Li-ion Battery Foil Cutting Using Pulsed IR Fiber Lasers

During the last decade we have witnessed the emergence of Li-ion batteries as a major force, empowering numerous technologies aiming to take mobility and clean energy to the next level. Recent advances have made pulsed fiber lasers a significant player in Li-ion battery manufacturing technology. In a typical Li-ion-cell manufacturing process, the electrode foils start out as rolled coated layers that need to be tailor-cut to the required shape before they are stacked, folded, sealed, and packaged, as depicted in Figure 1. Laser foil cutting provides many advantages over mechanical foil cutting techniques: it is a high-speed, high-precision, contact-free, cost-effective process with no tool wear, and it enables highly flexible pattern cutting, resulting in improved edge quality.

When a cross-section of the laser-cut coated foil is observed (Figure 2), it becomes clear that among the challenges associated with the laser foil cutting process are heat-affected zones (HAZ) and rough ridges left across the cut edges of the metallic sheets (generally known as burrs).

For applications, such as Li-ion battery foil cutting, Spectra-Physics® has introduced the VGEN-QS-HE-100 nanosecond fiber laser. The infra-red (IR) 100 W Q-switched fiber laser is capable of emitting high energy pulses at high pulse repetition frequencies (PRF), reaching an industry-leading 1.5 mJ pulse energy in a near diffraction limited beam with $M^2<1.3$. The energetic pulses exhibit peak power levels of 15 kW. Compared to other more commonly available pulsed fiber lasers with 1 mJ pulse energy, the VGEN-QS-HE-100 laser enables higher fluence and higher throughput with a higher cutting speed, and the superior beam quality keeps intensity high and spot size to a minimum. In this Application Focus, we describe the results of Li-ion battery foils (coated and bare) cutting using a 160 mm f-theta lens, 2D scanner and 7.5 mm laser beam. Although the laser is capable of reaching 1.5 mJ at 67 kHz, it can be operated at higher PRF to further improve throughput (e.g. 1.2 mJ @ 83 kHz, 1 mJ @ 100 kHz or even 0.8 mj @ 125 kHz).

Results achieved for cutting the coated film (anode and cathode) material, as well as bare film (aluminium and copper) are summarized in Table 1. The cut quality shown for coated and bare copper and aluminium foil in Figure 3 and 4 respectively are more than satisfactory.

Also, the very low burr and good cut edge quality are evident in Figure 3 and 4.

Thus a high speed and quality process for cutting Li-ion battery foils using the Spectra-Physics VGEN-QS-HE-100 pulsed IR fiber laser was demonstrated. The laser has high peak power, high energetic pulses, over a wide PRF range and high beam quality, enabling foil cutting at high scan speeds and high cutting quality that meets typical industry requirements.

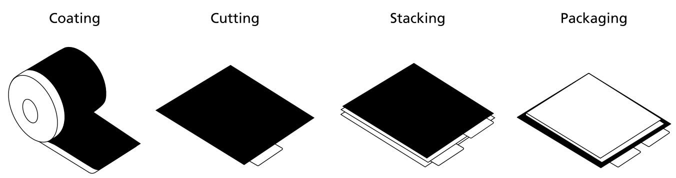

Figure 1: Typical key steps in Li-ion-cell manufacturing process.

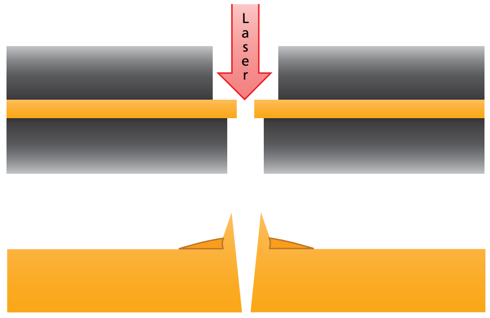

Figure 2: HAZ "pull back" effect (top) and burr creation on the edges of the metallic foil (bottom)

	Speed [mm/s]	PRR [kHz]	Entry HAZ [µm]	Exit HAZ [µm]	Avg. Burr [µm]	Peak Burr [µm]
Coated Cu	800–1,000	100	30–45	20–35	5	10
Coated Al	800–900	100	30–50	15–30	5	8
Bare Cu	>3,500	100	25–50	0–3	1	3
Bare Al	>3,500	100	50–100	0–5	2.5	4

Table 1: Summary of cutting speed and quality metrics for coated Cu (~90 um thick), coated Al (~100 um), bare Cu (9 um), and bare Al foil (15 um)

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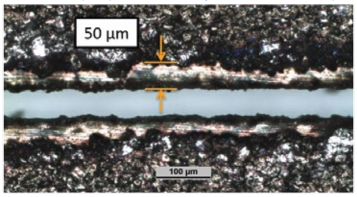
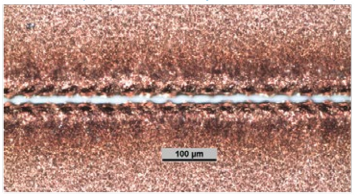
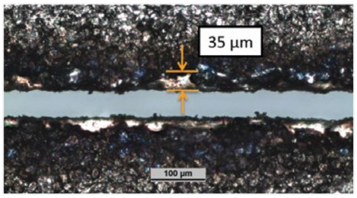
Microscope photo: entry HAZ: 30–45 µm



Microscope photo: entry HAZ: 25–50 µm



Microscope photo: exit HAZ: 20–35 µm



Microscope photo: exit HAZ: 2–5 µm

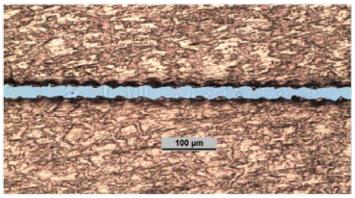
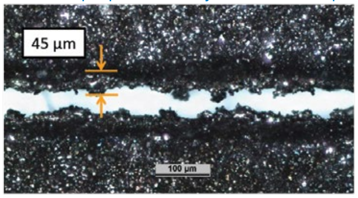
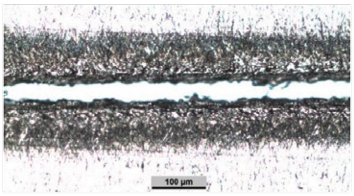


Figure 3: Microscope photos for coated Cu, entry HAZ; coated Cu, exit HAZ; bare Cu, entry HAZ; and bare Cu, exit HAZ

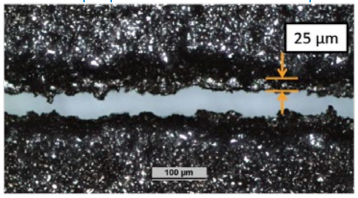
Microscope photo: entry HAZ: 30–45 µm



Microscope photo: entry HAZ: 50–100 µm



Microscope photo: exit HAZ: 0–30 µm



Microscope photo: exit HAZ: 10–20 µm

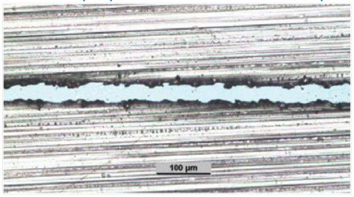


Figure 4: Microscope photos for coated Al, entry HAZ; coated Al, exit HAZ; bare Al, entry HAZ; and bare Al, exit HAZ

PRODUCTS: ***VGEN-QS-HE-100***

The Spectra-Physics VGEN-QS-HE-100 pulsed IR fiber laser incorporates leading edge technology in a gain switch configuration for top performance in a wide range of industrial micromachining applications in a 24/7 manufacturing environment where system uptime is critical.

	VGEN-QS-HE-100
Wavelength	1064 nm
Average Power	100 W
Max Peak Power	15 kW
Max Pulse Energy	1.5 mJ
PRF	20–200 kHz
M^2	<1.3
Beam Diameter	7.5 mm
Cooling	Air cooled

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