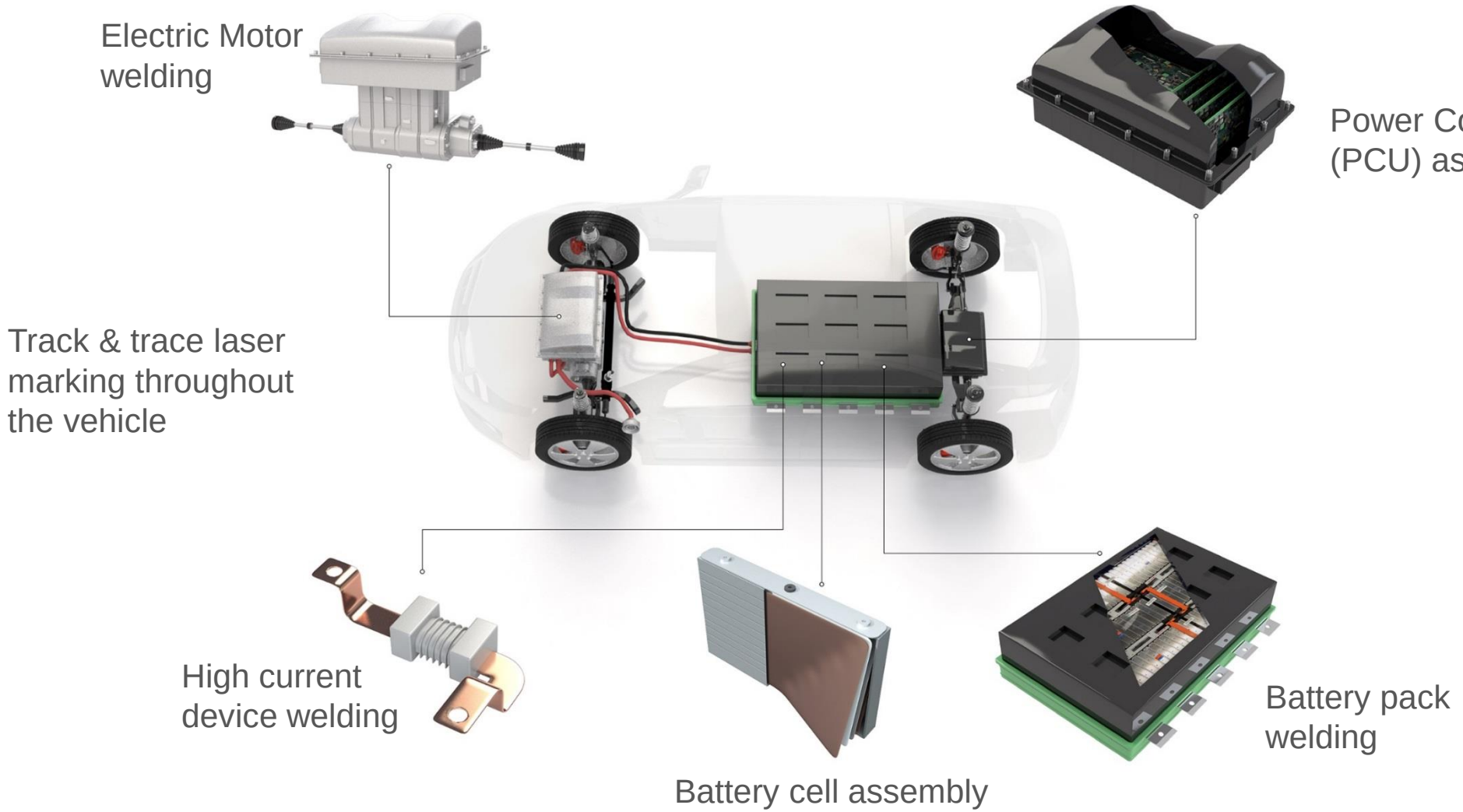
COHERENT | Solutions for E-Mobility

Webinar 18 Nov. 2020

Lavorazioni Laser nel Settore E-Mobility: Stato dell'Arte e Prospettive Future

The Anatomy of an Electric Vehicle's MP Laser Applications



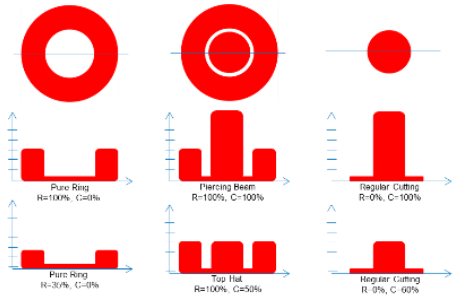
CleanWeld Technology for Superior Process Results

Standard Fiber Lasers

1 to 10 kW CW
Standard or Compact

Cutting, Welding,
Surface Treatment

Tailored Fiber Lasers



Adjustable Ring Mode (ARM)
Up to 10 kW
Standard or Tailored

Cutting, Welding,
Microelectronics

Standard Diode Lasers

1 to 8 kW CW
Standard, Compact, Rack

Welding,
Surface Treatment

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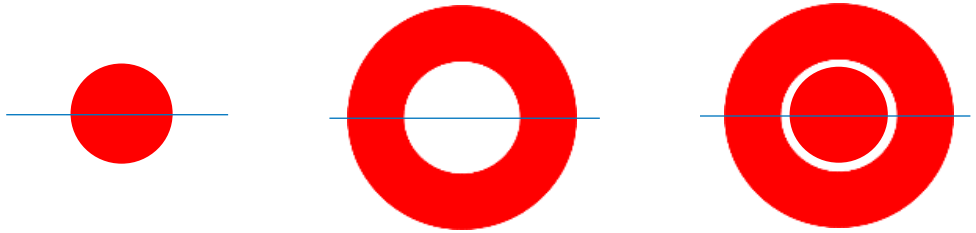
ARM-FL: Adjustable Ring Mode Fiber Lasers

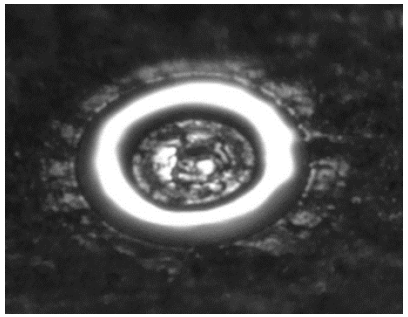
Standard Configurations from 2 to 10kW

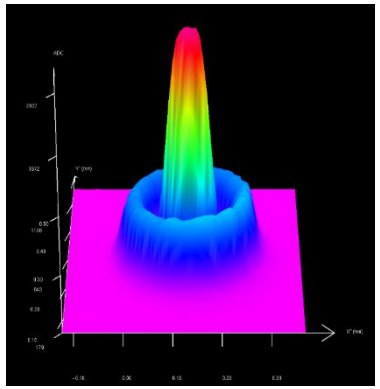
INDEPENDENT kHz POWER CONTROL OF CORE AND RING MODES

STANDARD PROCESS OPTICS and SCANNERS

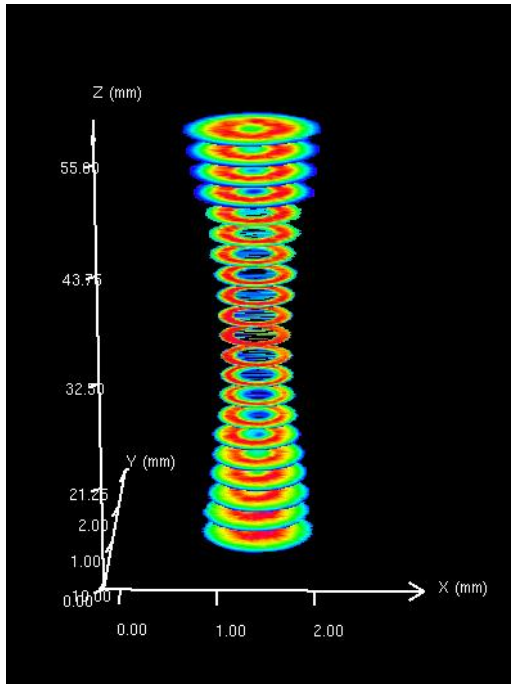
REAL-TIME CLOSED LOOP POWER MONITOR







Combination of two beams



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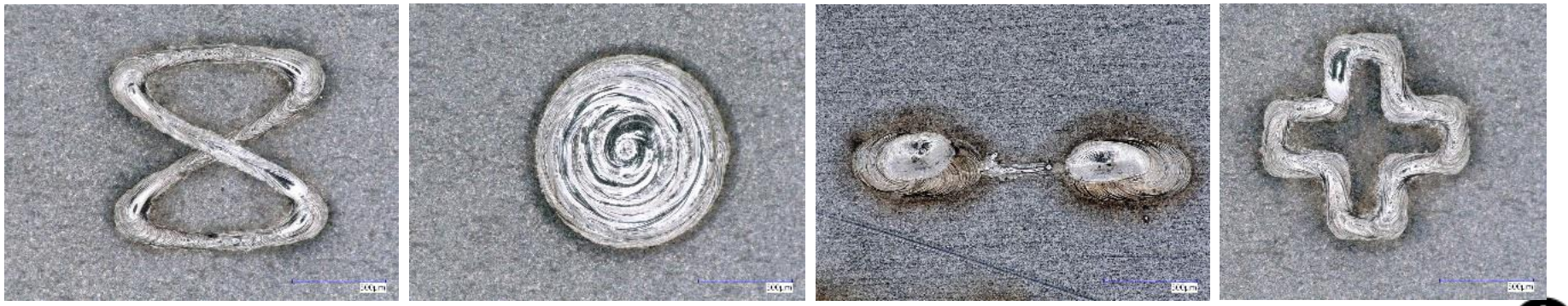
SmartWeld+ Beyond Wobbling

SmartWeld+ processing head

- Optimized dynamics for high speed repetition of micro patterns
- Various pre-programmed oscillation patterns, e.g. eight, spiral, ellipse, etc. – max. 15 patterns to store
- Selectable pattern size and orientation (angle) relative to feed direction
- AutoRotate function to follow a contour
- Synchronization with laser pulses
- Max. oscillation frequency - 4 kHz
- Excellent viewing quality with coaxial IR illumination, steady camera picture
- Compact, low weight

Examples for oscillation patterns



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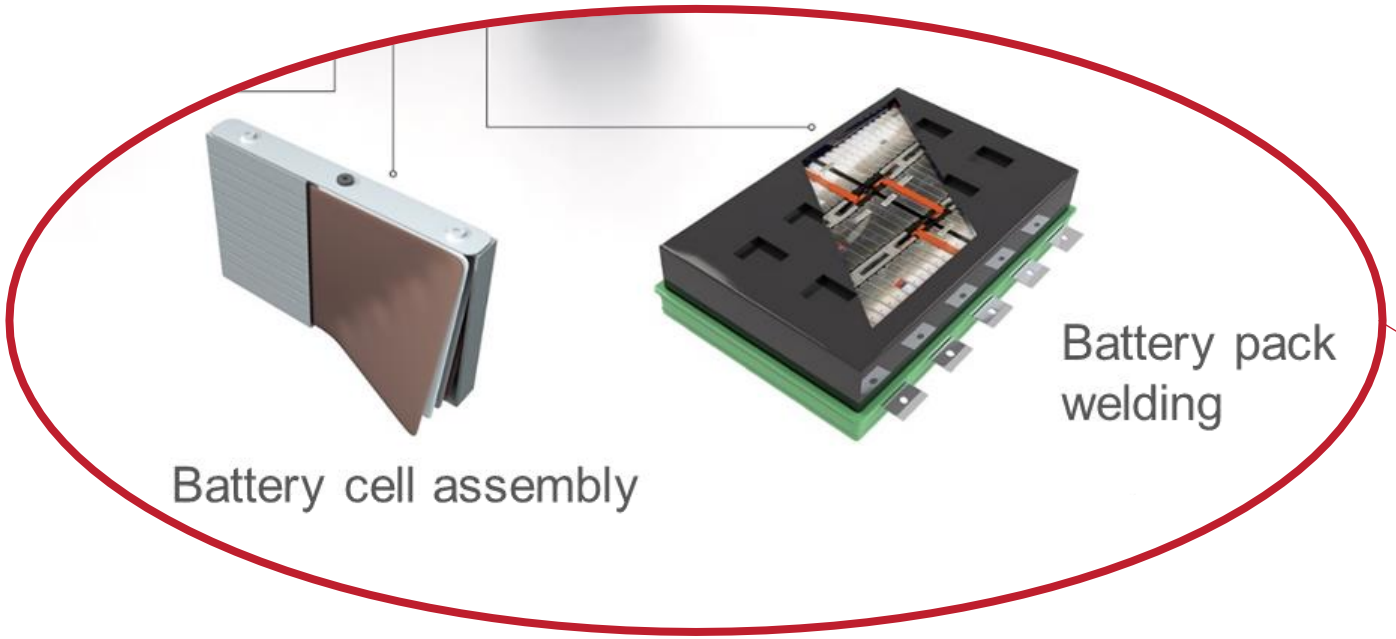
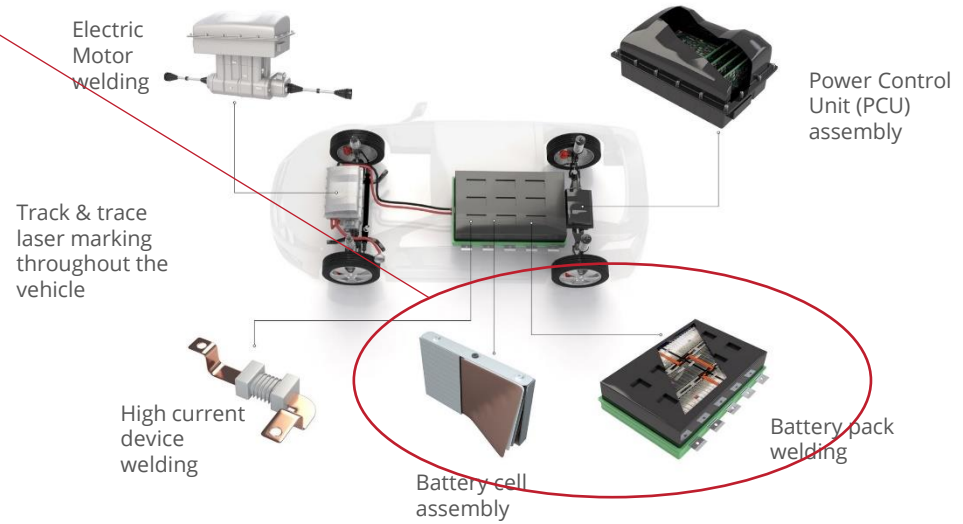
The Anatomy of an Electric Vehicle's MP Laser Applications

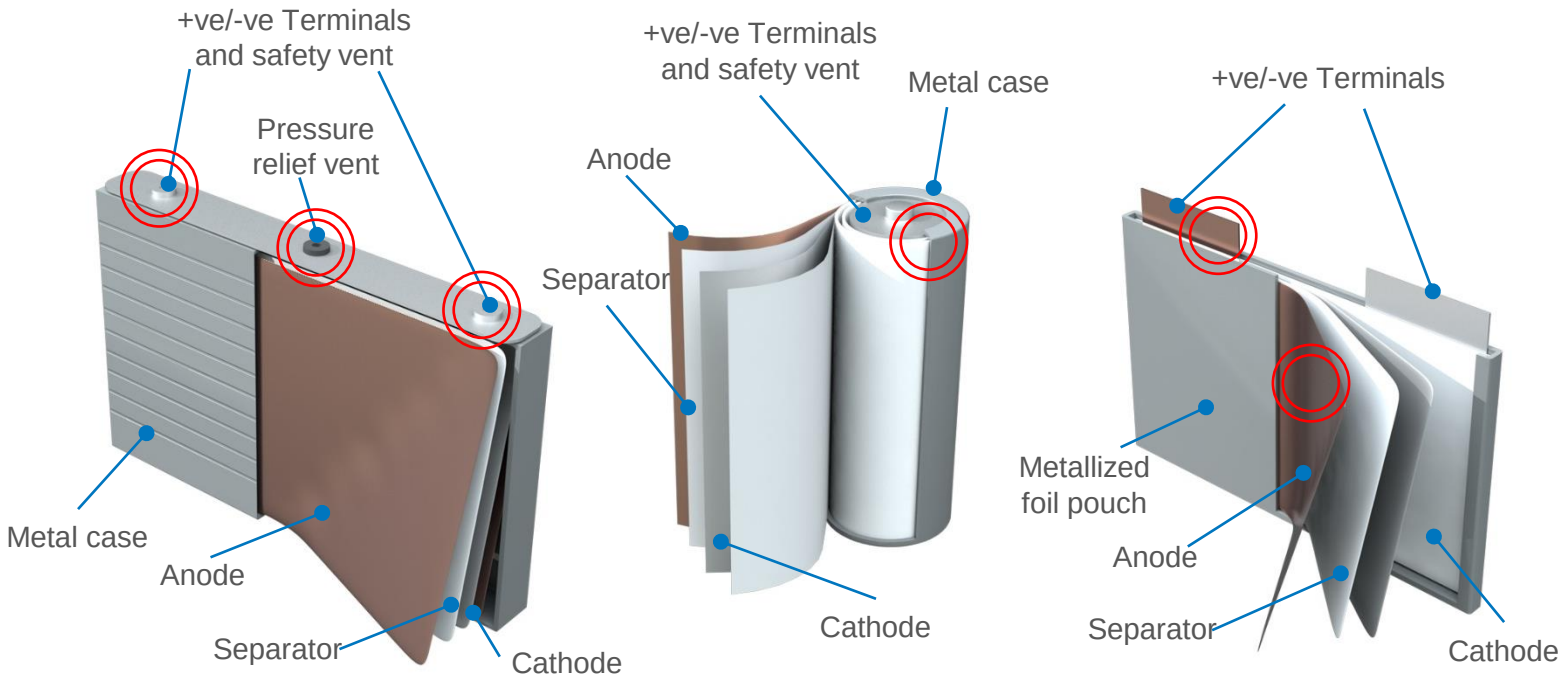
Battery Cell & Battery Pack





Battery Cell Assembly

Aluminium & copper processing



Prismatic
~20% Share

Cylindrical
>50% Share

Polymer pouch
~30% Share

Cutting

- Aluminium cathode
- Copper anode
- Separator foil

Welding

- Aluminium pressure vent
- Aluminium current interrupt device
- 3000 series aluminium alloy case
- Terminal blocks copper to aluminium, aluminium to aluminium
- Electrodes copper to copper, aluminium to aluminium
- Polymer case

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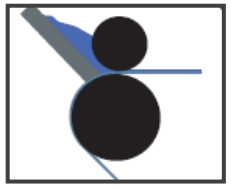
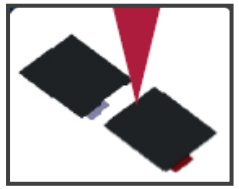
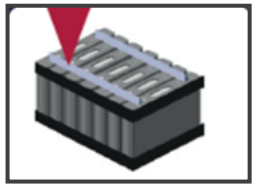
Laser Opportunities in Battery Cell & Pack Manufacturing

Pre Treatment → Coating → Tailoring → Connecting → Joining → Assembly

Battery Cell					Battery Pack
Structruring	Drying	Seperator & Electrode Cutting	Foil Welding	Welding (cans, contacts, burst plates, vents)	Cleaning & Marking Welding of bus bars & housings
Emerging	Emerging	Production	Emerging	Production	Production



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Ablation of Foil Coating with Pulsed Lasers

- To apply a continuous coating process for anode and cathode foils, it might be necessary to ablate sections for contacting afterwards.
- Coherent q-switched and ultrafast lasers enable precise ablation with very low heat affects.
- Depending on the required ablation rate and quality, pulsed (ns or ps) IR or green lasers of different power levels can be used.

Cathode foil ablated with
- 160 W average power
- ns pulsed IR fiber laser

Anode foil ablated with
- 50 W average power
- ps pulsed green laser

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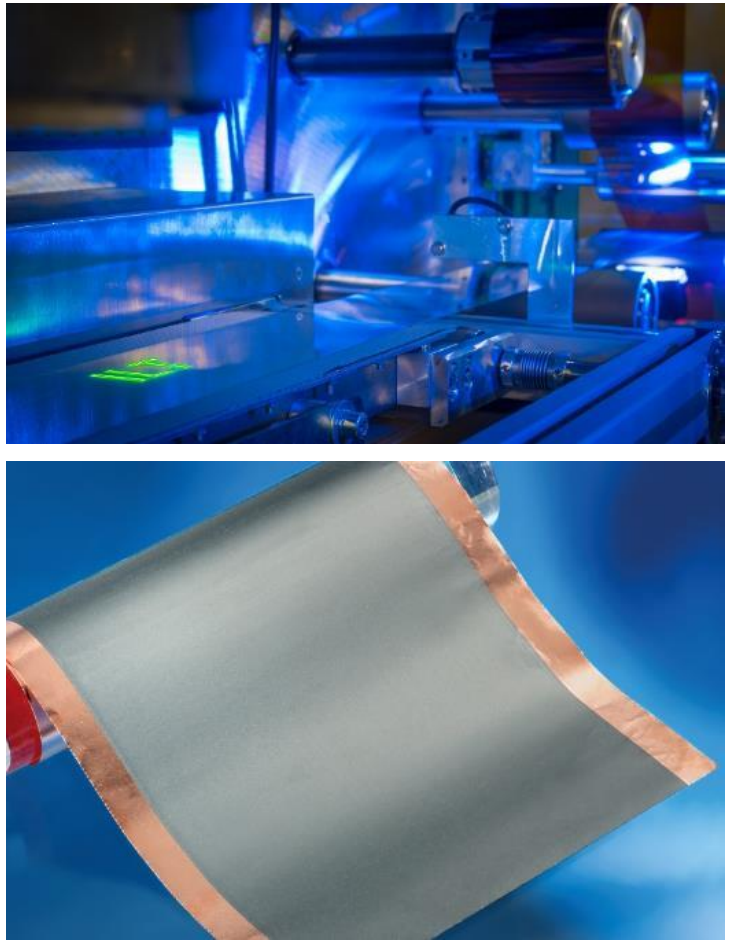
Laser Drying with Diode or Fiber Lasers

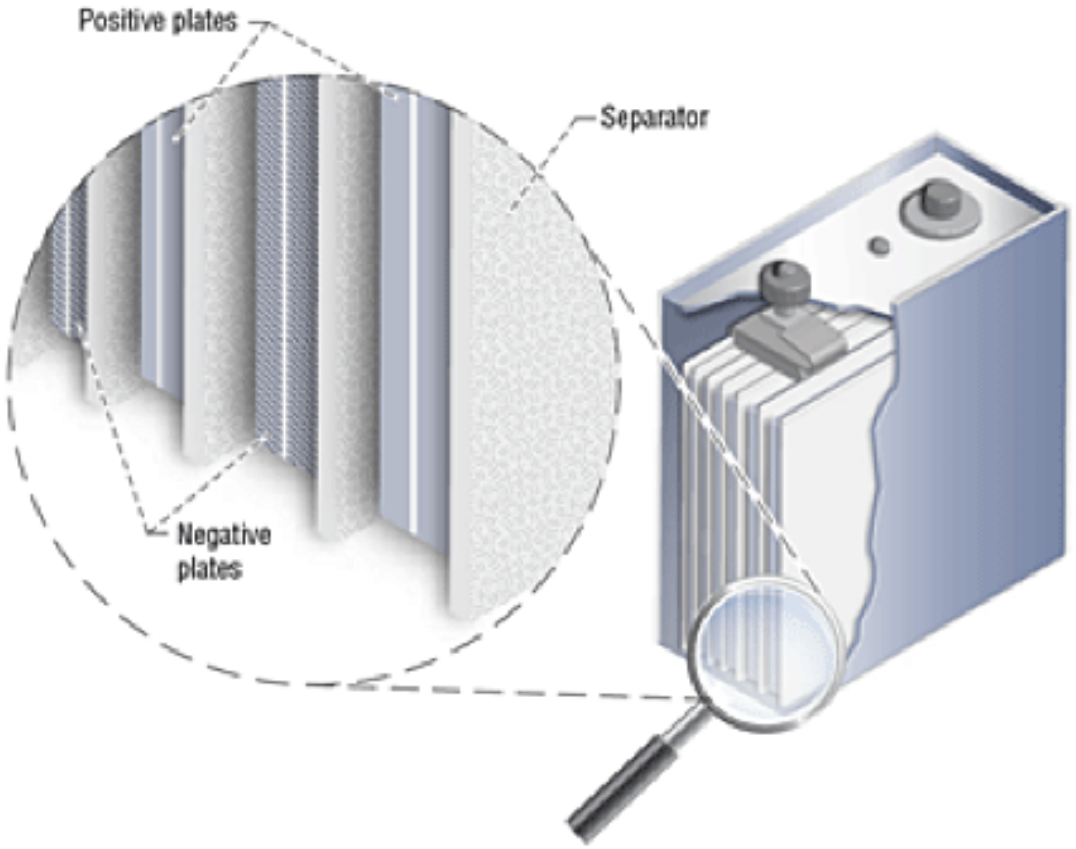
- Potential to substitute conventional vacuum furnace drying with inefficient energy deposition
- Direct absorption of the laser wavelength in the electrode layer
- Energy efficient due to excellent heat control.
- Reduction of energy process consumption by 50%
- Roll to roll process possible – reduction of line length



Source: Fraunhofer ILT, October 2015

Battery Cell Assembly – Separator Cutting

- Punch-press & knife cut
  - Tool wear & variable cut quality.
- Laser process
  - Scanner based high speed cutting process.
  - Speed of > 1 m/sec required.
  - CO_2 or CO laser wavelengths suitable for some basic materials PP or PE
- Next generation of hybrid ceramic materials, present new laser opportunity.



Battery Foil Welding

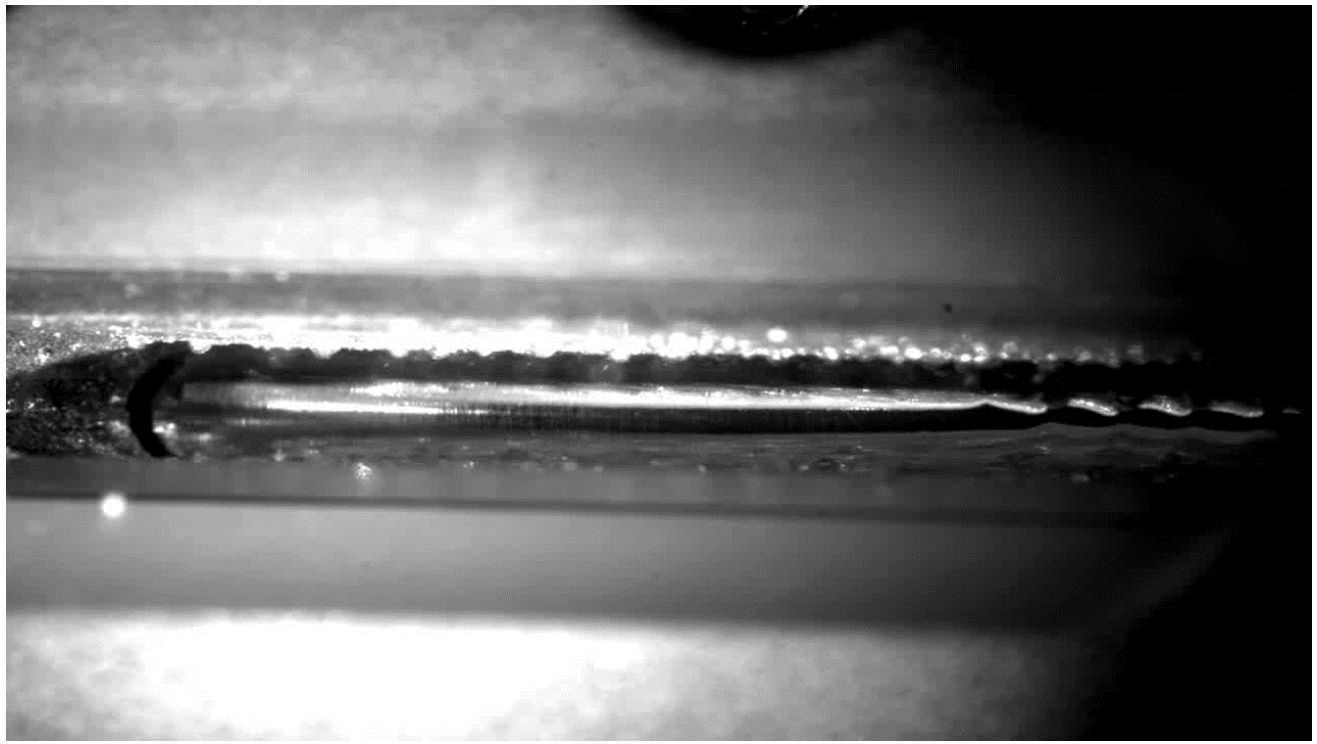
- Ultrasonic welding used today causes undesired debris.
- Depending on battery cell set-up stacks (Cu or Al) of up to 120 single foils (each 8…20 µm thick) need to be welded to a connector
- Spattering and voids can be avoided with proper laser and process parameter selection
- Process knowledge and dedicated laser required for stable process window with no spatter or voids

Successfully welded stack of 100 Cu foils (8 µm each) with ARM laser

Copper Foil-to-Tab Welding by ARM Laser

ARM: No Spatter and No Voids

- Ultrasonic welding used today causes undesired debris.
- >50 foils, each 5 µm thick, need to be welded to a connector



Top

Bottom

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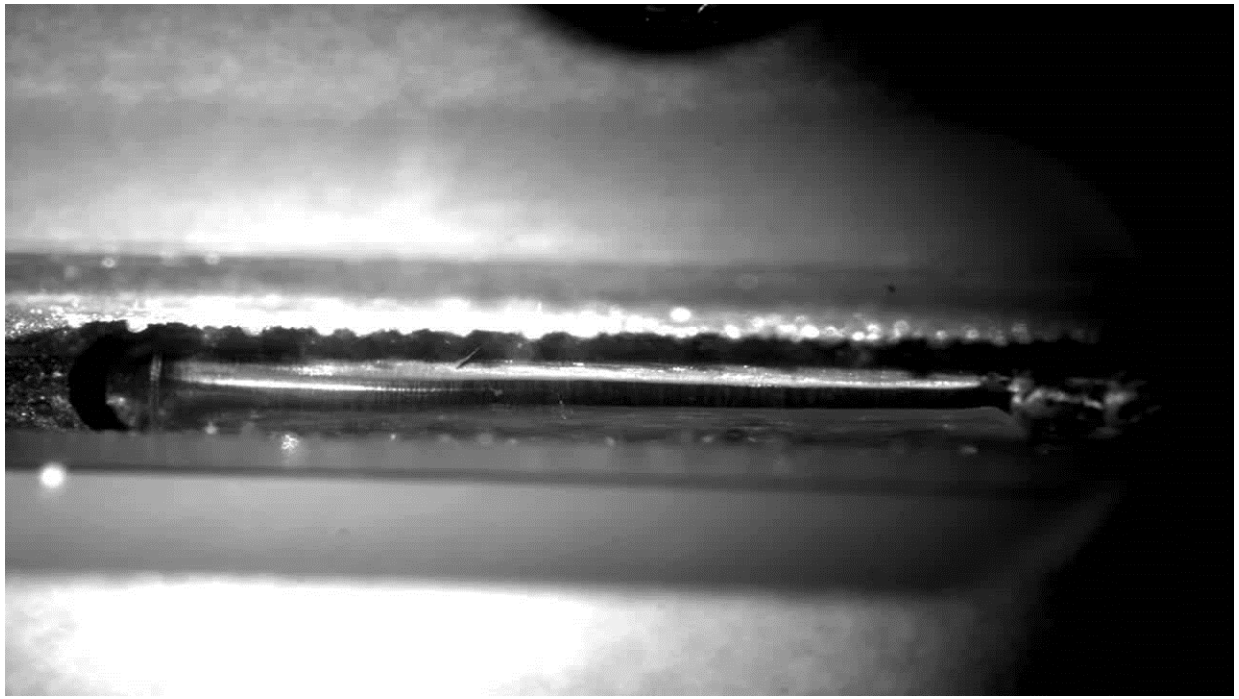
Aluminum Foil-to-Tab Welding by ARM Laser

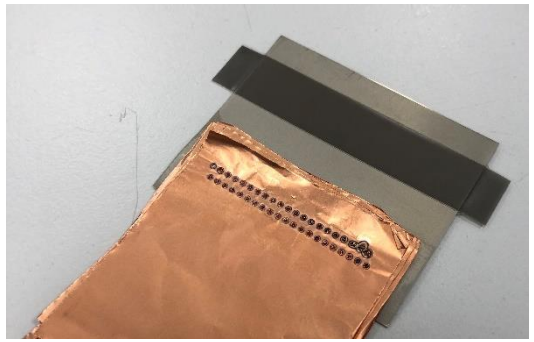
ARM: No Spatter and No Voids

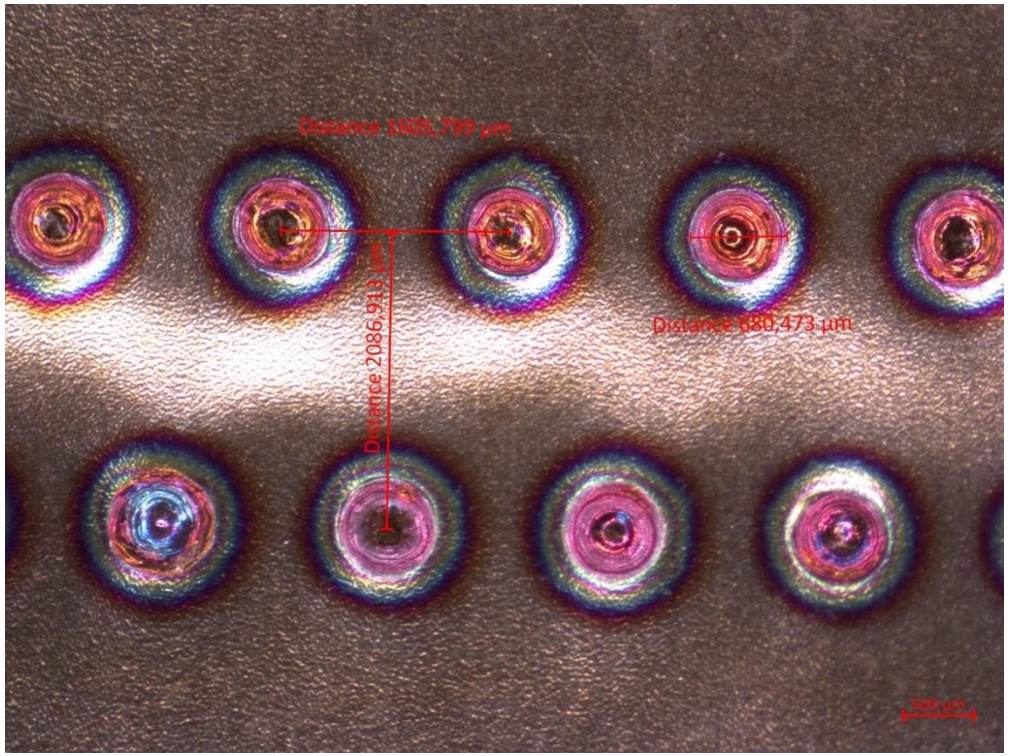
- Ultrasonic welding used today causes undesired debris.
- >50 foils, each 5-30 µm thick, need to be welded to a connector



Single Mode ARM - Foil to Tab Welding

- **Material**
  - Foils: Cu, 30 pcs
  - Tab: Cu (Ni-plated)
- **Setup**
  - FL-ARM single-mode laser
  - Optics: HighYag RLSK magn. 3x
- **Welding pattern**
  - 42 points (21 points in 2 lines)
    - Distance between points in line 1.5mm
    - Distance between lines 1.3 mm or 2.0 mm
  - Weld duration 9 ms/point
- **Summary**
  - All the spots welded, without punctures





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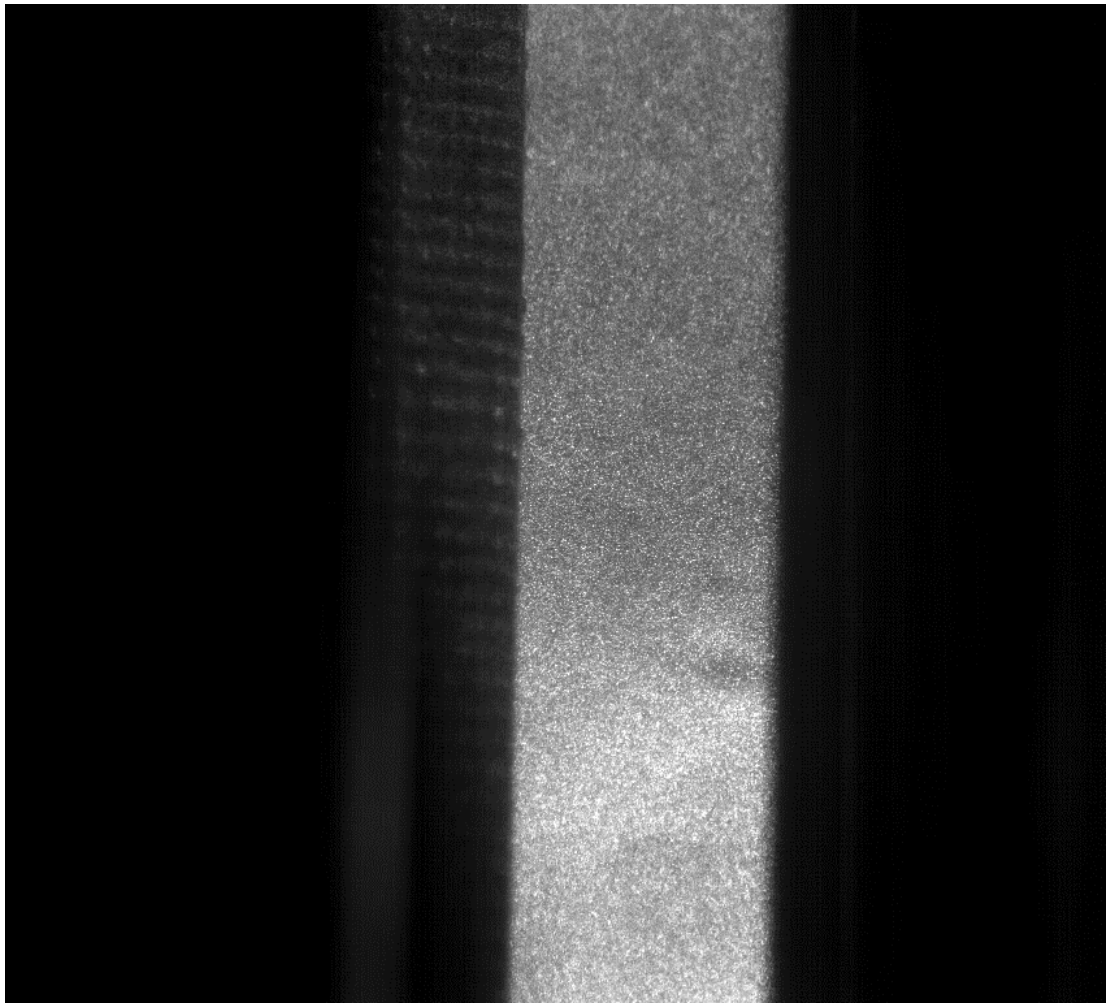
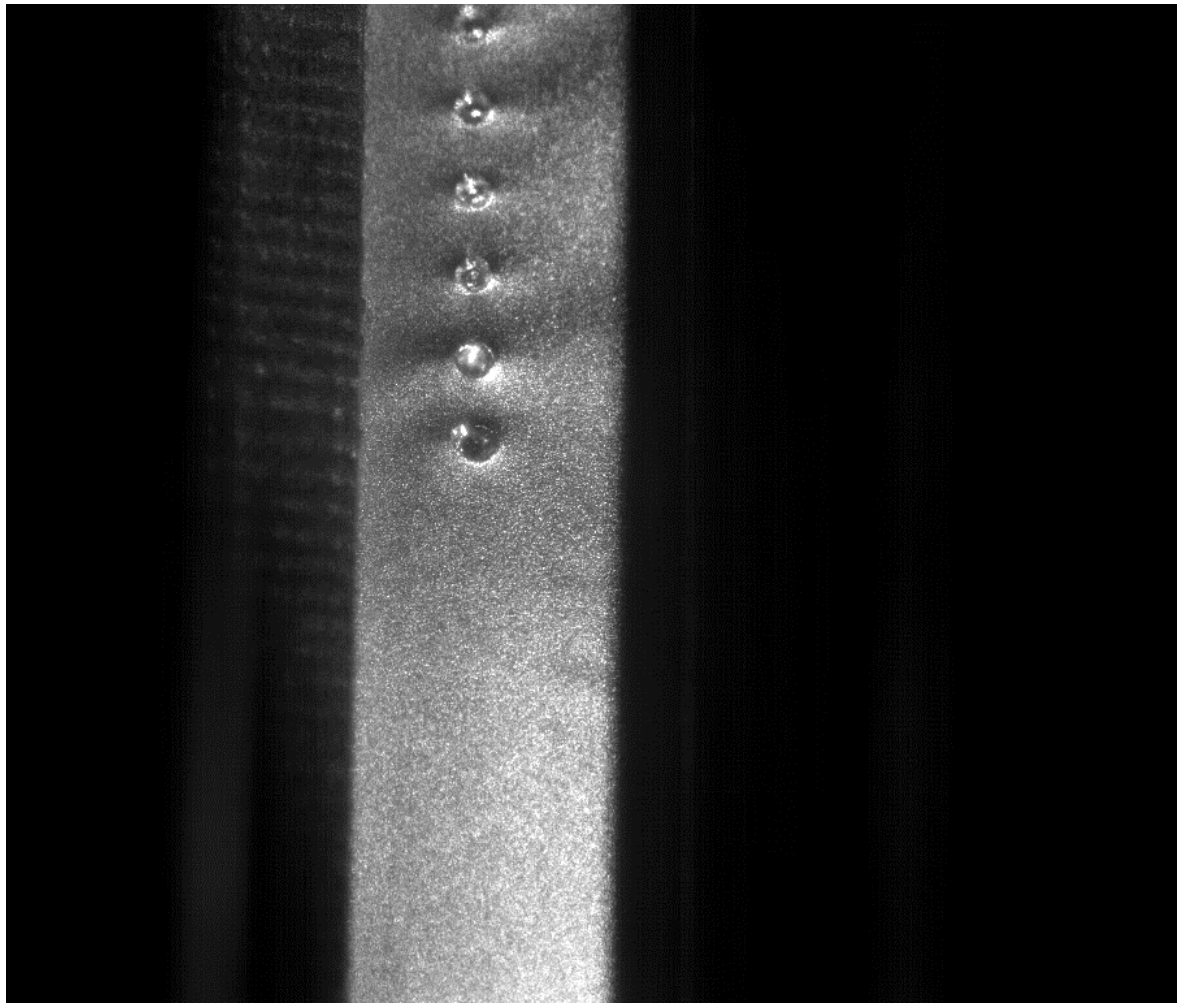
Battery Foil Welding
Single Mode ARM

High Speed Video: Single Mode ARM Welding





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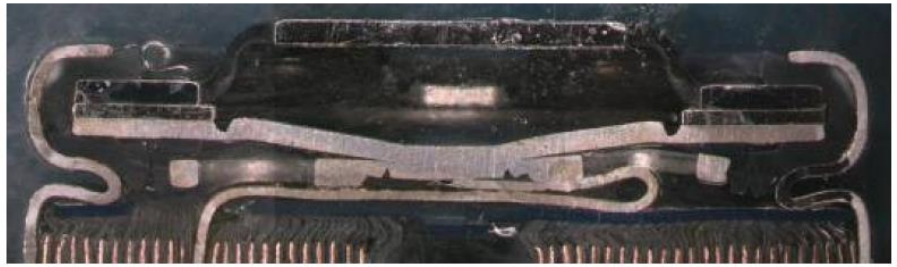
Fiber Laser Scanner Welding of CID on 18650 Cells…

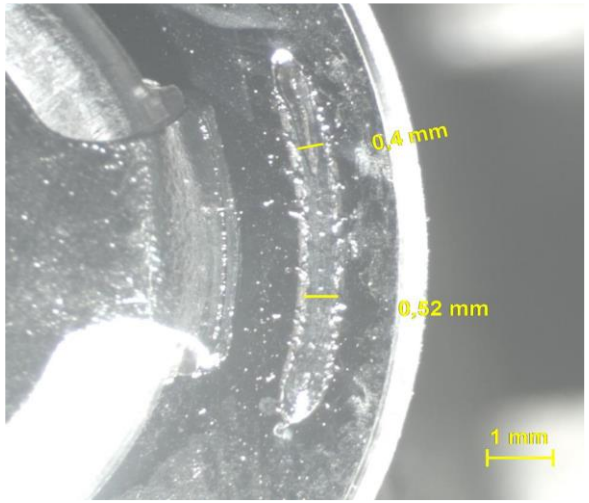
Process control for required welding depth… no weld through

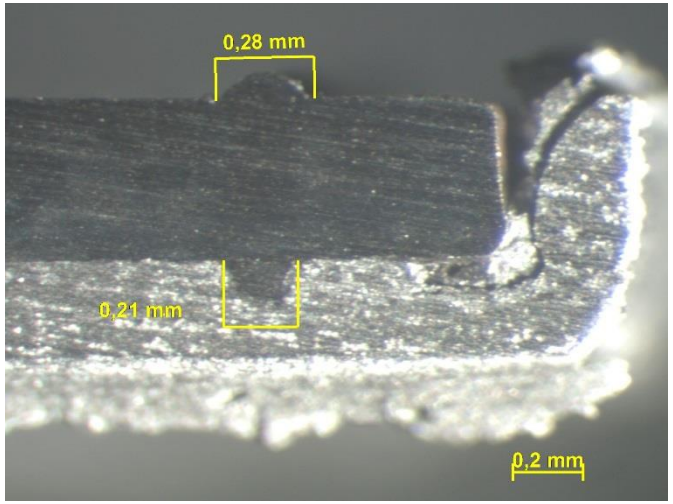
- 3 segments
- Aluminum 0.25 mm thick
- Stainless 0.5 mm thick (coated)
- < 0.8 sec. cycle time for 9 parts
- No effect on backside

18650 battery cell, sectional side view
Source: www.batteryuniversity.eu



laser power: 900 W
welding speed: 300 mm/s





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Surface Treatment for Joining Metal and Plastics

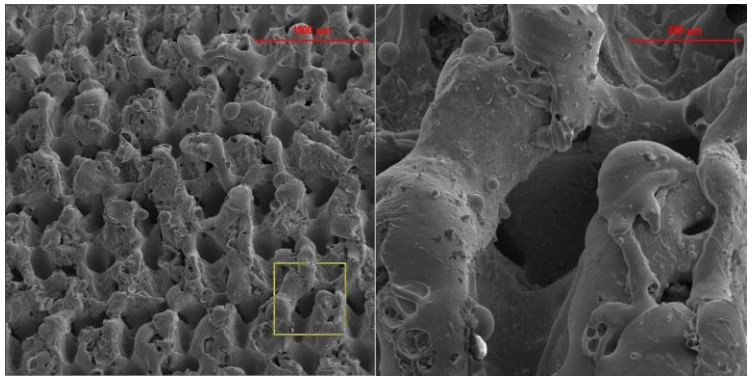
(PowerLine F 50 varia)

S-CID (Slim Current Interrupt Device): Detachable Type/Integrated Type

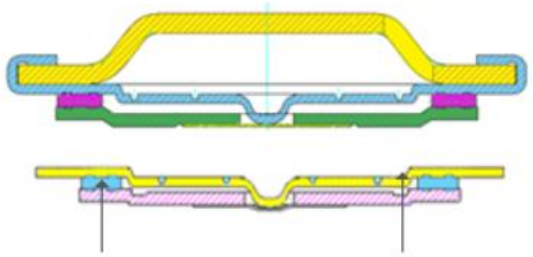
Product

Detachable Type

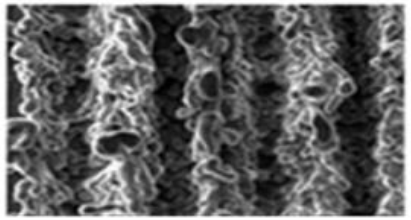
Integrated Type



Technology



Heat sealing film insulator Slim-structured vent



Special Surface Treatment
- Easy heat sealing due to laser surface treatment
- Space secured due to insulator heat sealing
  → Capacity increase

Using short pulsed micro laser to make pockets on metal surface.

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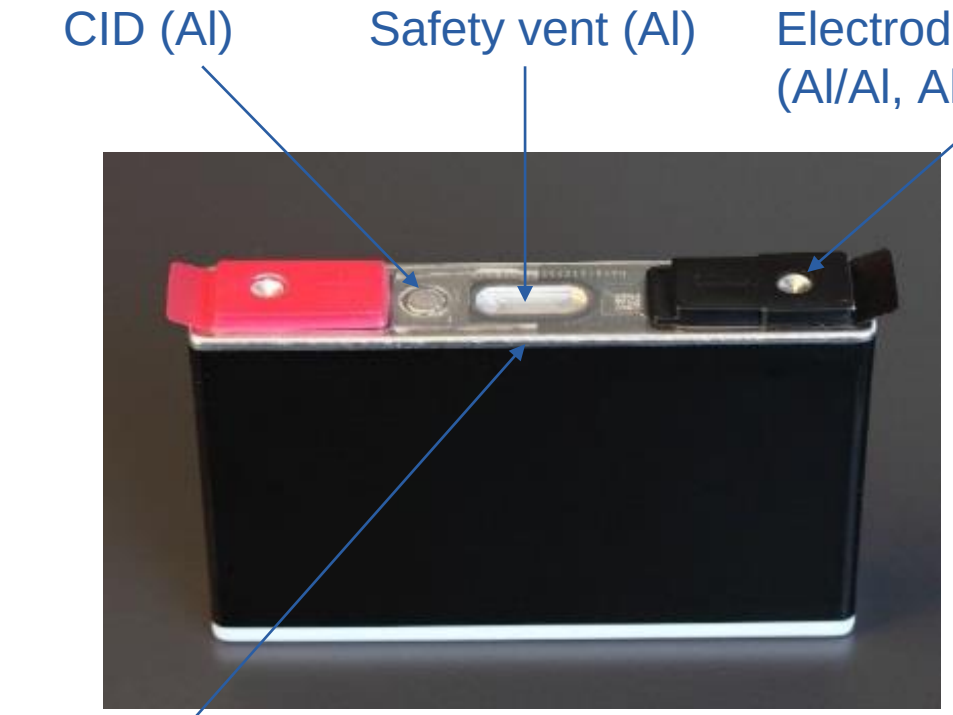
Battery Cell Assembly – Prismatic Cell Assembly

Materials

- Aluminum (typically 3000 series)
- Copper

Laser process

- Legacy pulsed Nd:YAG process.
- QCW fibre laser as direct replacement for pulsed Nd:YAG lasers on existing lines.
- Currently - Disk, fibre & ARM fibre, hybrid diode laser.
- High speed contour typical for lid - can weld
- Scanner welding possible for electrodes, CID, and overpressure protection



Source: Voltabox

Battery Lid Welding <1mm Weld Depth

Welding of CID and safety vent – 3000 series aluminum

Requirements:

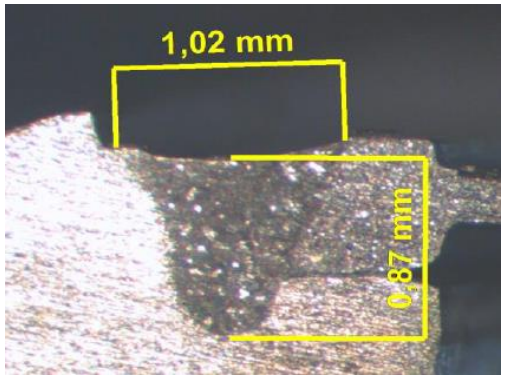
- Smooth and shiny weld seam surface
- No pores or cracks

Achievements:

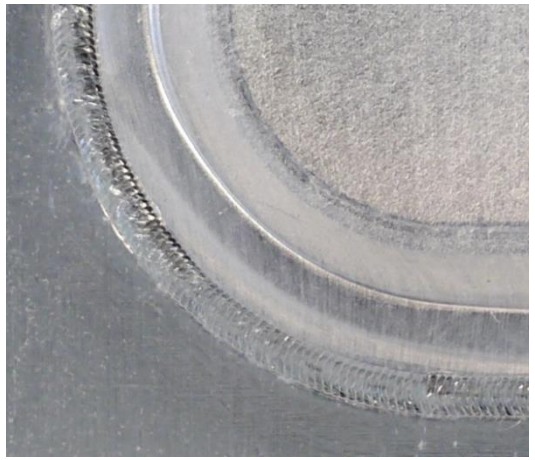
- Welding speed up to 400 mm/sec
- up to 1,0 mm penetration
- up to 1,0 mm seam width
- 1,5 kW laser power

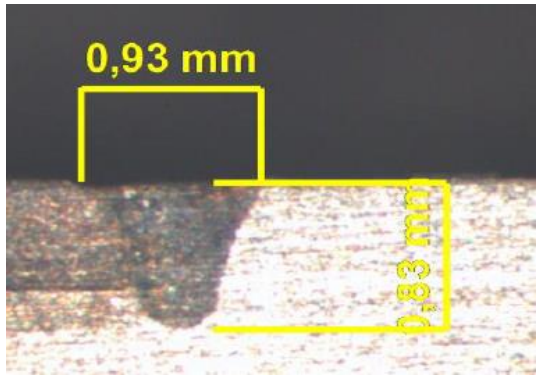
Premier weld results with standard fiber lasers @ weld depth <1mm

CID



Safety vent





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Battery Tab Welding

Welding of terminals

Requirements:

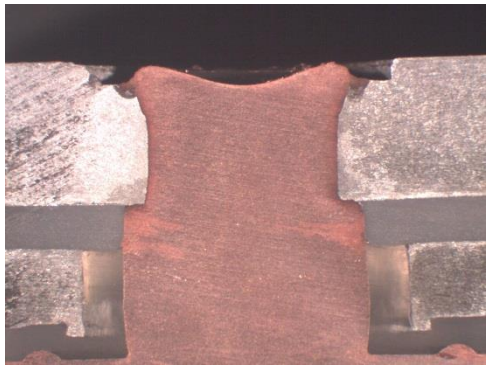
- No pores or cracks
- Controlled inter-metallics

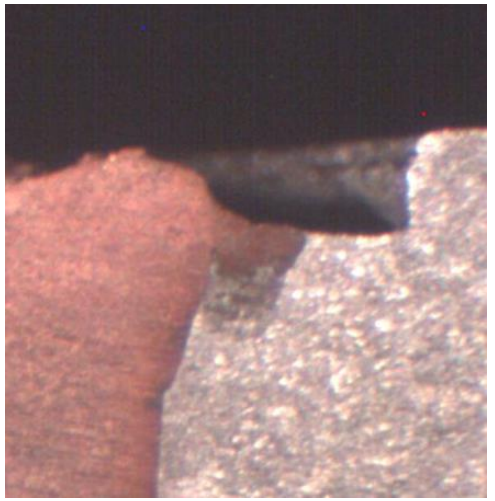
Achievements:

- Welding speed up to 250 mm/sec
- about 1,0 mm penetration
- up to 1,0 mm seam width
- 1,5 kW laser power

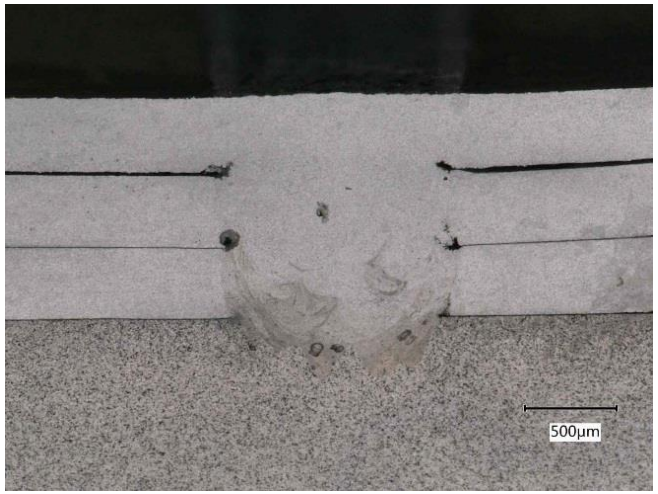
Precise welding of dissimilar materials enabled by superior beam quality and application experience.

Al/Cu





Al/Al



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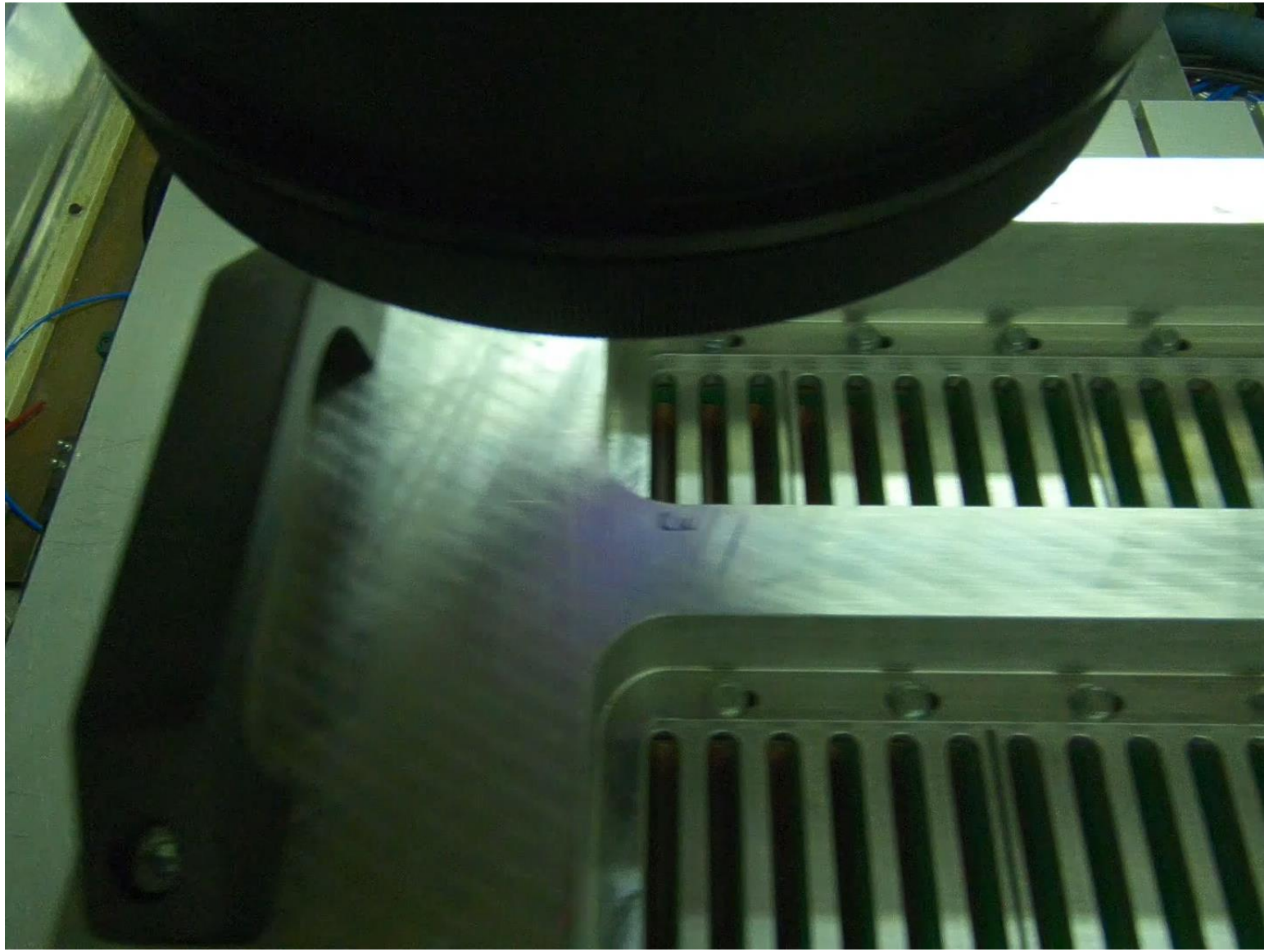
Battery Tab Welding with Single Mode Fiber



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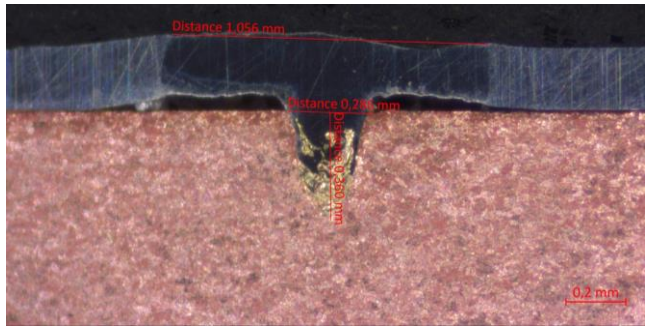
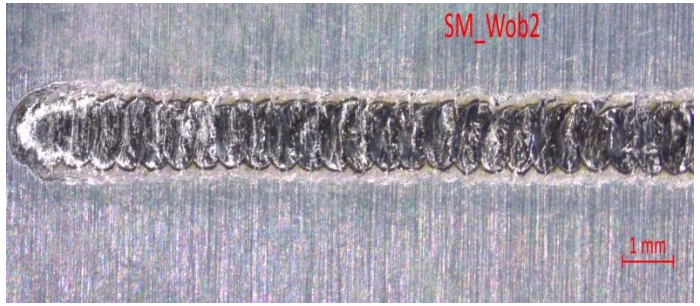
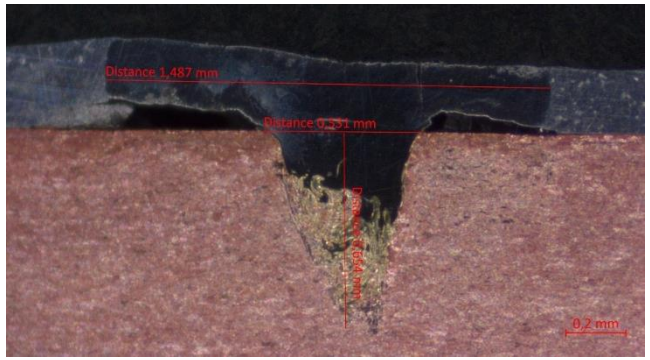
Single Mode ARM - Aluminum Tab to Bus Bar

- **Material**
  - Tab: Al
  - Plate: Cu
- **Setup**
  - FL-ARM single-mode laser
  - Optics: HighYag RLSK magn. 3x
- **Welding pattern**
  - Linear
  - Linear with wobble
  - Snake with wobble
- **Summary**
  - Customer very positive, low spatter, g

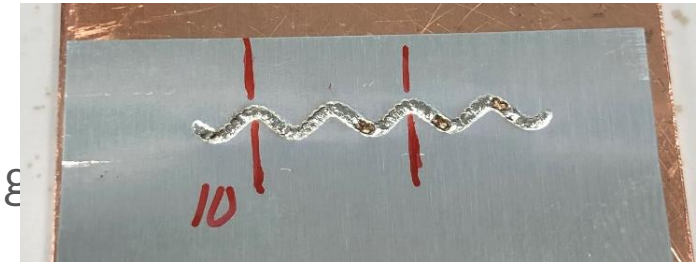
Linear

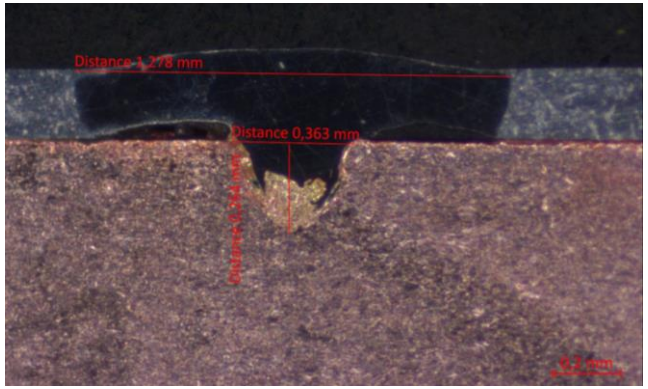






Linear with wobble





Snake with wobble

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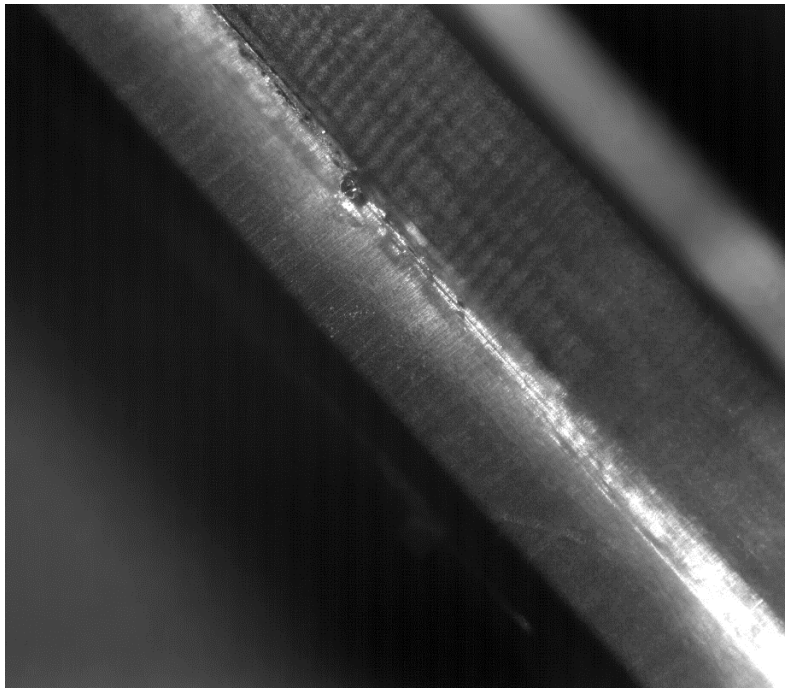
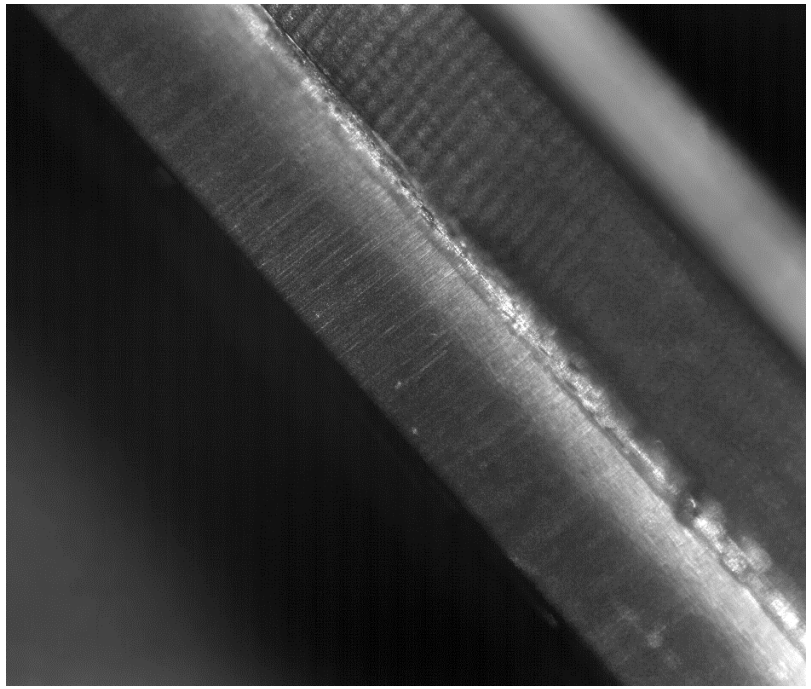
High Speed Video - Single Mode ARM Welding



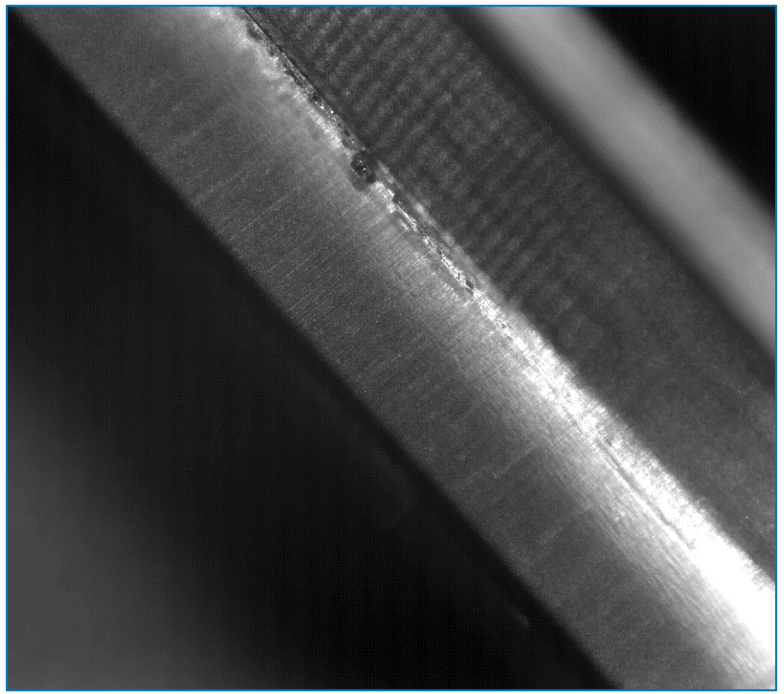
Linear

Velocity: 10mm/s
Power: C700W/ R1200W
Duration: 0.180s
Shield gas: N2 20 l/min



Linear with wobble

Velocity: 60mm/s
Power: C700W/ R1000W
Duration: 0.300s
Shield gas: N2 20 l/min



Snake with wobble

Velocity: 45mm/s
Power: C700W/ R1000W
Duration: 0.302s
Shield gas: N2 20 l/min

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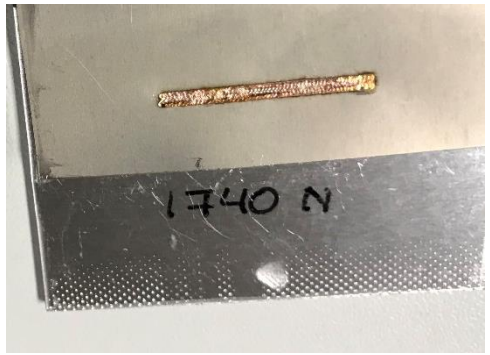
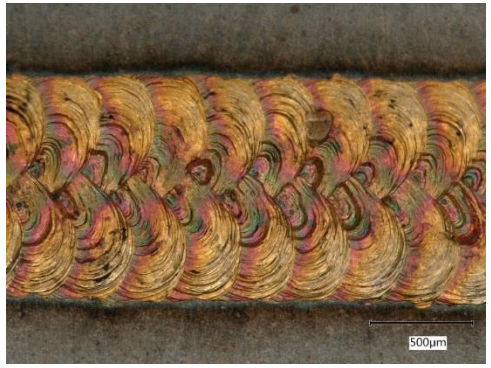
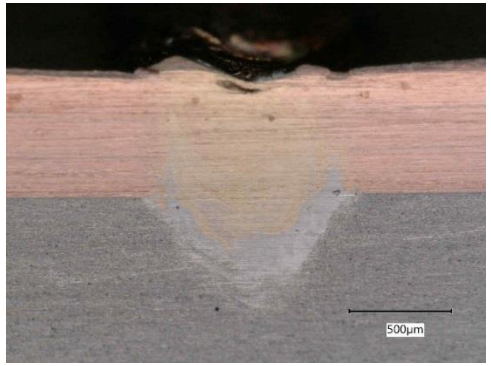
SmartWeld+ Application Examples







- Market: Battery manufacturing
- Material: 3 x 0.2mm Ni plated Cu to Al
- Application: Busbar welding
- Sub-system: FL 010, SmartWeld+

- Rectangular, homogenous cross section
- Very low porosity, minimum pores
- No impact visible on back side

- Length / width: 20mm / 1.4mm
- Tcycle.: 0.6 s
- Welding depth: ~1 mm
- Shear strength: > 1740 N
- Pavg.: 500 W

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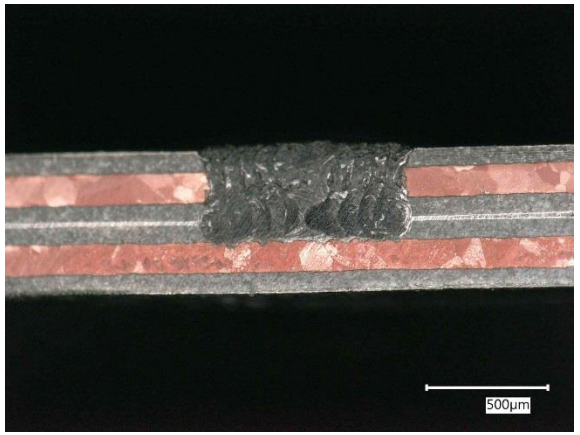
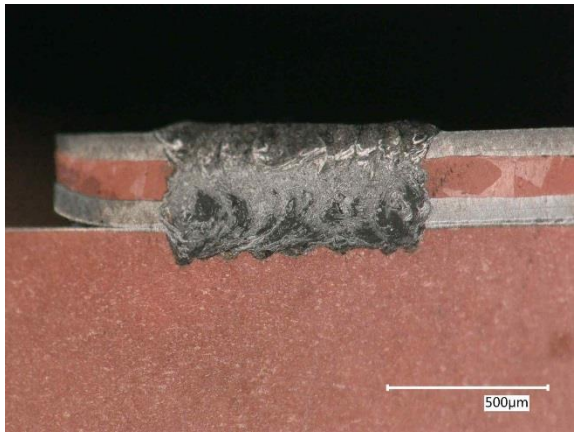
SmartWeld+ Application Examples





- Market: Battery manufacturing
- Material: 2 x 0.3 mm Sigmaclad and 1 X 0.3 mm to 1 mm Cu (composite of Ni-SS-Cu)
- Appplication: Busbar welding
- Sub-system: SF600, SmartWeld+

- Rectangular, homogenous cross section
- No impact visible on back side

- Length / width: spot weld, Ø 1 mm
- Tcycle.: 0.04 s
- Welding depth: ~ 400 µm
- Pavg.: 250/350 W

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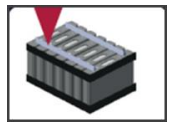
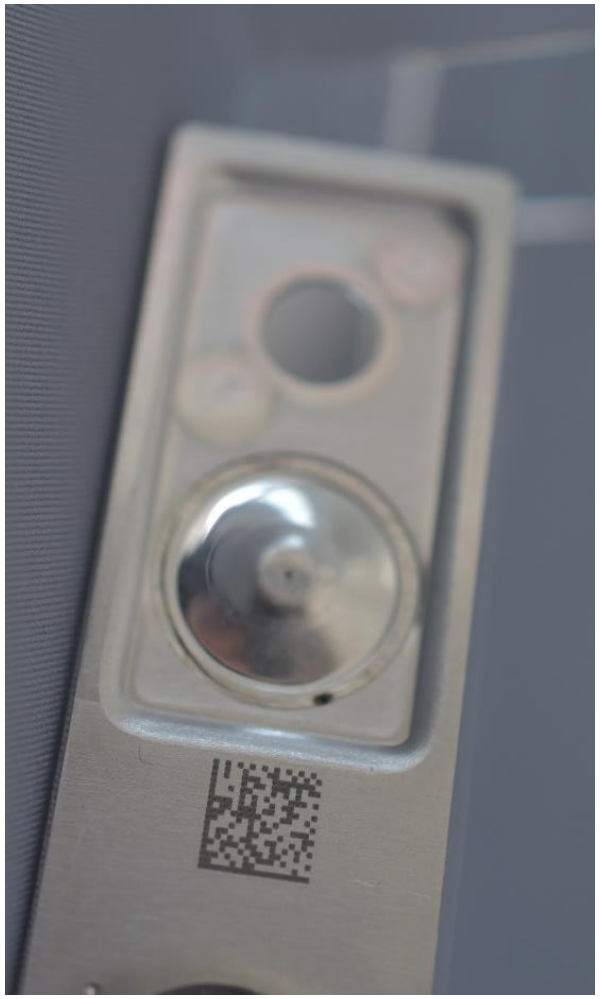


Battery Track and Traceability

- Track & Traceability mandatory for safety relevant parts
- Battery individual serial data coded in machine-readable datamatrix codes
- Direct part marking requires necessary contrast ratio for good readability, even by hand held devices
- DPSS or fiber laser are a common choice for the marking onto aluminum material
- DM2 code 5x5mm in less than 3 secs



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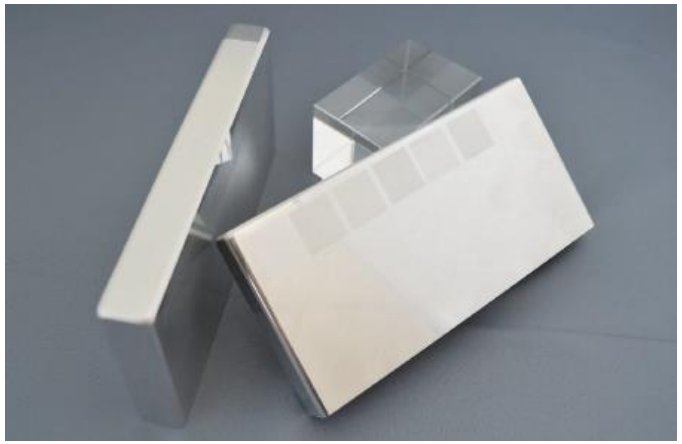
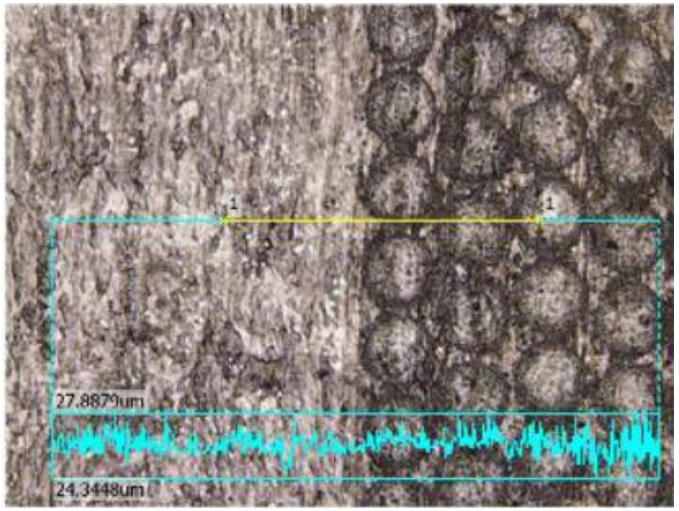
Battery Housing Cleaning

- Contamination by electrolyte remains on the exterior face of the battery housing
- Laser cleaning of aluminum pocket to maintain adhesive forces of spray paint layer at all environmental conditions
- Sub-ns / ns laser for minimal abrasive process, no change in material properties, wall thickness, no smoke residue and minimal particle contamination
- Cleaning performance up to 80cm2/sec

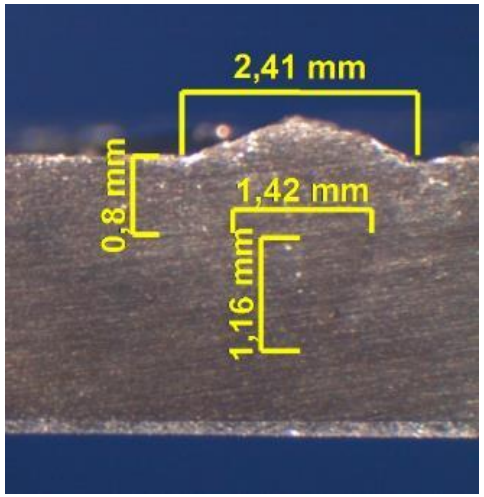




Welding of Connectors/Busbars

- Bus bars connect various cell terminals.
- Consists of either Aluminum, Copper or Ni-plated steel
- Flexible high-speed welding process with 2D Scanner
- High Power cw Fiber Laser (e.g. 2 kW for 2 mm penetration in Al at 4 m/min)
- Mixed metal welding requires process knowledge and dedicated laser sources for a stable window.

Source: Amada Miyachi



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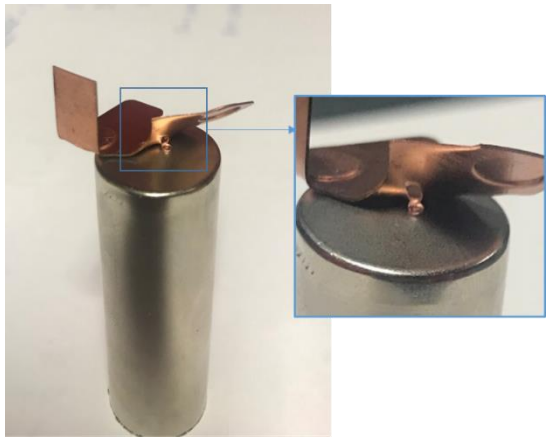
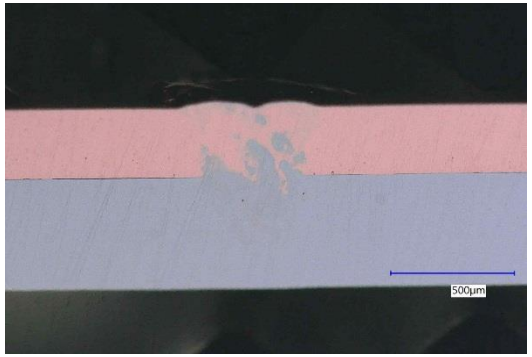
SmartWeld+ Application Examples





- Market: Battery manufacturing
- Material: 0.2 mm Cu to 0.3 mm SS
- Appplication: Busbar welding
- Sub-system: SF150P, SmartWeld+

- Rectangular, homogenous cross section
- No impact visible on inner side

- Length / width: spot weld, Ø 1 mm
- Tcycle.: 0.026 s
- Welding depth: ~ 300 µm
- Yield strength: 150 N / spot

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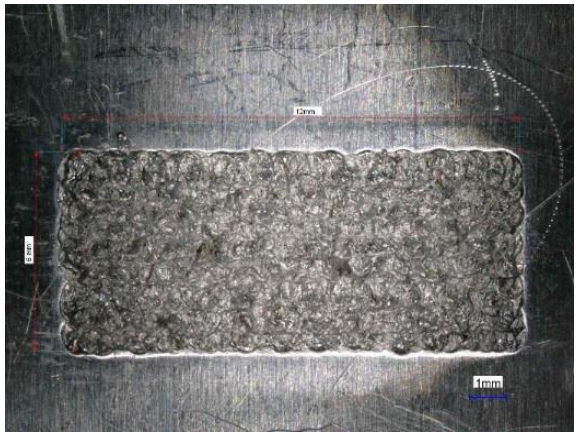
SmartWeld+ Application Examples



- Market: Battery manufacturing
- Material: 2 mm Al to 1 mm steel
- Appplication: Busbar welding
- Sub-system: SF150P, SmartWeld+

- Large contact area
- Homogenous penetration depth
- Bridging large gap and misalignment

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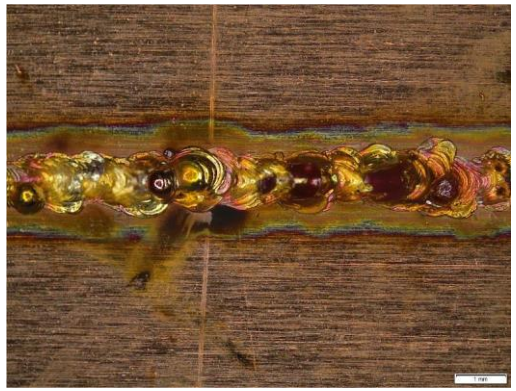
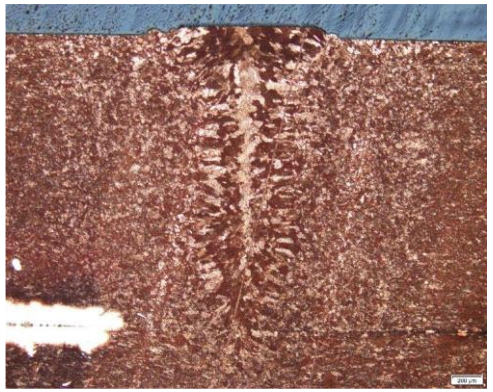
Welding Copper with ARM



4 kW, 5m/min



4 kW, 5m/min;
optimized beam profile

power modulation for
copper foil (100 x 10µm) welding

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Lap Welding Cu1020P 0.8mm Speed 12m/min

Center 3kw

Ring 4kw

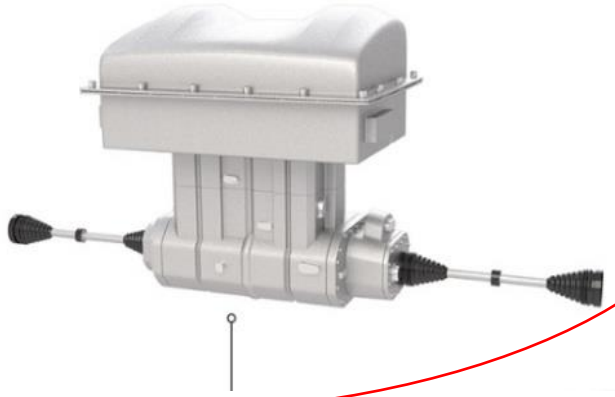
Center 3kw+Ring 4Kw

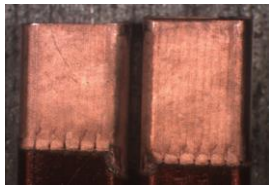
COHERENT.

The Anatomy of an Electric Vehicle's MP Laser Applications

Electric Motor Welding

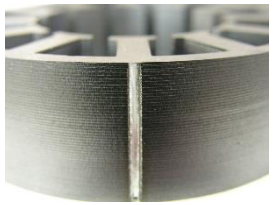
Electric Motor welding





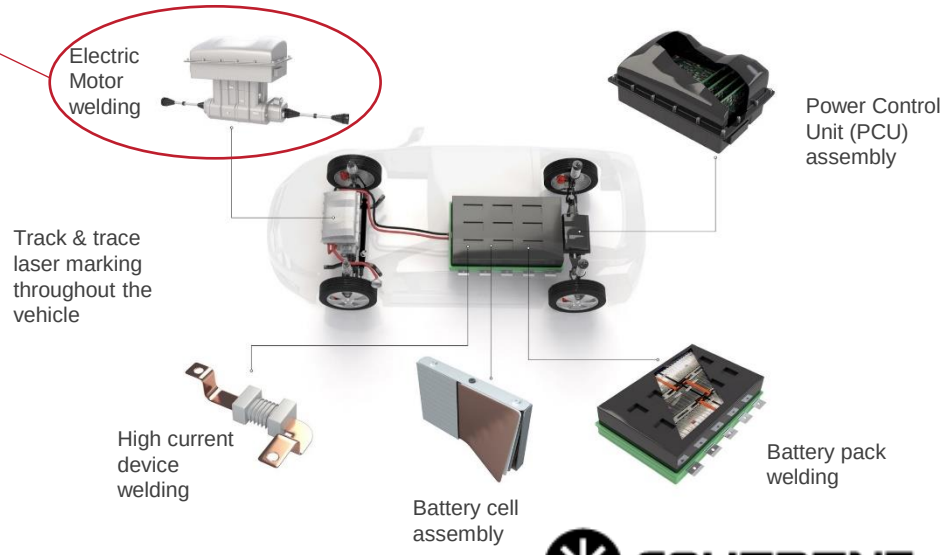
1. Cu Pin stripping

2. Cu Pin welding



3. Cutting and welding of stators (prototypes)

Source: Polaris LLC



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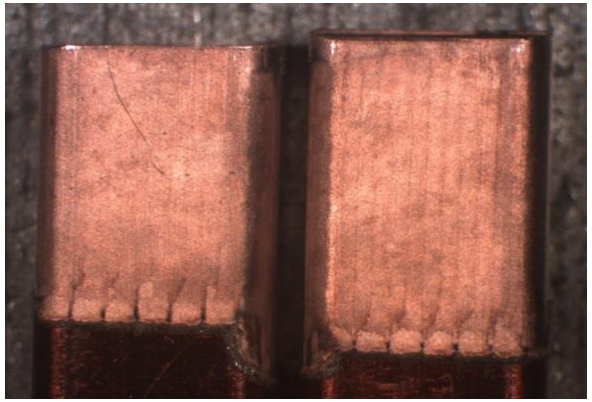
Electric Powertrain: 1. Cu Pin Stripping

- Copper wire has lacquer layer, polyamide-imide PAI, for protection.
- Residual lacquer layer has a significant impact on welding process.
- Complete removal of lacquer layer necessary for consistent welding process, quality and cleanliness by 2-step approach.
- Step 1: CO_2 laser to remove lacquer layer without structuring surface.
- Step 2: Small remaining lacquer spots are removed by F100 IR ns fibre laser or Pico 50, to provide a clean and structured surface, which is beneficial for subsequent welding process.



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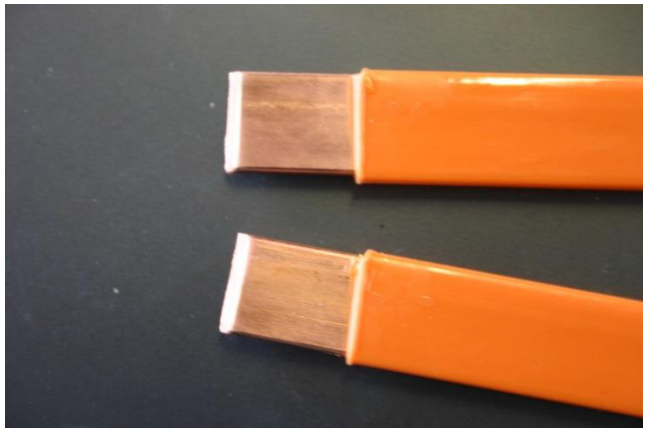
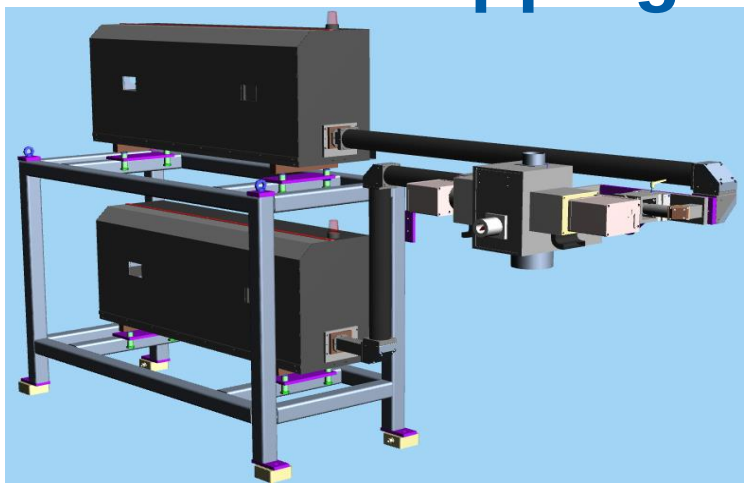
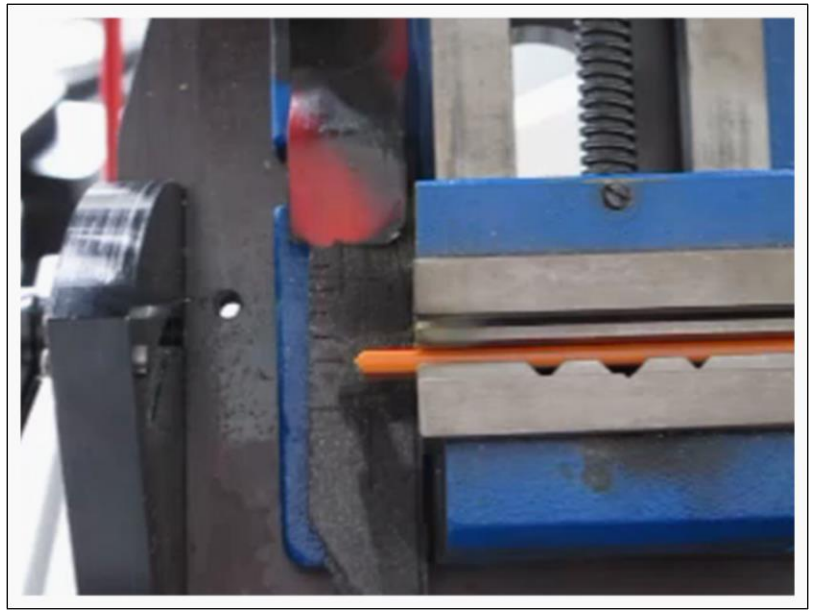
StarShape Application: Wire stripping





Stripping of conductor rails or hairpins. Special designed process chamber is available.



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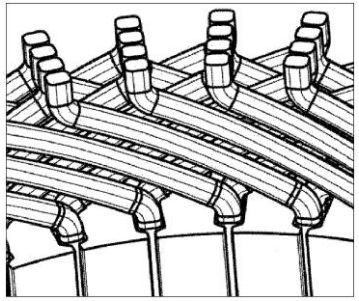
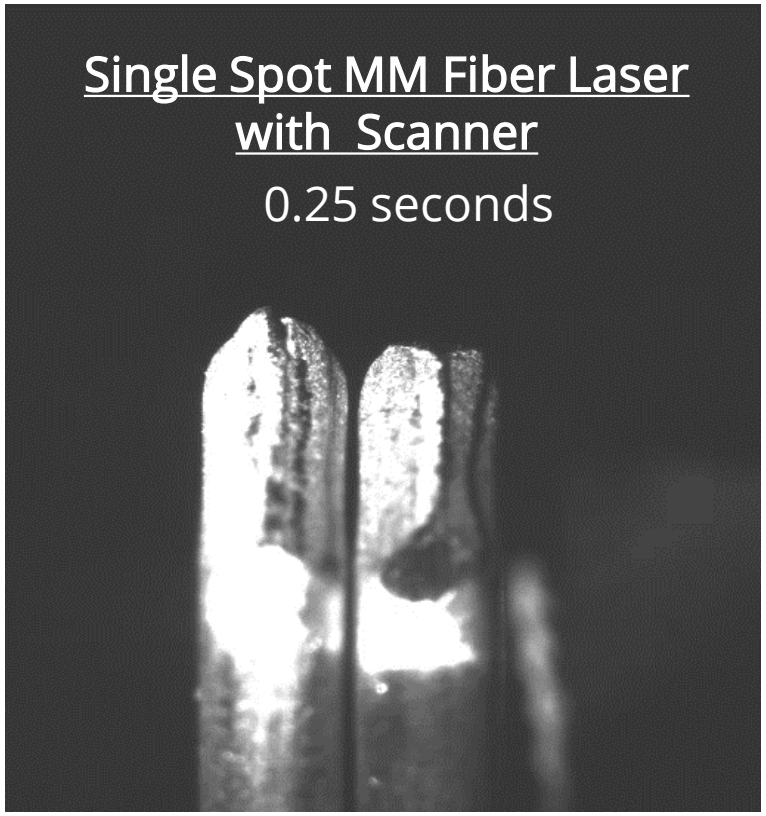
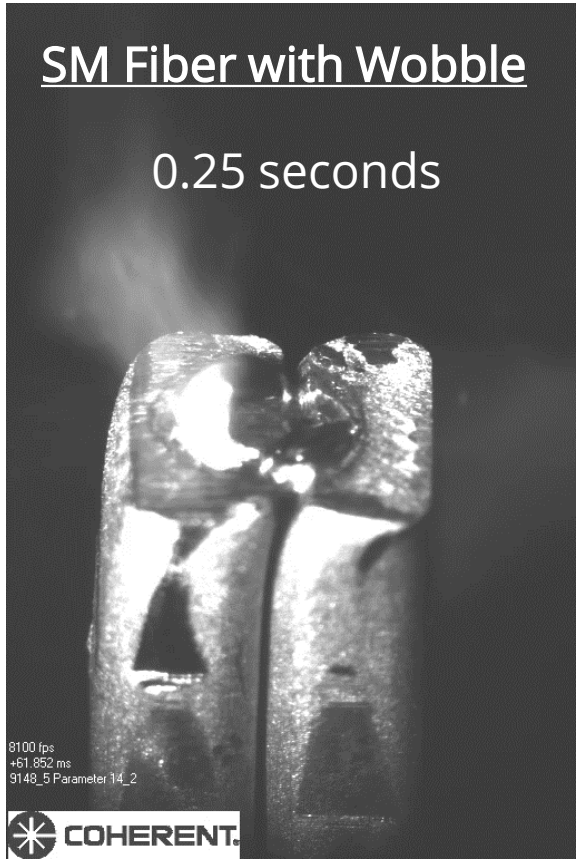
Electric Powertrain: 2. Cu Pin Welding

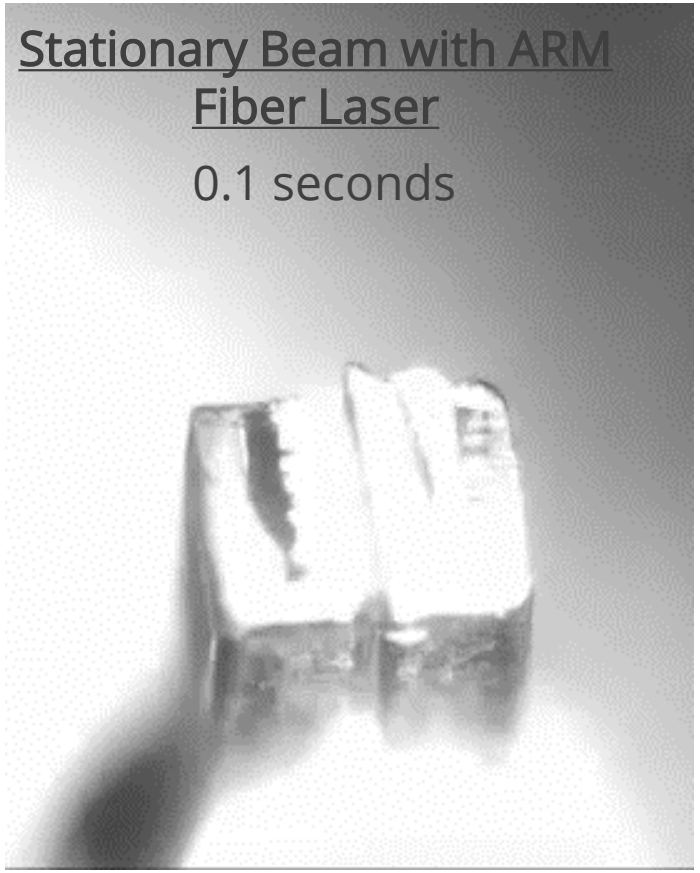
- The stripped Cu Pins are welded in the stator
- Proper alignment of the pins and a weld without any defects (inclusions) are essential for the motor performance



Hair Pin Welding: Fiber Laser Comparison







Three Approaches
- Multimode fiber laser
- Single Mode fiber laser
- ARM fiber laser

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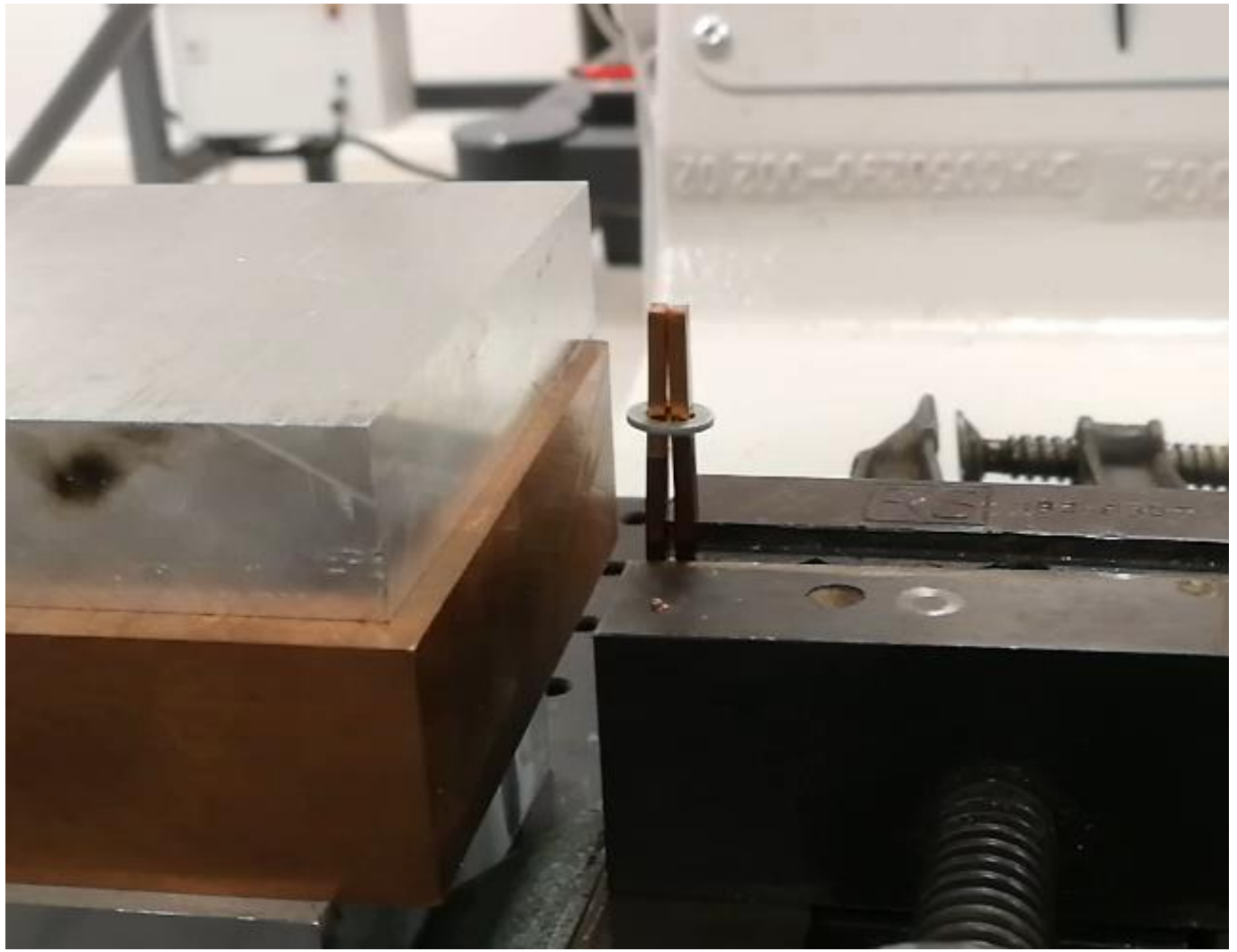
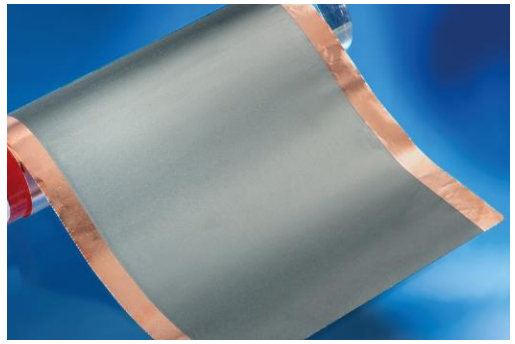
Hair Pin Welding: ARM

Realtime

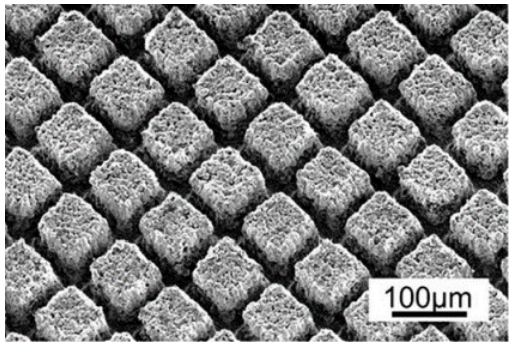


Lasers for Lithium-Ion Battery Cell Assembly

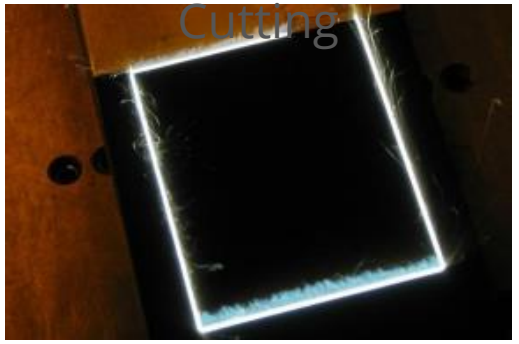
Slurry Drying



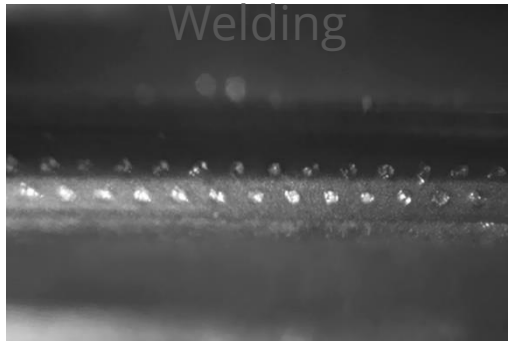
Surface Structuring



Electrode Foil Cutting



Electrode Tab Welding



HighLight DL Series

HyperRapid NX Series

Avia NX Series

HighLight FL ARM

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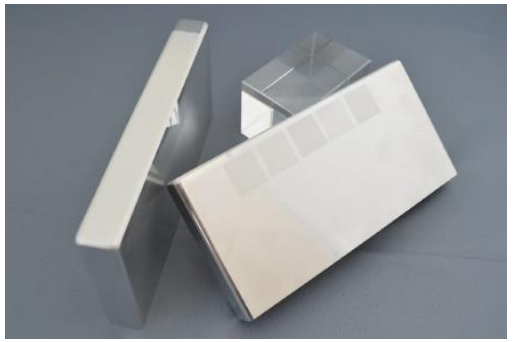
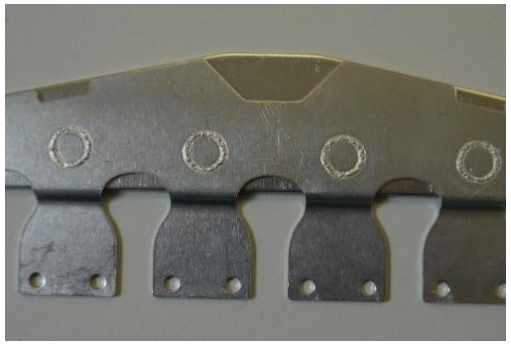
Lithium-Ion Battery Pack Assembly

Terminal Welding

Surface Cleaning



Bus Bar Welding



Track & Trace

HighLight FL Series

Foto LP rail

PowerLine Pico Series

HighLight FL Series

PowerLine F Series

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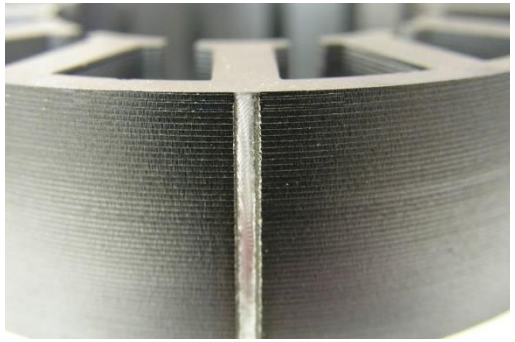
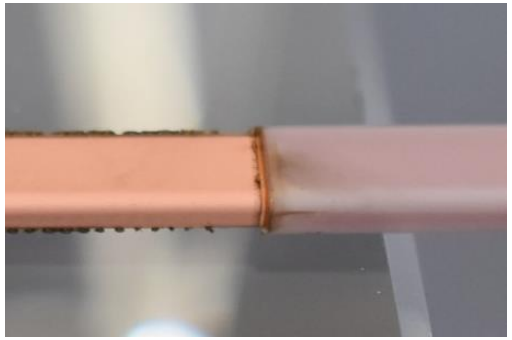
Products for Electric Motor Assembly

Lamination Welding

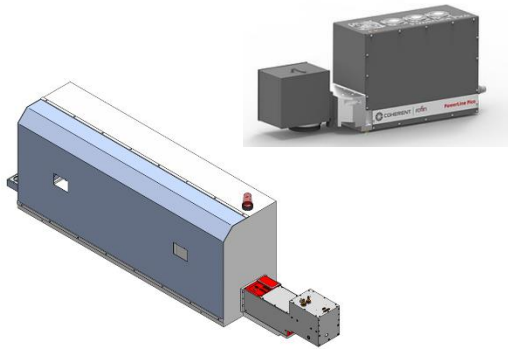


HighLight FL Series

Wire Stripping



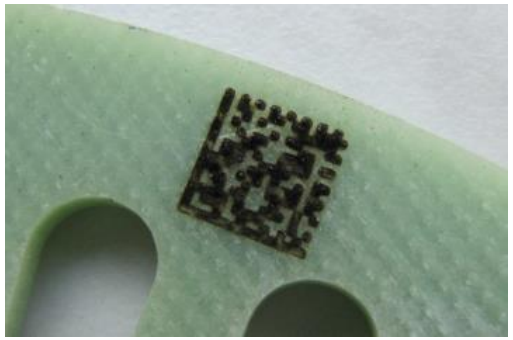
PowerLine Pico Series
HighLight FL Series
Starshape



Hair Pin Welding

HighLight FL Series

Track & Trace



PowerLine F Series

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Thank you for your Attention

Paolo Cardani – Market Development Manag
paolo.cardani@coherent.com
+39 348 521 1754