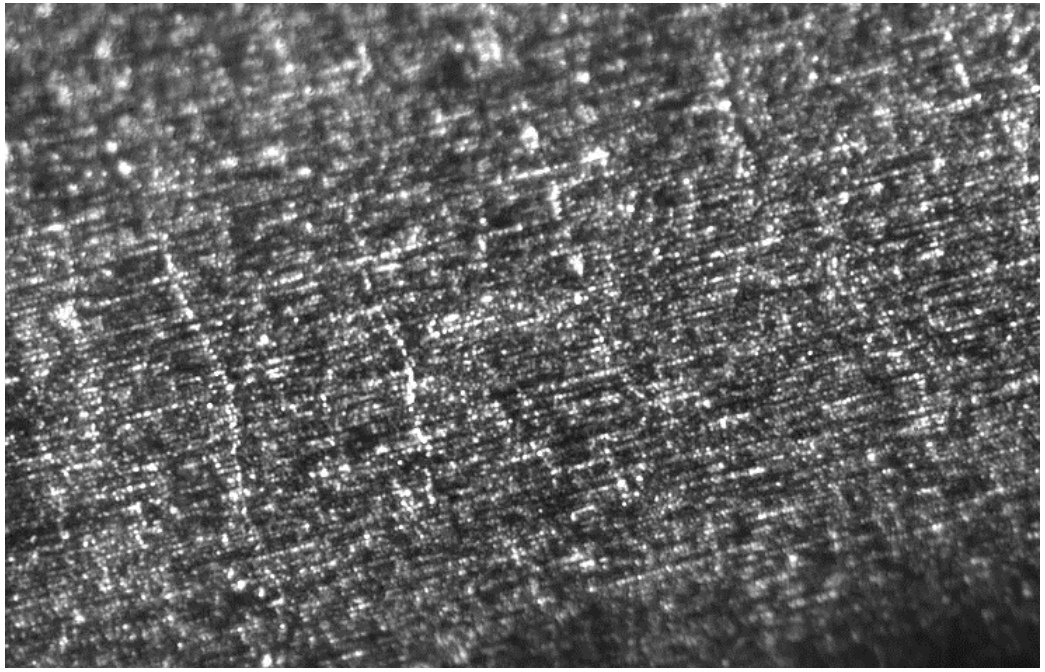
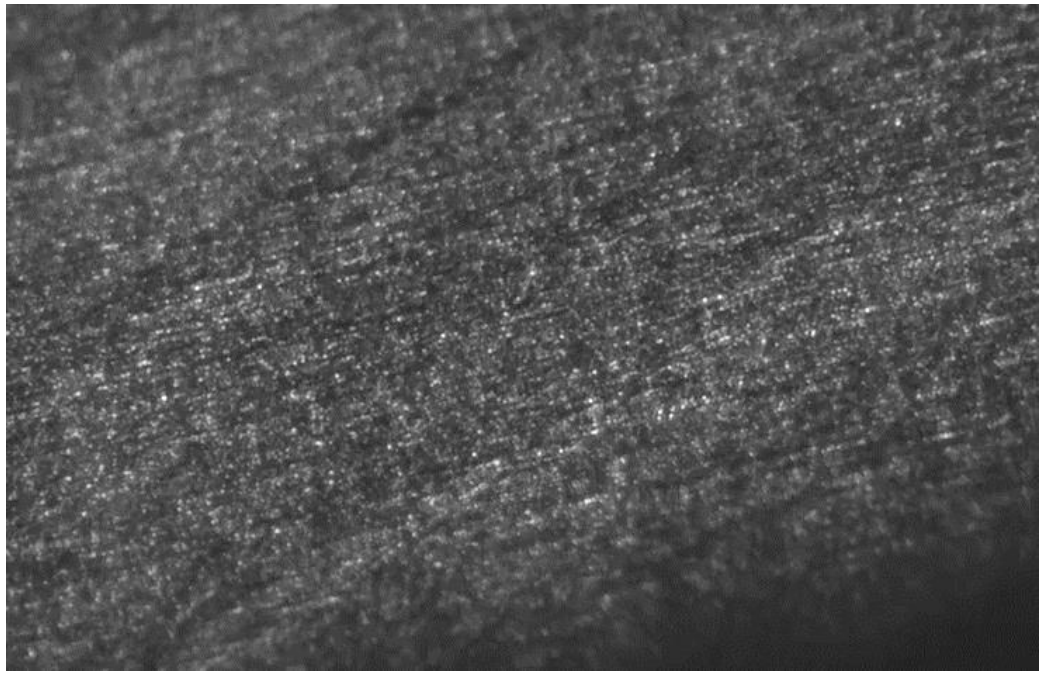
Reduction of the Humping due to the Ring



v = 100%



v = 150%

Eliminating the humps using SM ARM Laser

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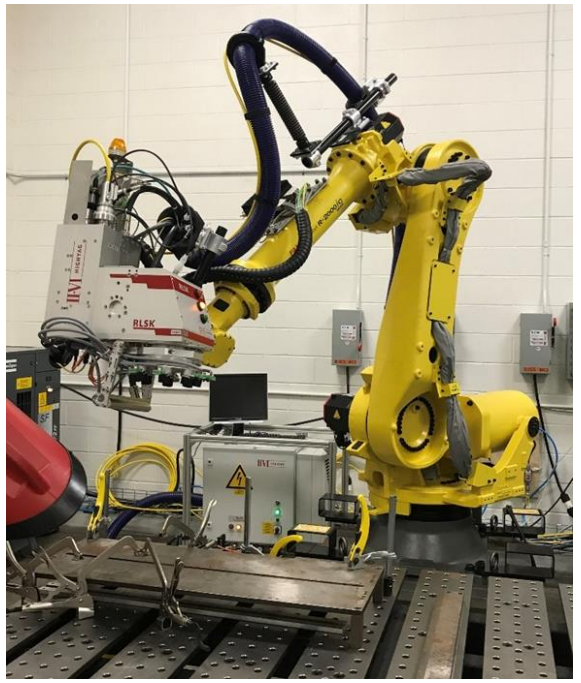
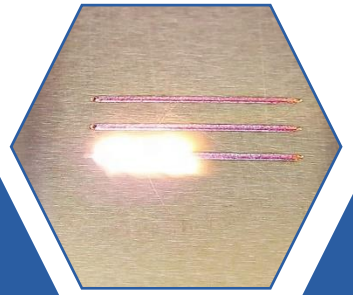
Coherent Laser Application Labs



Customer support

- Labs in Europe, North America and Asia
- Joint Laser Process Development
- Intense Material Testing
- Define Laser Power and Parameters
- Design Feasibility Check
- Prototype Production



Apps labs:
Support from development to scale production

Application development:
Laser Technology, Power and Parameters are the perfect choice

Stay in touch:
Face-to-face meetings or video conferences with livestream from the lab

Bundled knowledge:
75 application engineers in 19 labs around the globe are here to help you

Get in touch:
Initial ideas - description of the task and the goal

Equipment:
Latest laser and automation technology combined with modern diagnostic tools

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High-Power ARM Fiber Lasers

- **Independent** Power Control of **Center / Ring**
- Power Control from **1% to 100%**
- Power Modulation up to **5 kHz**
- Real Time **Closed Loop** Power Control
- Superior **Back Reflection** Resistance Concept
- Highest **Beam Brightness**
- Compatible with most **Process Optics + Scanners**

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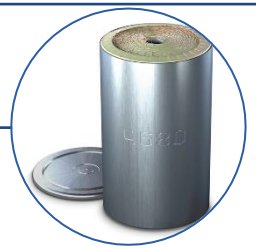
HighLight Fiber Laser Family - Designed for Welding

Demanding Materials

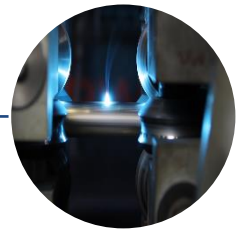
- Aluminum
- Copper
- High strength, galvanized and stainless steel
- Dissimilar materials
- Coated materials

Challenging Applications

Automotive



Battery Cell Energy Storage



Profile Welding

High Power Electronics

... and many more

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Thank you for your Attention

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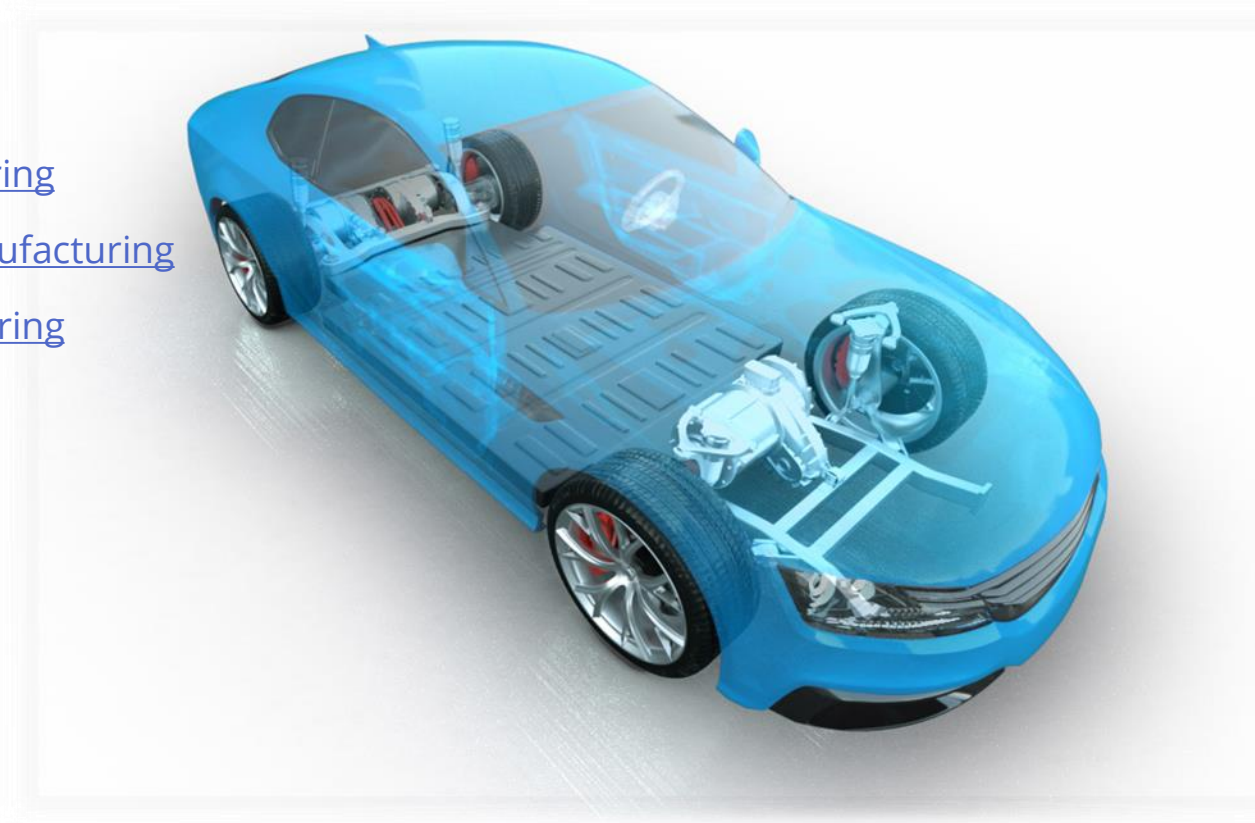
YouTube: Coherent Laser Solutions for E-Mobility

YouTube: Coherent Laser Solutions for Automotive



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