LaserEMobility Workshop,
10th and 11th March, 2022

Tailored Solutions from a Partner in Laser e-Mobility: Results from Wavelengths and Beam Shaping Blend

Eng. Salvatore Salerno

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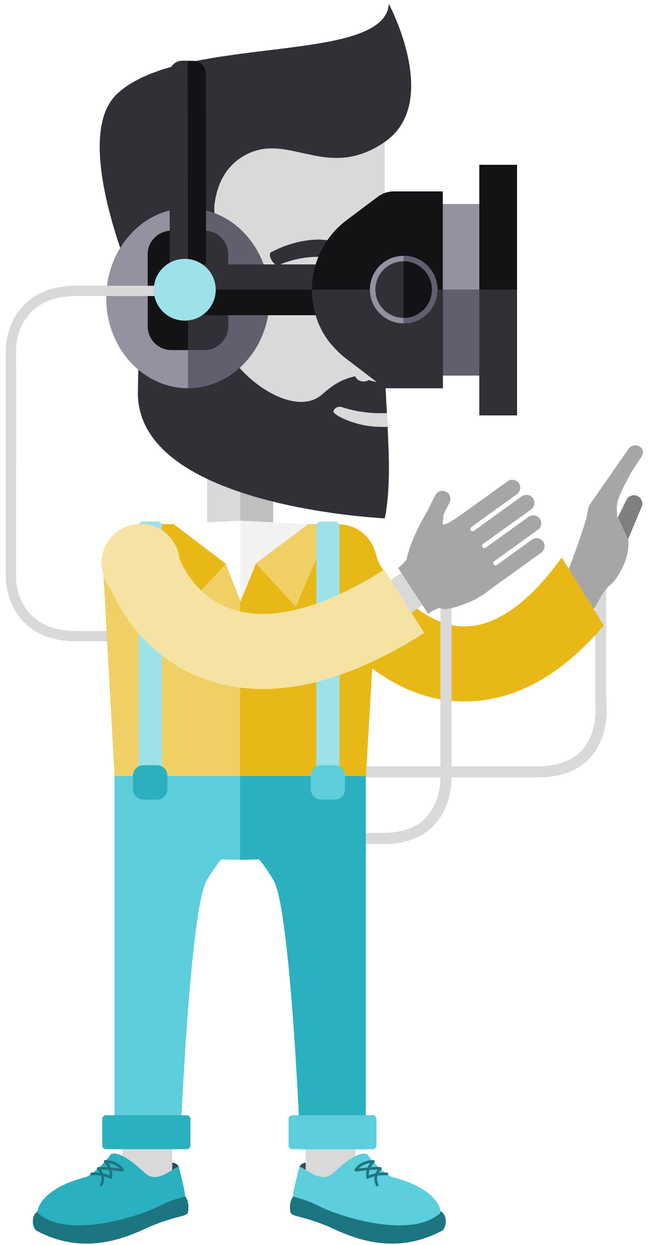

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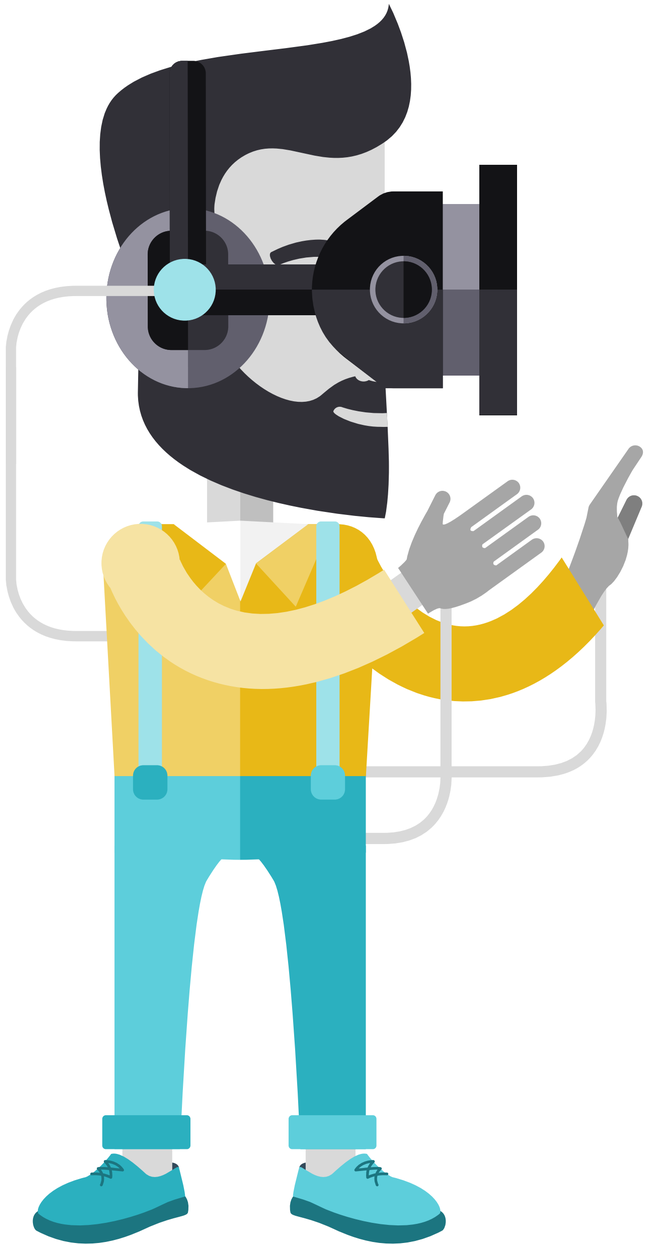
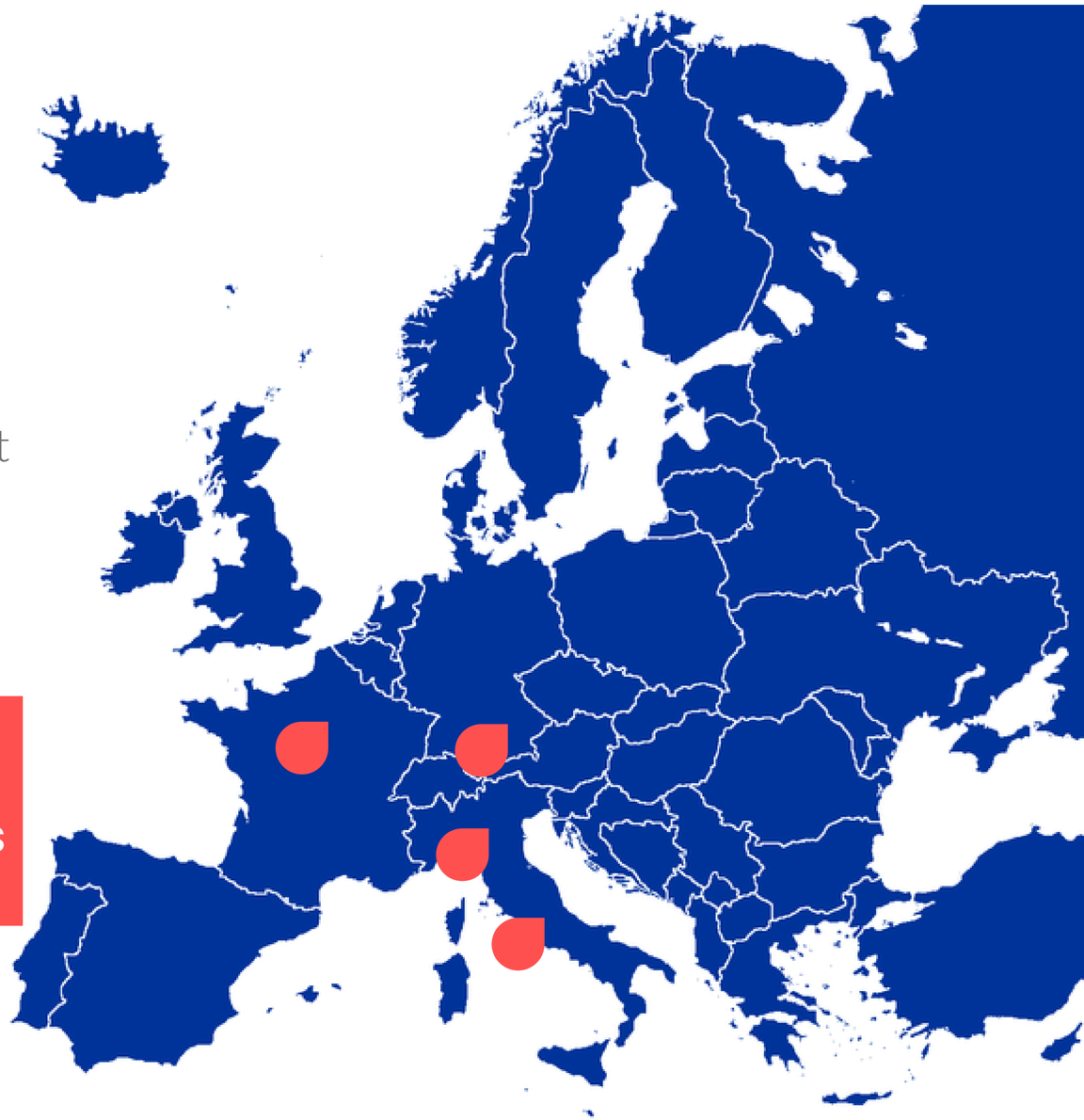


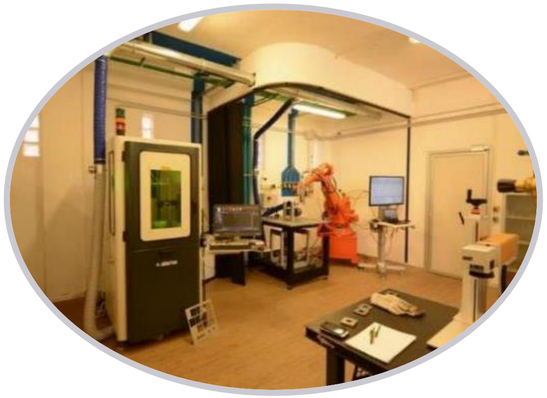
Who we are – Our Structure

- Optoprim Group was founded in France in 1994
- It has also been present in Italy (Monza & Rome) since 1999 and in Germany since 2004
- The Laser Application Center was inaugurated in Italy in 2014 (equipped with the latest laser technology and all that is needed to develop new applications and processes)
- We are about 85 people, including 20 technicians.

From marking to micromachining,
from cutting to welding, from hardening to cladding
Optoprim is constantly developing new processes for its **Industrial Customers**.



Who we are – Laser Application Center



Who we are – Laser Application Center

Marking & Engraving

Heat Treatment

Cladding & Additive Manufacturing

Welding & Brazing

Cutting

Micromachining

Who we are – Why choose us as your partner?

Turning Point

Thanks to our technical department with transversal background we can be the turning point for new companies in this market

Technology Selection

We can supply different technologies that we personally select according to the application

Experience

We have already developed various processes and are able to develop new ones

Support

From the idea to the installation, from the know-how transferring to aftersales support

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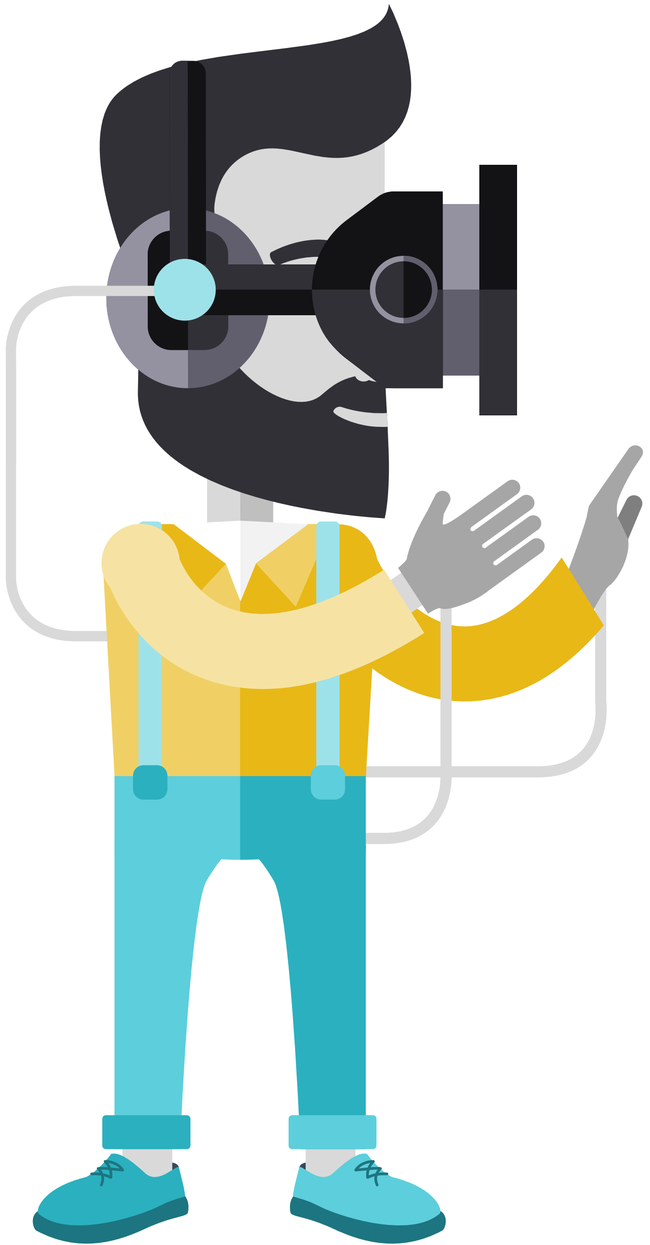
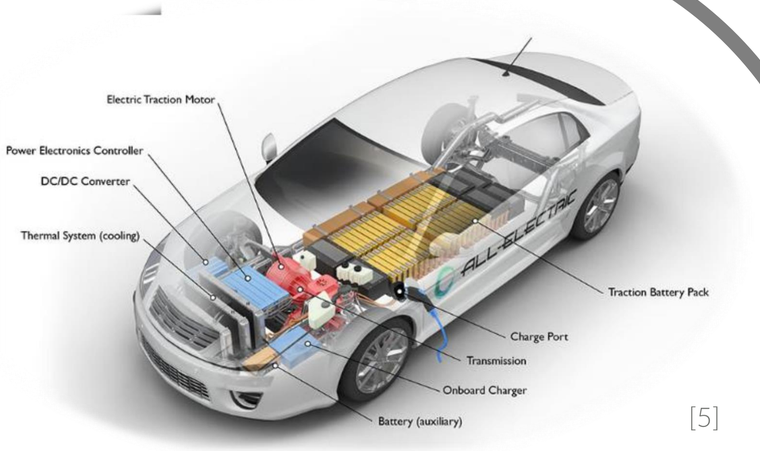


EMobility’s Market Needs– Electric Car Components

Battery Manufacturing



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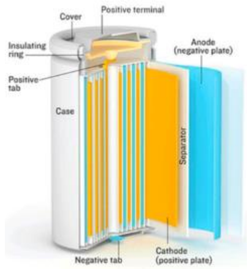


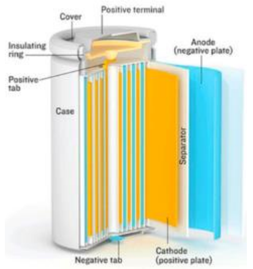
Role: Current storage

Laser processes involved:

- Remote laser cutting
- Remote Laser welding,
- Laser marking

EMobility's Market Needs– Electric Car Components

Battery Manufacturing



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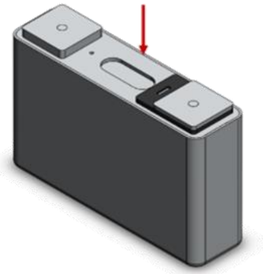
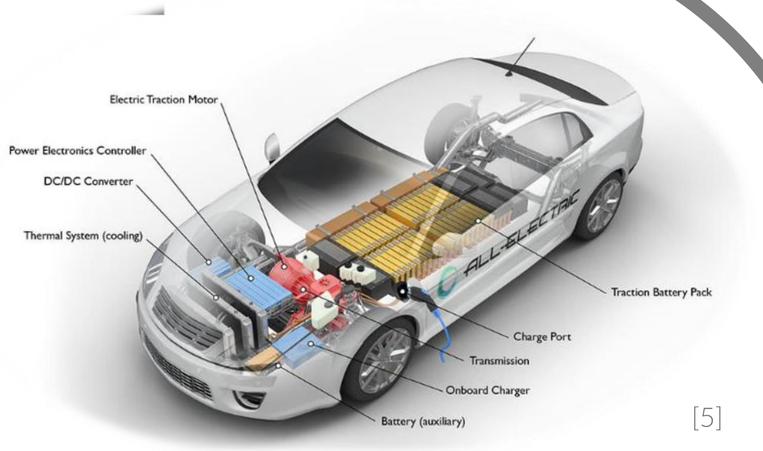
Battery Packaging



Role: Enclose the storage current environment

Laser processes involved:

- Laser Proximity welding
- Laser Marking



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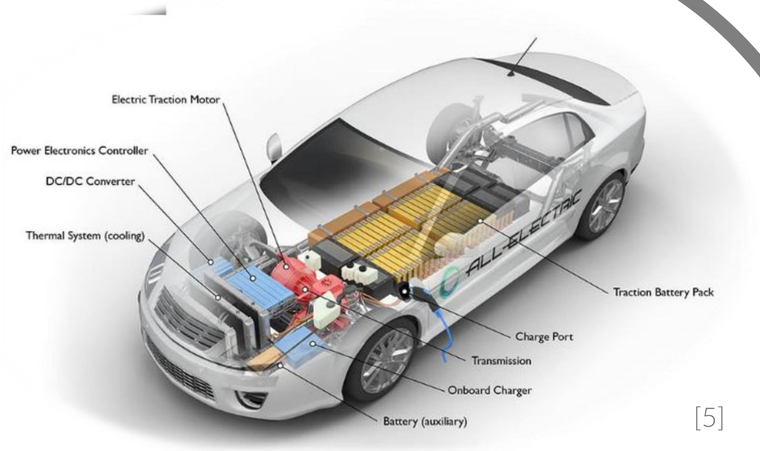

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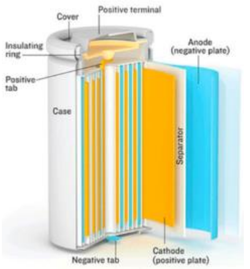
Battery Manufacturing



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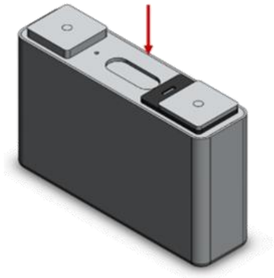


Role: Enclose the storage current environment

Laser processes involved:

- Laser Proximity welding
- Laser Marking

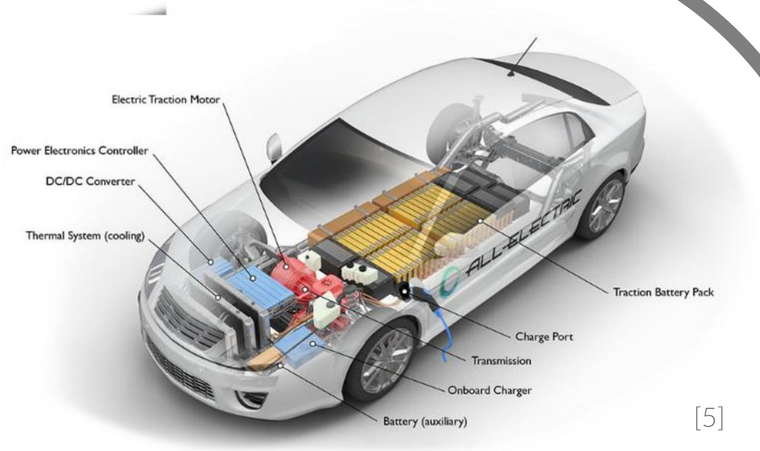
Battery Connection

Role: Interconnect different battery packaging

Laser processes involved:

- Laser remote welding
- Laser Marking

EMobility's Market Needs– Electric Car Components



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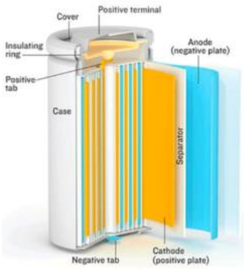

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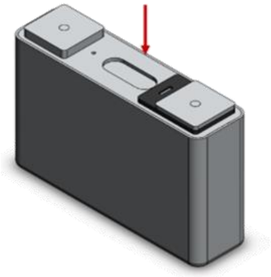
Battery Packaging



Role: Enclose the storage current environment

Laser processes involved:

- Laser Proximity welding
- Laser Marking

Battery Connection

Role: Interconnect different battery packaging

Laser processes involved:

- Laser remote welding
- Laser Marking

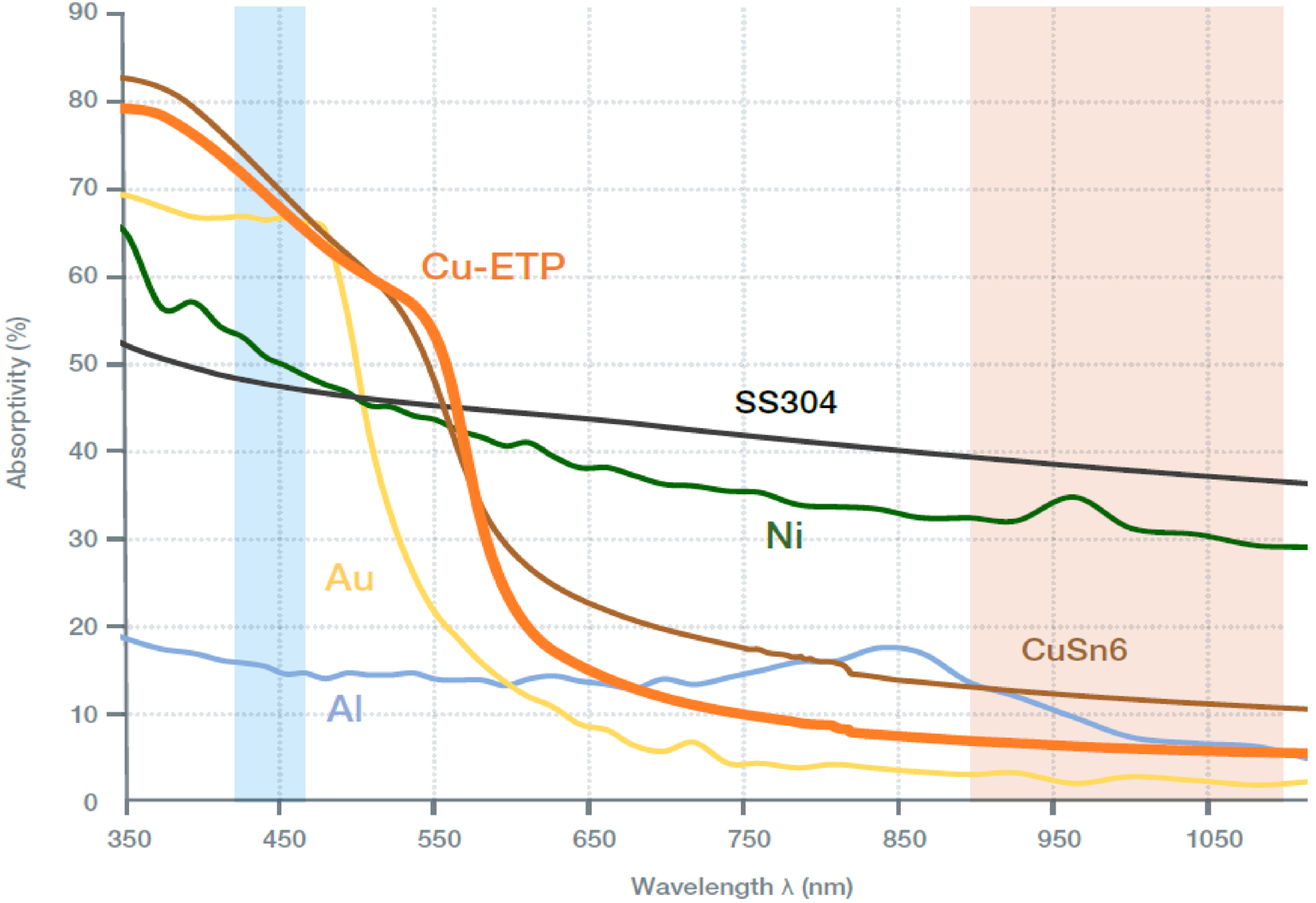
Electric motor, stator

Role: Convert current into mechanical movement

Laser processes involved:

- Laser remote welding
- Laser marking

EMobility's Market Needs– Copper features



Highly innovative demands, require adoption of highly performing materials. The most tricky is COPPER

- To heat-up (to get welded or cut) it prefers shorter wavelenghts or need high power density
- In short, there is the need of some knowledge and ability to smoothly handle it

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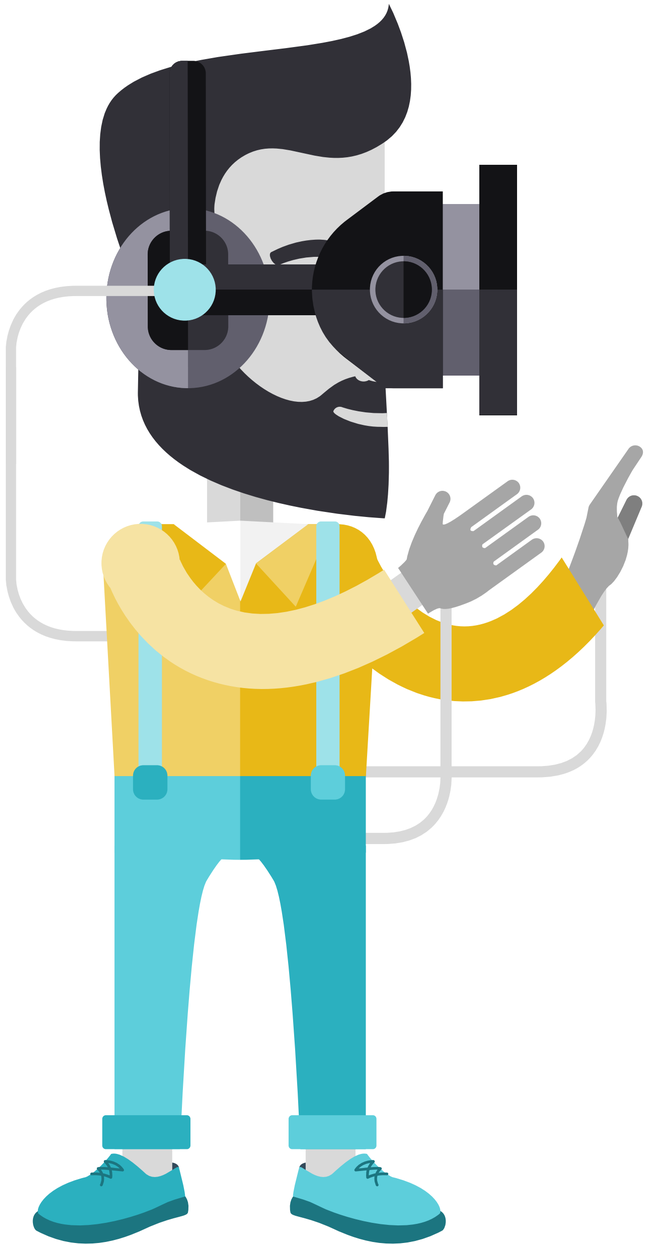


Who we are

- Our Structure
- Our Laser Application Center
- Why choose us as your partner?

EMobility's Market Needs

- Electric Car's Components
- Copper Features

Remote cutting of thin copper foils

- Why?
- Set-up and process
- Results

Remote welding of hairpin

- Why?
- Set-up and process
- Results

Conclusions

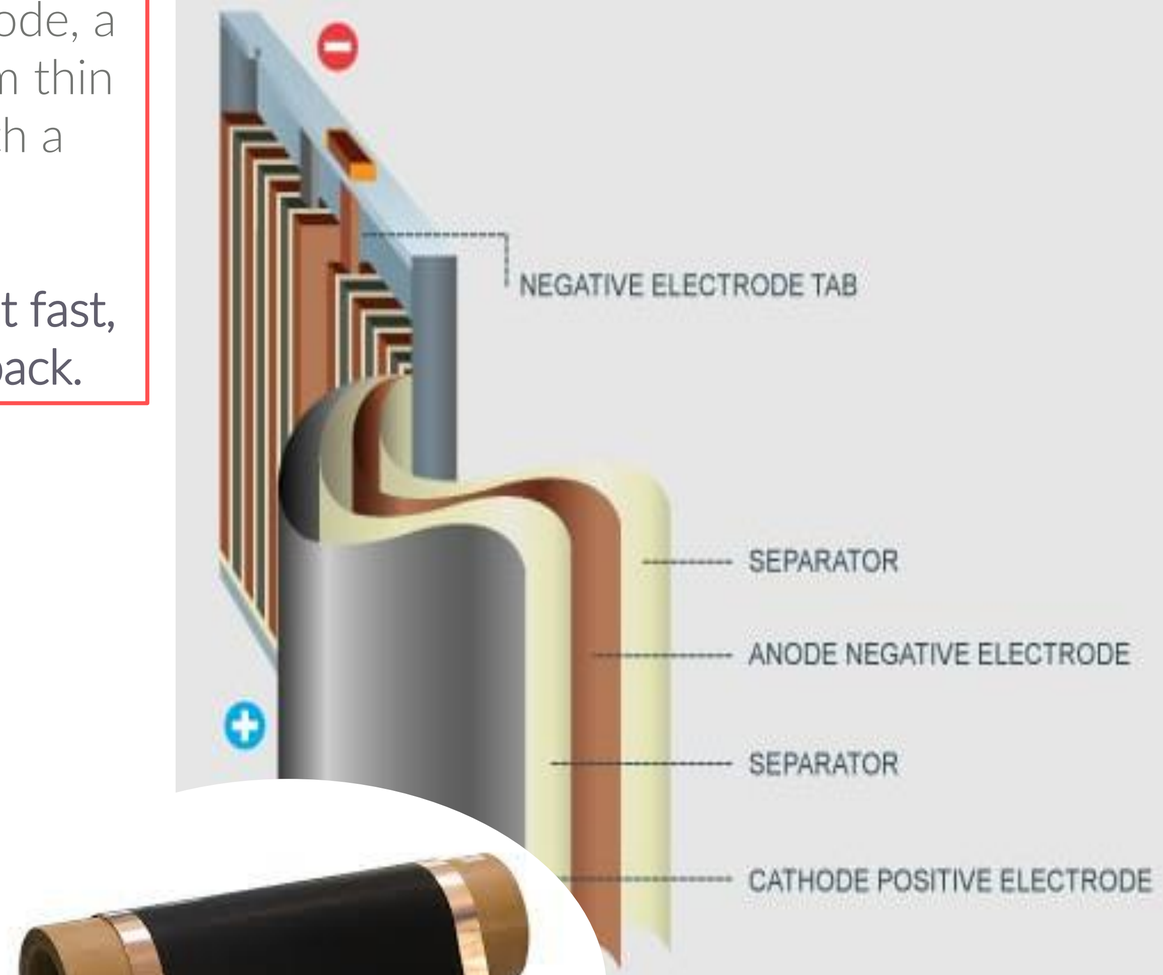
Remote cutting of thin copper foils – Why?

Inner core of battery comprise a cathode, a separator and an anode: all made from thin sheets of copper and aluminum with a functionalizing coating.

They come in rolls, that need to be cut fast, with sharp edges and minimal burn back.

The clues bring to a **remote laser cutting**

Targray courtesy



Anode electrode: Anode active material applied to the copper foil.

Cathode electrode: Cathode active material applied to the aluminum foil.

Remote cutting of thin copper foils – Set-up and process

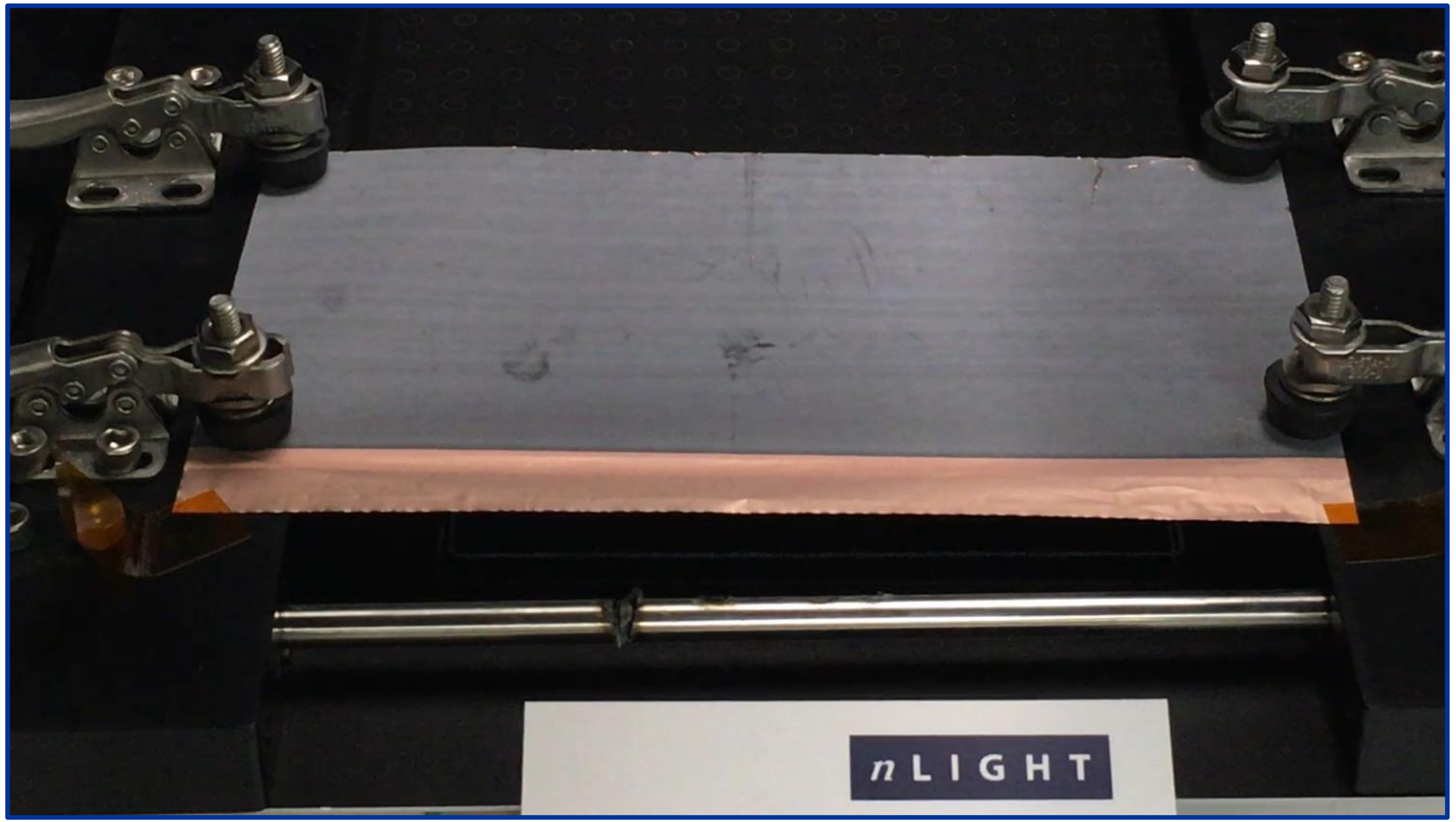
Product: Anode/cathode foil cutting

- Remote cutting of rolls or foils
- Coated copper or aluminum (bare sometimes)
- Majority of foils are ~20µm thick (coating excluded)
- ~150µm total thickness

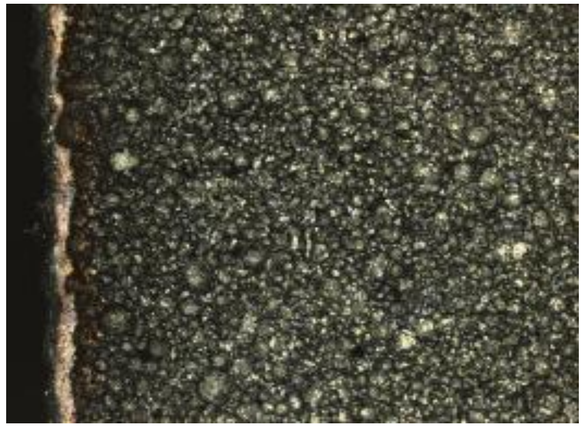
Optimized Set-up

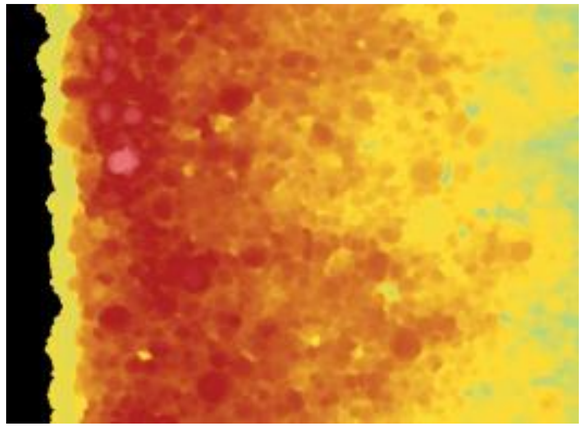
- 3-axis Scanhead
  - large process area & fast cut
- Single-Mode fiber laser, high modulation
  - Finer spot and minimal heat transfer

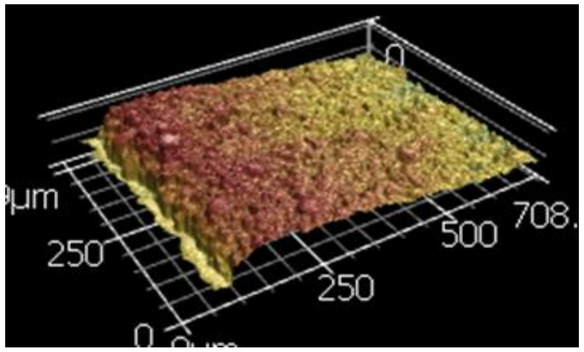
Remote cutting of thin copper foils – Set-up and process



Remote cutting of thin copper foils – Results







- 40um spot size, resulting in single pass cut > 6m/s (coated copper)
- Over a working area of 500 x 500 mm^2

- <25µm depletion zone (burn back)
- Minimal burr (<5µm, difficult to measure)

Advantages over mechanical stamping and shearing

- More flexible than stamping dies for quick change over of designs
- Minimal resulting mechanical deformation
- Scalable with multiple lasers and multiple scanners for higher throughput

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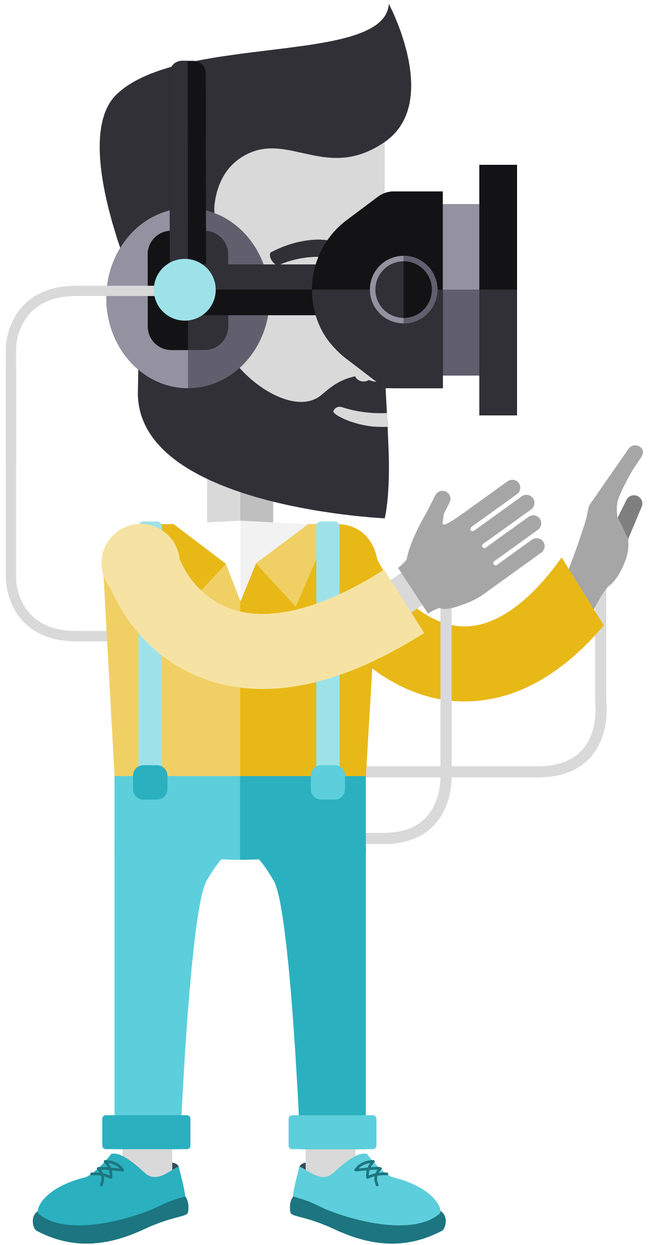


Remote welding of hairpin – Why?

- Stator winding is a key process in electric motor design, shape&size of the used copper make a huge difference
- Wires or “harpins” of different sections are used
- Whilst we standardly use high power IR laser for welding large section haripins our case study will focus on an optimized solution for welding of low-medium sections ones (up to 8mm^2 pin pair cross section).
- Welding process needs to show:
  - ✓ Low spatter & low porosity
  - ✓ Penetration similar to the width of the welded bar
  - ✓ Low cycle time (0.2-0.3 s / welding)
  - ✓ Process must be robust towards hairpins’ relative position and geometrical deviations

Laser Technology developments have brought an effective way to address all of the above needs: **a blue laser!**

Remote welding of hairpin – Set-up and process

Blue laser: industrial and effective option

- Direct emission by 450nm diode bars, WPE ~30%
- Higher absorption and process stability
- Compact 19“ design

2018
500 W (60 mm*mrad)
1000 W (100 mm*mrad)
→ Fixed optic spot 0,6 mm

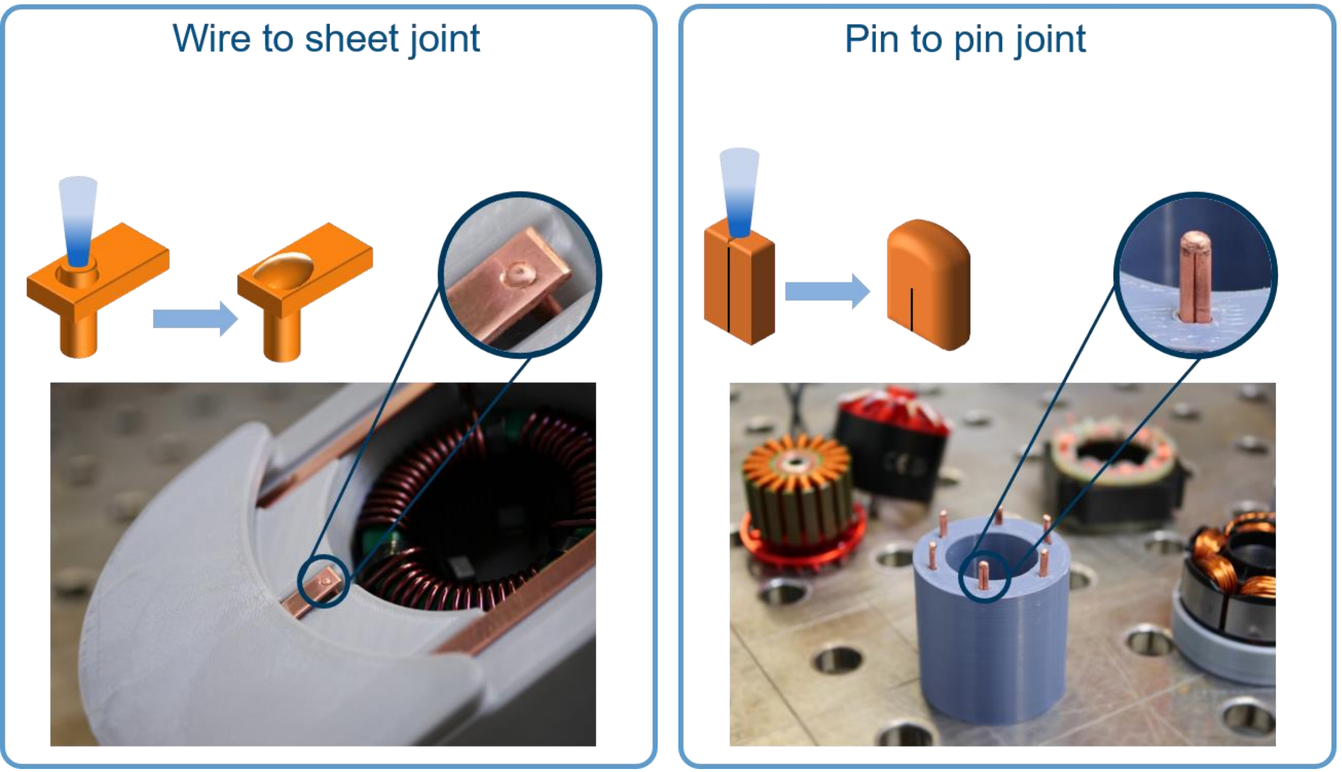
2019
1500 W (60 mm*mrad)
→ Fixed optic spot 0,6 mm

2020
1500 W (30 mm*mrad)
2000 W (60 mm*mrad)
→ Fixed optic spot 0,35 mm
→ Scanner spot 0,72 mm

2021
800 W (20 mm*mrad)
1800 W (30 mm*mrad)
→ Fixed optic spot 0,25 mm
→ Scanner spot 0,45/0,72 mm

2022

Remote welding of hairpin – Set-up and process



Remote welding of hairpin

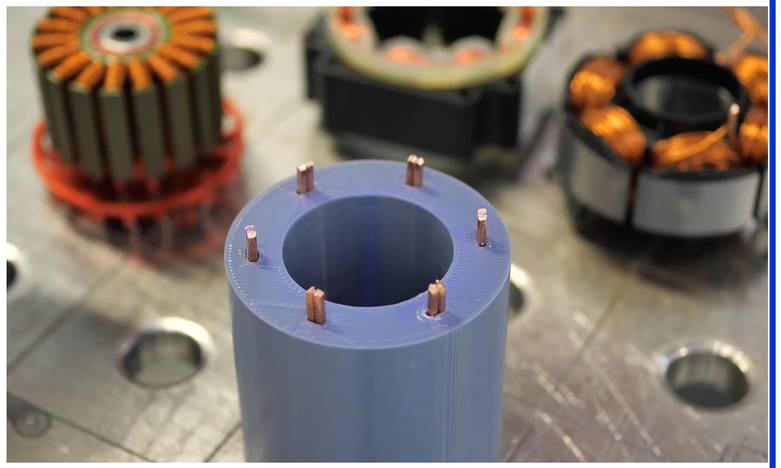
- Remote welding of pure copper
- Cross section up to 8mm^2 pin pair
- Fast and robust process: independent from pin shape, cutting quality and alignment

Optimized Set-up

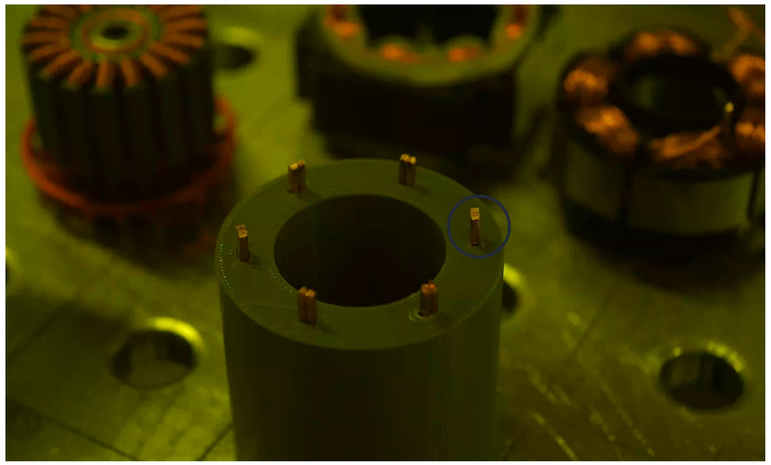
- 2-axis Scanhead
  - Large process area & fast positioning
- 1kW Blue Laser
  - Large spot, optimal power absorption

Remote welding of hairpin – Set-up and process

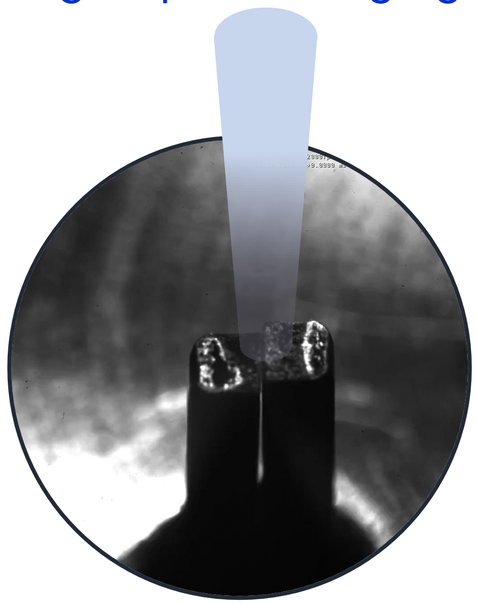
Real processing time
(simulation with pilot laser)



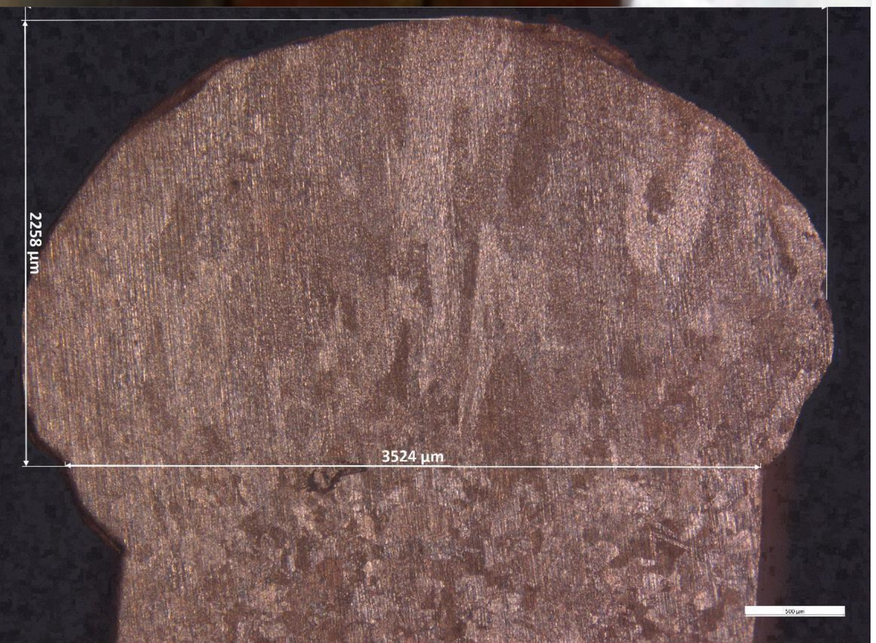
Slow- motion video
(welding process)



High-speed imaging



Remote welding of hairpin – Results



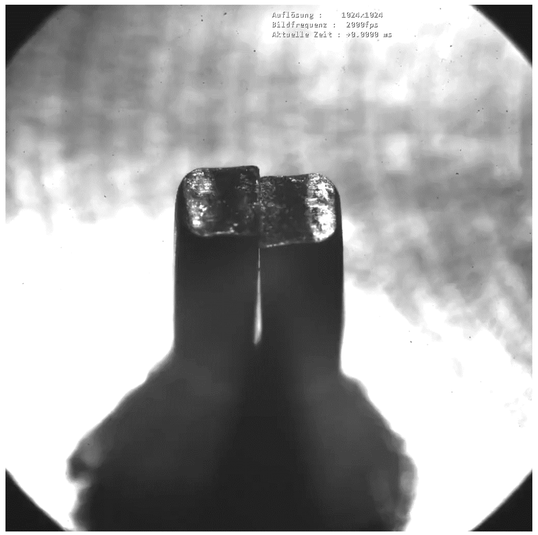
- Higher blue absorption enables quite welding process with low spatter
- Fast and reliable process with very good weld quality (welding time in the example: 100ms)
- Lower porosity (compared to IR laser based processes)

Remote welding of hairpin – Results

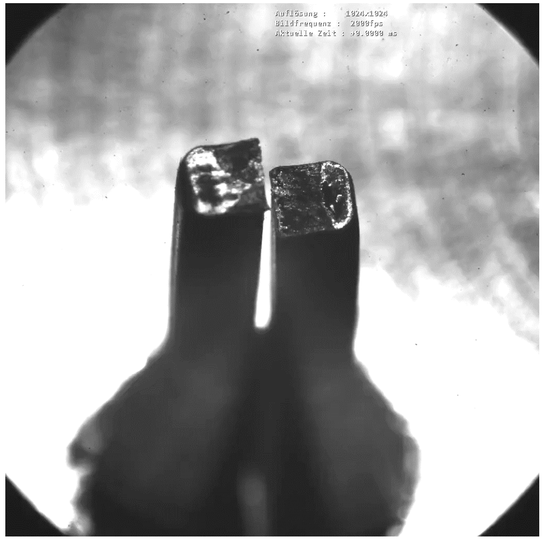
Larger spot allows robust process: accommodates parts tolerances and is independent from shapes. No need for high intensity to ignite the process, no wobbling needed

Hand/nippers-cut

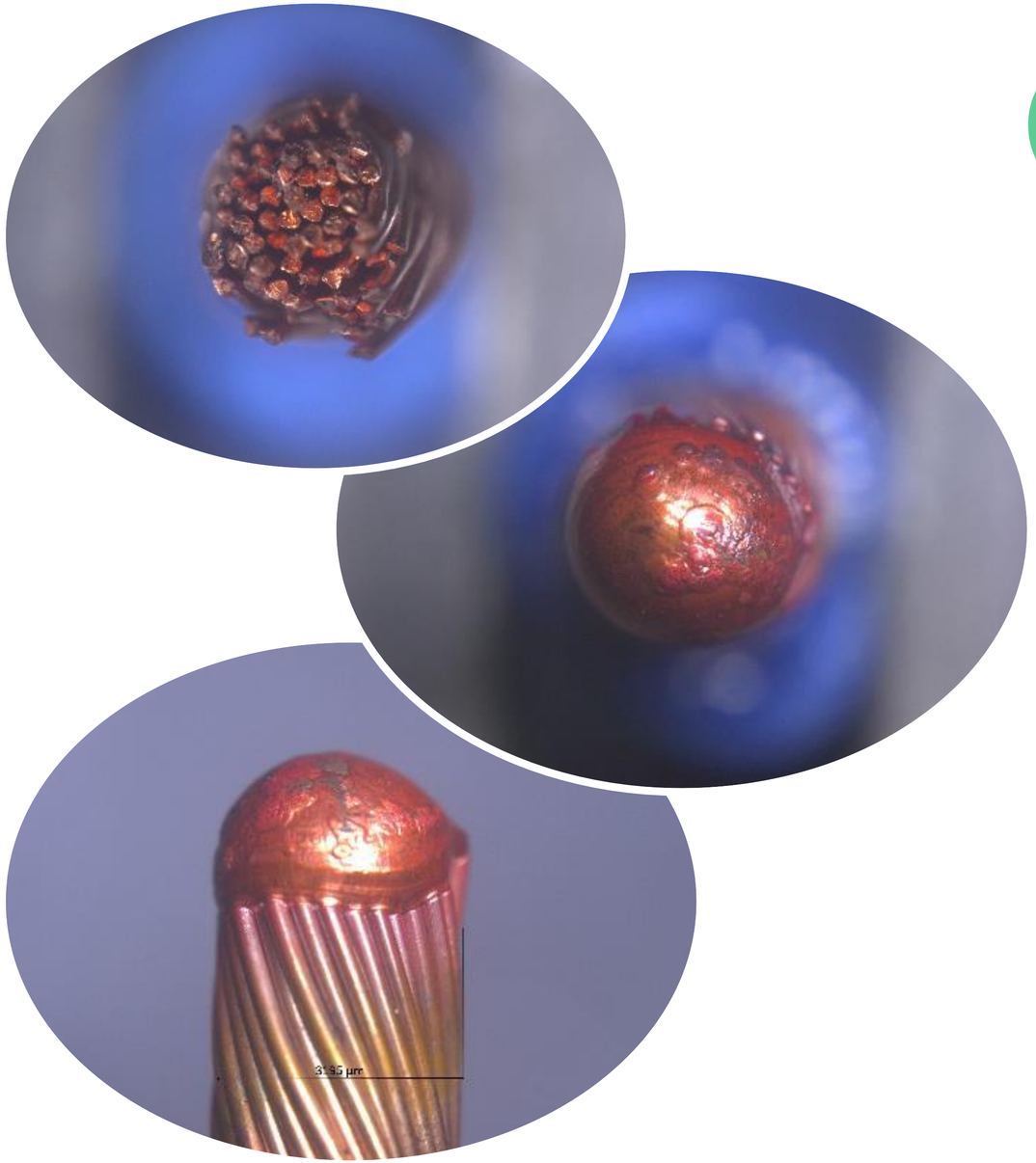
flat surface



Misaligned pins



Remote welding of hairpin – Results



Flexibility to adapt to different parts geometries (larger spot bridges gaps)

Conclusions – Why choose us as your partner?

Technology Selection

We have a comprehensive set of laser technologies with skilled process engineers able to properly use them

Experience

We can rely on the support and knowledge of key world players in laser technologies

Support

Our core business is the success of our industrial customers with the target to be their Laser R&D

Turning Point

We are your turn key solution to drastically reduce time to market with the adoption of reliable, cutting edge technologies

Thanks for your attention.

Optoprim.
The laser partner you are looking for!

Eng. Salvatore Salerno