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How CO_2 lasers contribute to battery manufacturing

and help reduce carbon footprints

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EPIC Online Technology Meeting on Industrial Laser Processes for Automotive and Electro Mobility

Lasers4
Batteries

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Table of contents

- Introduction to Luxinar
- Why use CO_2 lasers in battery applications
- Case study – separator foils
- Case study – unwrapping prismatic cells
- Conclusion

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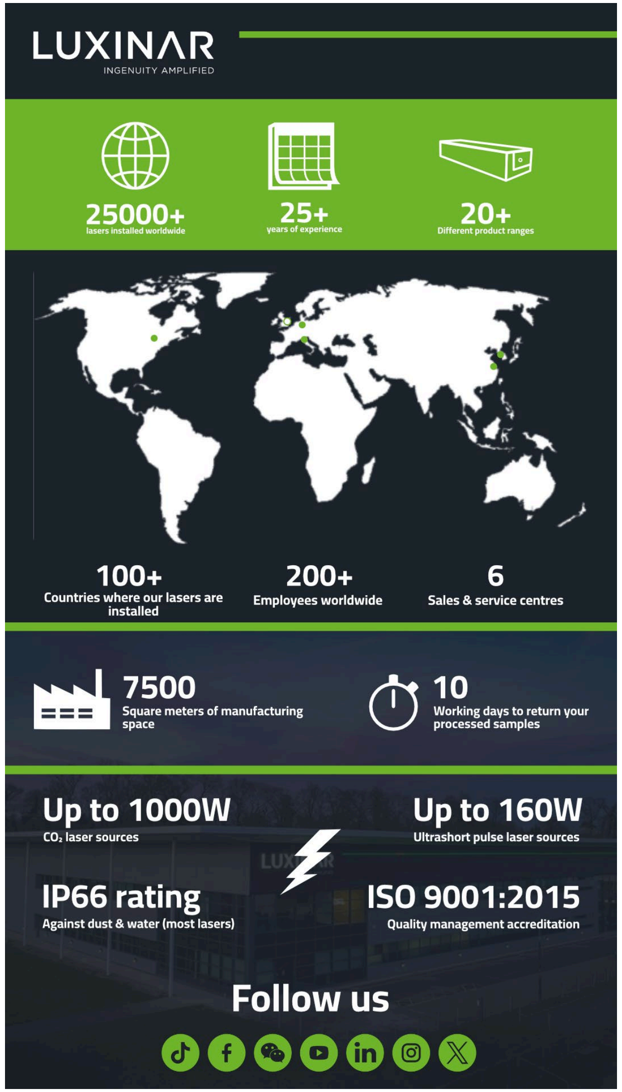

Industries & applications

About 3000 Application reports on file

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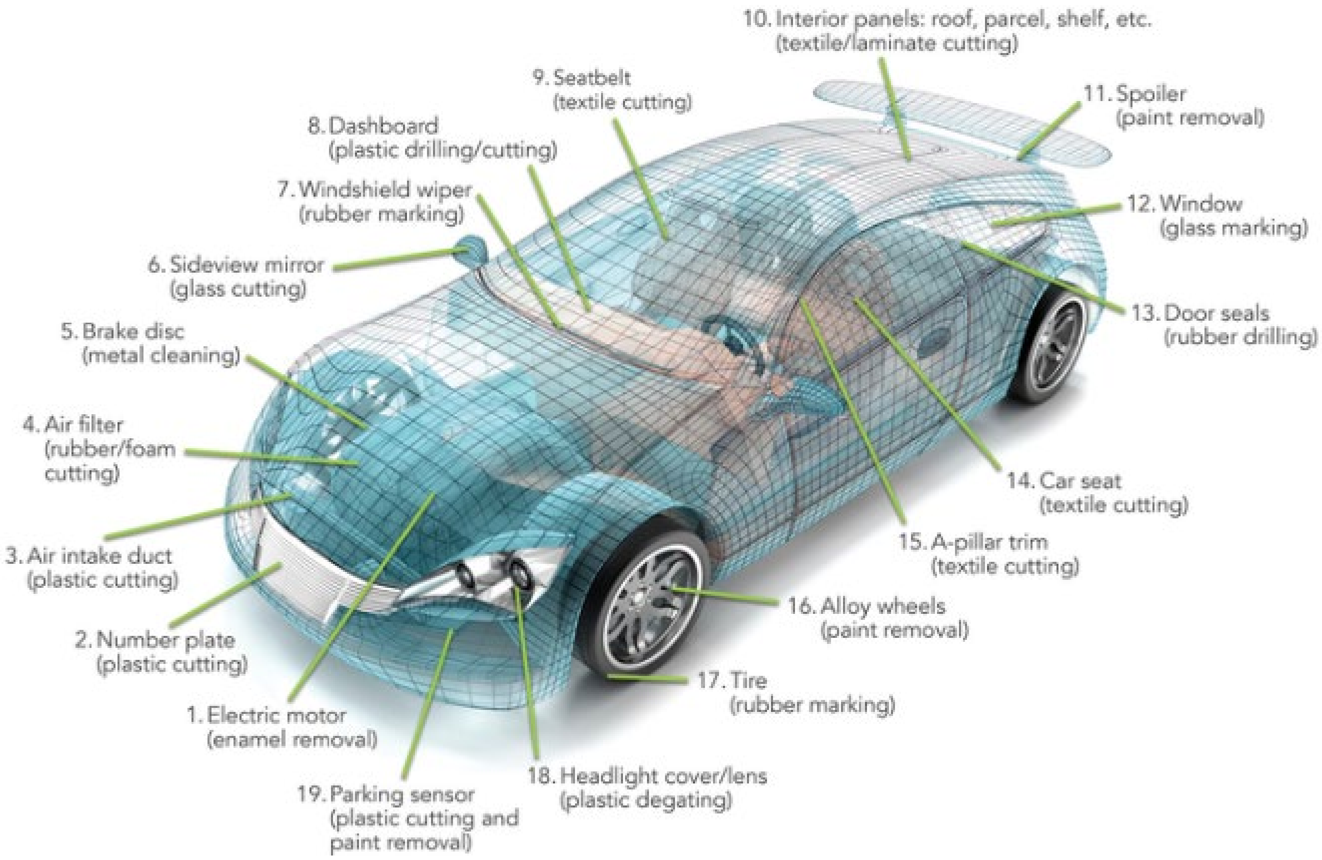
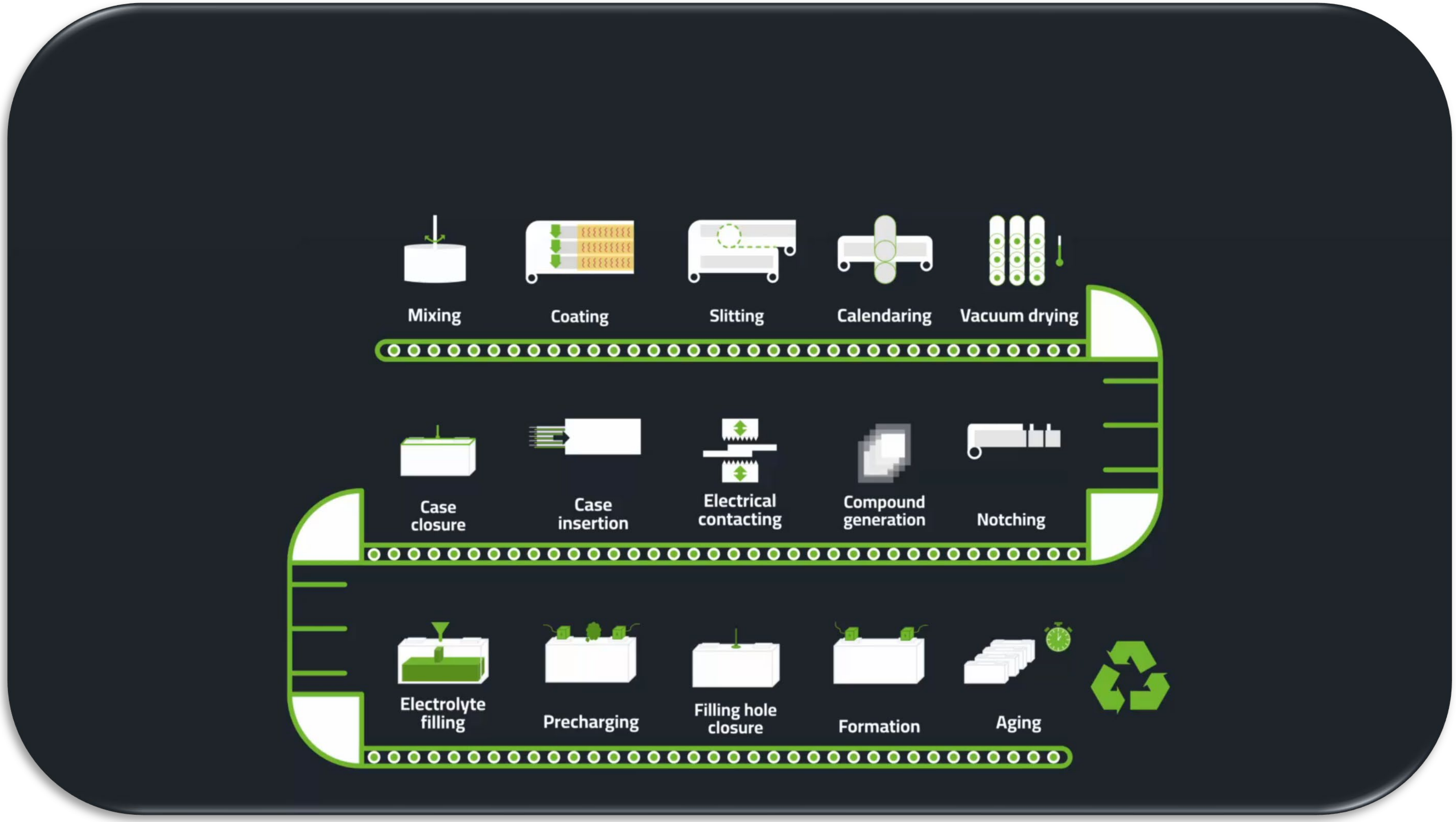
19 applications for Luxinar CO_2 lasers on a car



… and a few more for ultrashort pulse lasers

Luxinar lasers in battery manufacturing



USP Laser LXR® Series

Notching of Electrodes (copper)

CO_2 laser SR Series

Cutting of (ceramic coated) Separator

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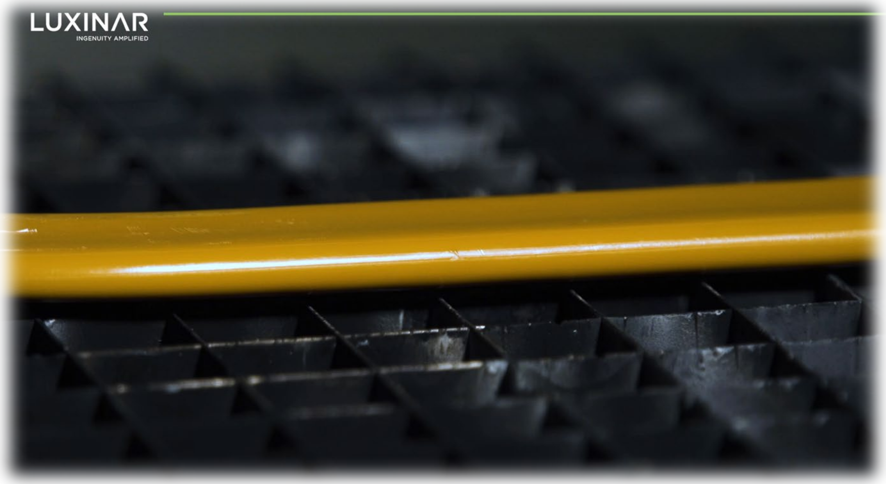
USP Laser LXR® Series

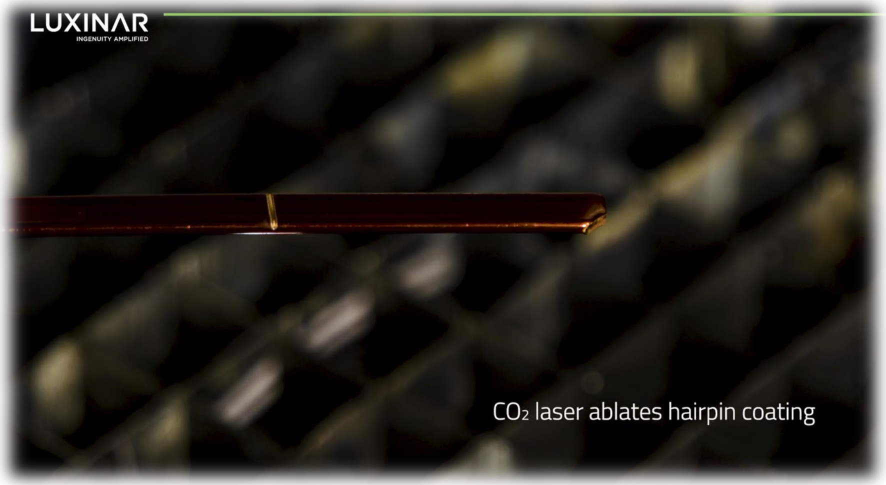
Surface texturisation of electrodes

CO_2 laser OEM Series

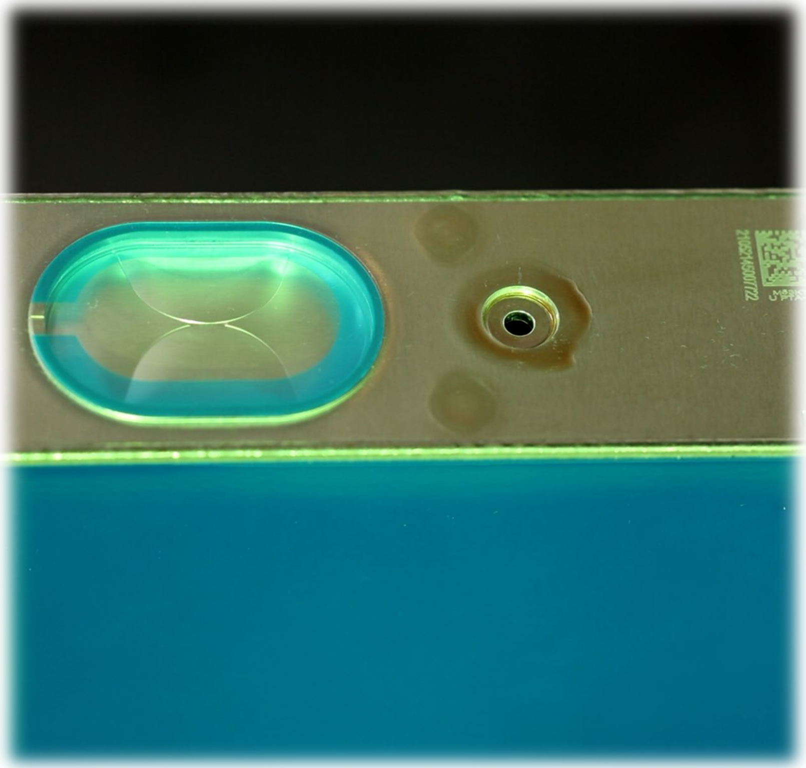
Ablation of heat shrink film

Lasers4 Batteries





CO_2 laser SR Series



Cleaning of filler port

CO_2 lasers

First industrial CO_2 lasers became available 1964. Whilst high power CO_2 lasers have mainly been replaced by fibre laser technology, the range of low power ($\leq$ 1 kW) demonstrates continuous growth ever since.

A mature technology for industrial processes, offering several tens of thousands of hours of operation, literally maintenance free.

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Sealed CO_2 laser sources

80W  10.6µm/10.25µm/9.3µm

125W  10.6µm/10.25µm/9.3µm

175W  10.6µm/10.25µm/9.3µm

250W  10.6µm/10.25µm/9.3µm

75W & 150W  9.3µm (10.6µm on request)

Luxinar SR & SR AOM series

10.6µm/10.25µm/9.3µm  300/350W

10.6µm/10.25µm/9.3µm  450W

10.6µm/10.25µm  650W

10.6µm (9.3µm on request)  1000W

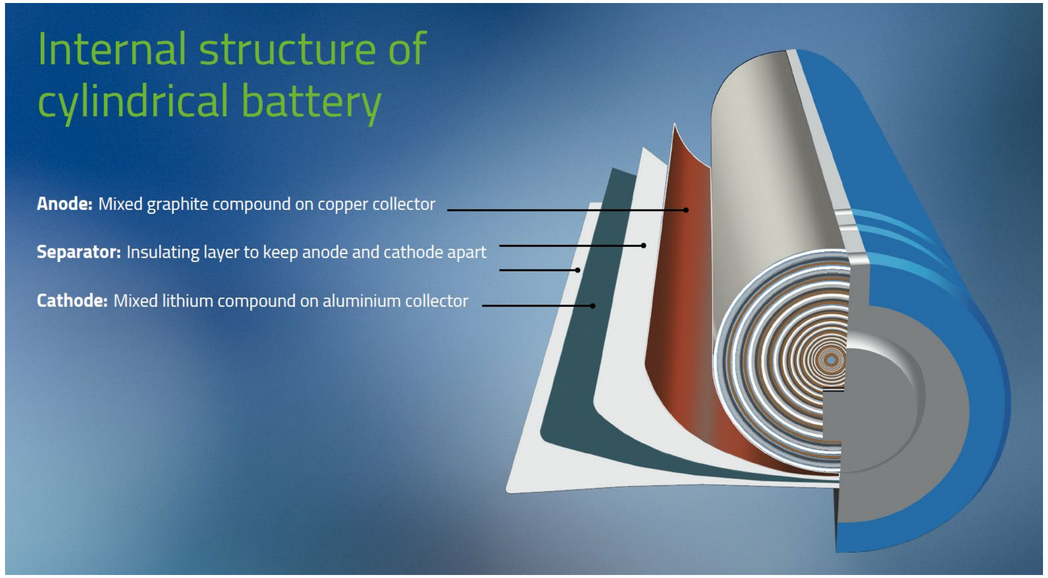
Luxinar SCX and OEM series

Why use CO_2 lasers for batteries?

- Presence of organic material responding well to CO_2 wavelengths (9.3 µm – 10.25 µm – 10.6 µm)
- Maintenance-free
- Longevity (typical service life in the range of 30 – 50.000 hours, which is comparable to or even exceeding pump diodes / seed lasers of solid-state USP lasers)
- Low refurbishment cost (total cost of ownership)

CO_2 laser case studies

- Cutting of separator foils
- Unwrapping prismatic cells



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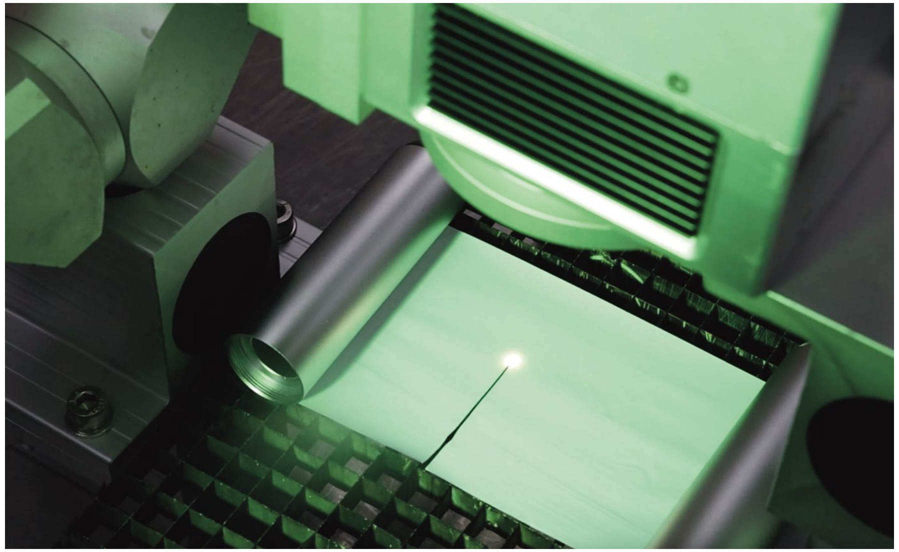
CO_2 laser cutting of separator foils

- Replace mechanical cutting process
  - No force applied to thin material
  - No tool wear
  - No chipping of ceramic coatings > dust contamination



- Lower investment than for USP-Laser
  - Simple integration (laser safety)
  - Long wavelength less sensitive for optics failure (scratches…)

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Experimental approach

1. The experiment set out to investigate **the material interaction** with **different CO_2 laser wavelengths**.

2. It was carried out utilising a Luxinar MULTISCAN® VS, swapping out three laser sources with different wavelengths of **9.3 µm, 10.25** µm and **10.6 µm**.

3. To allow direct comparison, all three wavelengths were used at 100 W at the output. For the same reason, a scan head with a 10 mm aperture was used for the shorter wavelengths, and a 14 mm aperture was used for the 10.6 µm laser, leading to spot sizes around **240 µm** for the 9.3 µm and the 10.6 µm. A spot size of **270 µm** was achieved for 10.25 µm, considered close enough for an initial comparison.

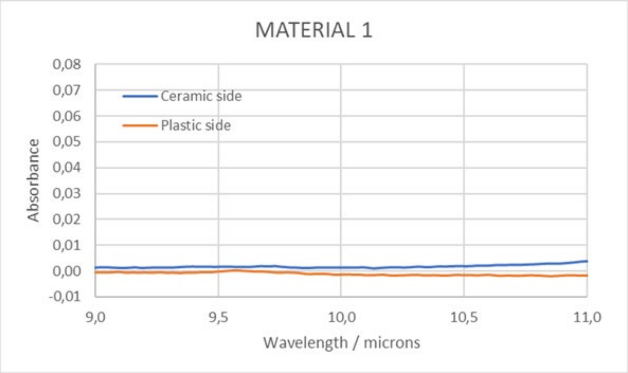
Material under test

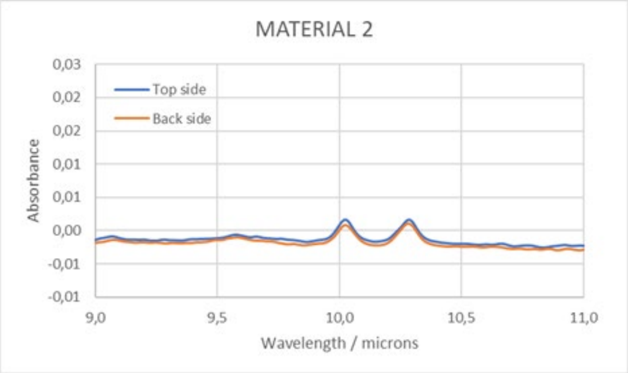
Material 1 – Predominantly PE-based substrate with a ceramic coating applied on one side, identified by the matte finish versus the glossy finish of the raw PE.

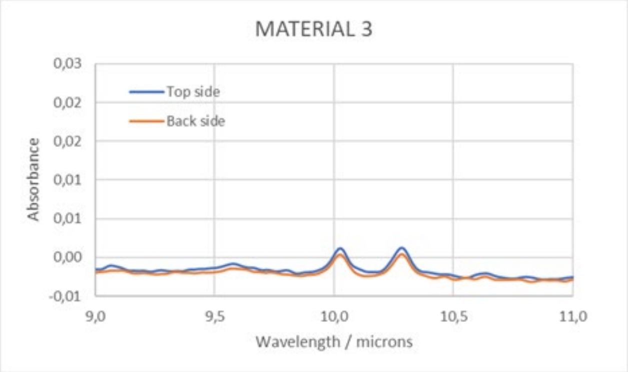
Materials 2 & 3 – Uncoated materials with the ATR-FTIR scans indicating a higher concentration of polypropylene within the composition.

**Attenuated Total Reflection - Fourier Transformation Infrared Spectroscopy*

ATR - FTIR*







Cutting performance comparison

Table 1. Cutting speed comparison for different wavelengths, based on 100 W laser power

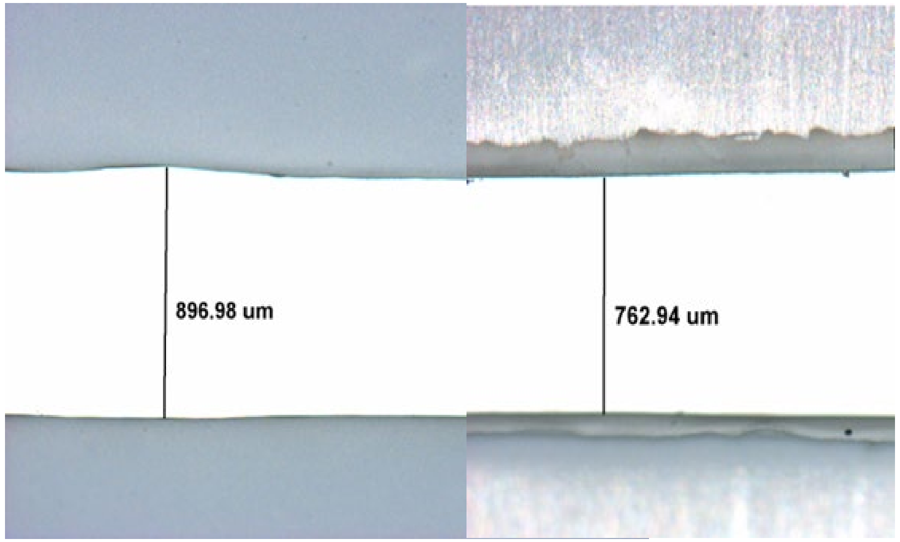
Wavelength	9.3 µm.	10.25 µm	10.6 µm
Material 1	1200 mm/s	1400 mm/s	1200 mm/s
Material 2	1200 mm/s	4000 mm/s	1200 mm/s
Material 3	1400 mm/s	4500 (6000) mm/s	1800 mm/s

Cutting quality material 1 (ceramic coated)

Using the 10.25 µm laser, the maximum process speed was between 1300 mm/s and 1400 mm/s.

Process quality is similar for all three wavelengths - while the material is cut cleanly with no burning or discoloration, the process causes some shrinkage and deformation of the material.

A burr is formed on the plastic side of the material, caused by curling of the edge towards the plastic side.



left: view of ceramic side– right: view of plastic side @ 1300mm/s with 10.25µm

Mitigation of shrinking effect:

Higher cutting speeds through smaller spot size (higher power density)

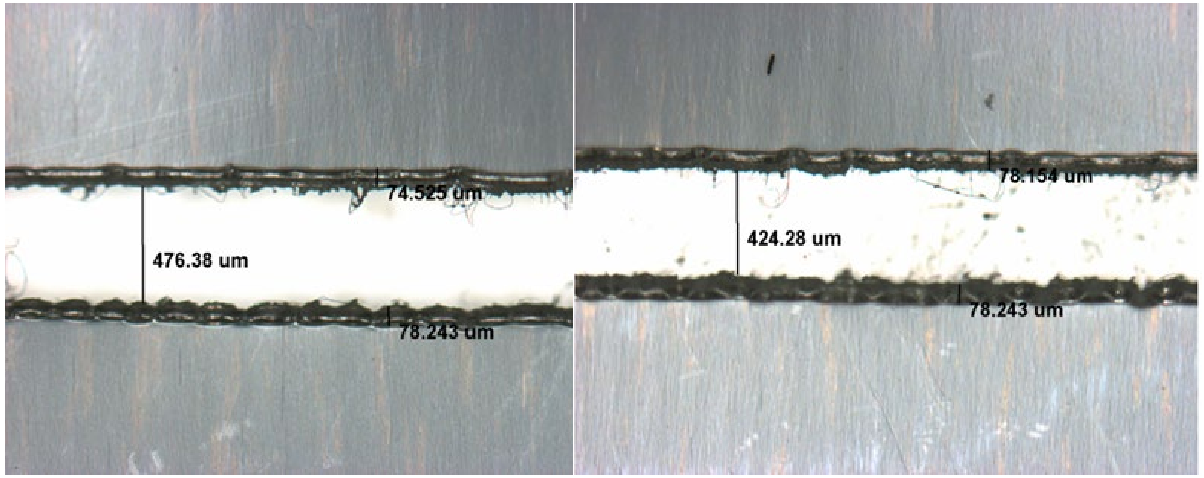
All images shown are from cutting trials with 10.25 µm, taken under a microscope with 5x magnification

Cutting quality material 2

10.25 µm maximum process speed is significantly faster at around 4000 mm/s.

No burning or discoloration, but the edges appear slightly rough under the microscope, similar to the 9.3 µm cuts (the 10.6 µm results were a little smoother).

No noticeable burr or curling of the edge, although there is a heat affected zone (HAZ) of roughly 80µm and some filaments of material protruding from the edge.



left: view of top side – right: view of back side @ 4.500 mm/s with 10.25 µm - further reduced meltback and no fraying

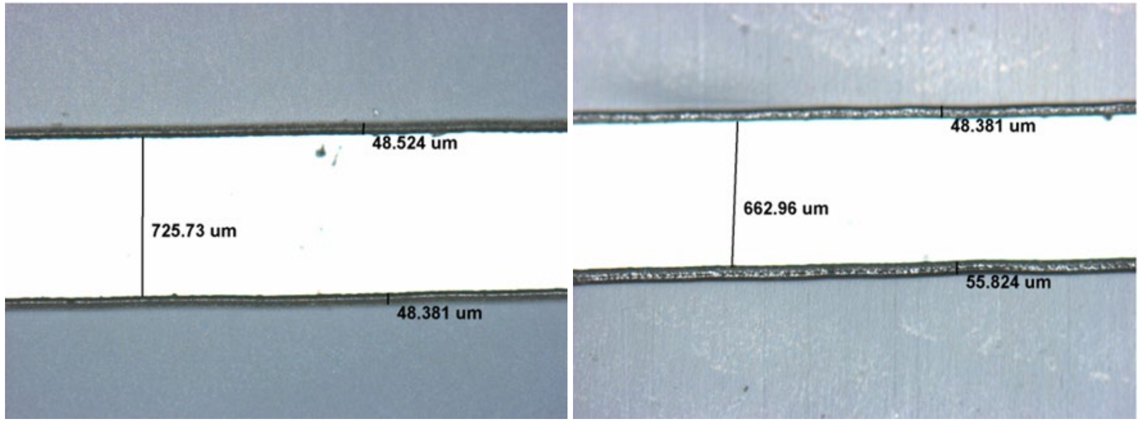
All images shown are from cutting trials with 10.25 µm, taken under a microscope with 5x magnification

Cutting quality material 3

FTIR spectrum very similar to that of Material 2. Significantly faster cutting was possible with the 10.25 µm wavelength.

Maximum speed was around 6000 mm/s, although this produces slightly ragged edges. Cleanest results were produced at 4500 mm/s, which is still more than twice the 9.3 µm and 10.6 µm speeds.

The material is cut cleanly with no burning or discoloration, but some shrinkage is observed; the gap between the cut edges is up **to 750 µm at 4500 mm/s, or 500 µm at 6000 mm/s.**



left: view of ceramic side– right: view of plastic side @ 1300mm/s with 10.25µm

Key take away for separator foil cutting

- CO_2-Lasers do offer a reliable and cost-effective way to cut separator foils, in particular when the material composition is designed with the laser cutting process in mind (hence PP being part of the mixture)
- Higher wall plug efficiency of solid-state lasers can be compensated by high cutting speed of CO_2 laser when matched material is used. Power consumption per meter cut length to being considered.
- Comparable low total cost of ownership and simple operation
- CO_2 lasers are a standard solution to cut separator foils for battery manufacturers in Asia

Laser unwrapping battery cells

- Yield issues in the production of new cells lead to a significant rate of non-conforming battery cells

- Used batteries will require recycling after end of life (even a second life will come to an end one day)

  - ➢ Demand for automated recycling will grow over time

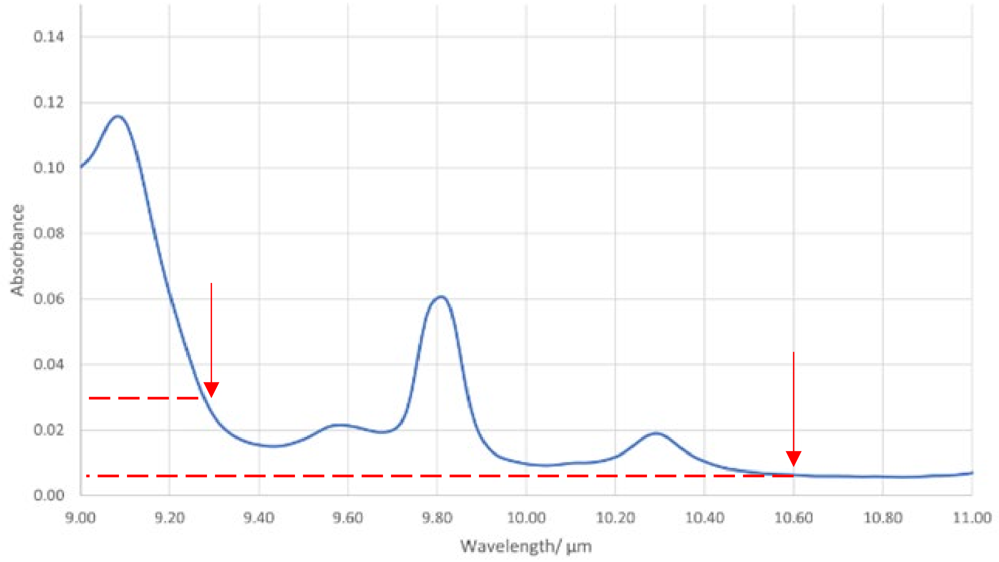
CO_2 laser-based unwrapping of battery cells

- Replace manual cutting/stripping/scraping/rubbing process
  - ➢ No force applied to housing (dents, scratches…)
  - ➢ Automation for repetitive results including documentation if required
- No hazardous, aggressive heavy chemical solvents required
  - ➢ No exposure of staff to those chemicals
  - ➢ No need for hazardous waste disposal

Experimental approach

Since the working area can be quite big, and even become 3-dimensional when ablating around corners for unwrapping a full prismatic cell, a 3-axis scan head with 30 mm aperture was used in combination with a **Luxinar OEM 45iX**. This laser delivers **> 500 W** in power at **10.6 µm**. The test setup also included a professional fume extractor with filter system.

Before testing at high power, a wavelength comparison was conducted to compare **9.3 µm** and **10.6 µm** lasers, since an ATR-FTIR scan of the material suggested 9.3 µm might be more effective.



Ablation test results

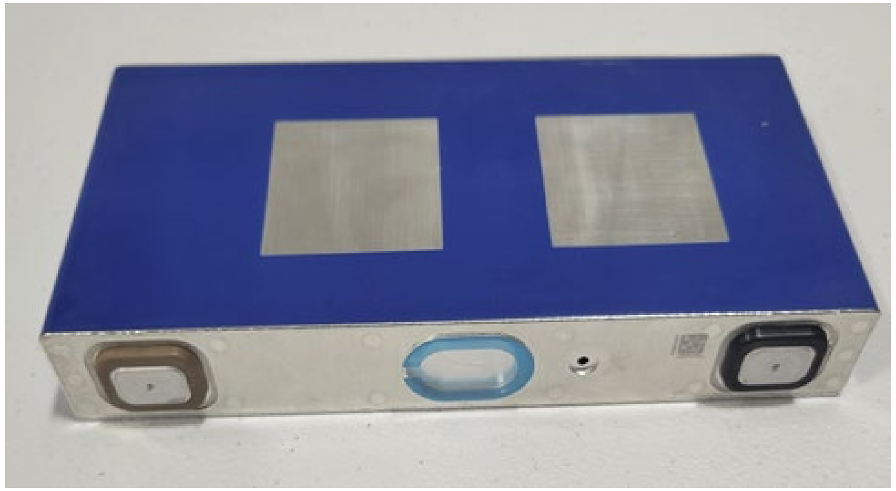
Contrary to expectations, the experimental results were in favor of the 10.6 µm wavelength, achieving higher ablation rates.

For new batteries the maximum ablation rate is limited by the amount of heat introduced to the cell; it is important to stay well below the thermal damage threshold of 80 °C within the cell.

Ablation test results

A multi-pass strategy was applied with a cycle time **below 40 seconds for roughly 29 cm^2** in area. Laser power was **450 W**, and temperatures remained in the **low 60 °C regime** throughout the process.

The surface was then wiped off with isopropanol. Alternatively, the ablated canister could undergo final cleaning by a NIR laser beam for a fully contact-free and automated process without the application of solvents.



Conclusion battery unwrapping with CO_2 laser

The process can be automated with adequate cycle time to help recover nonconforming cells, saving valuable resources.

Since a lot of material is evaporated throughout the process, an adequate fume extraction system is essential.

For used/pre-assembled cells it proved feasible removing the heat shrink film wrapping even with residues of glue contaminating the surface.

Lasers recommend themselves as a preferred tool for a high degree of automation to avoid work that is potentially hazardous for health and substances with potential environmental impact.

What can Luxinar do for you

We have an application database with roughly 3.000 feasibility reports growing every day – We support you in the laser process development

With decades of experience in laser system design layout we can help you finding the best solution for your laser machine requirements

What can you do for Luxinar

Speak to us whenever you have a laser application for organic materials

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Thank you for your attention

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