Laser Processes for Li-ion Battery Cell Manufacturing

The drive to reduce carbon emissions and make our renewable energy sources such as solar and wind energy more sustainable requires improvement and development in battery technology. Among various battery technologies Lithium-ion (Li-ion) batteries are at the forefront of advanced battery development for applications in consumer electronics, automotive, and energy storage.

Li-ion battery manufacturing is a roll-to-roll process and can be divided into two main process chains: first, roll-to-cell production and second, the cell-to-battery system assembly. Typical Li-ion battery cell structures consist of three layers of foils: the anode, the separator, and the cathode foil, as shown in Figure 1.

The thickness of electrode foils is typically ~100 µm, whereas separator foils are ~50 µm. Anode foils are made of graphite coated copper foils, and cathode foils are made of lithium-metal-oxide coated aluminum foils. Separator films are made of polypropylene or polyethylene. Various steps involved in the roll-to-cell process chain are listed in Figure 2.

Among the steps shown in Figure 2, lasers are well suited for foil slitting, foil cutting, tab cleaning, and separator foil cutting due to the precision, control, and high machining quality required for these processes. Lasers provide a number of advantages over conventional mechanical processes, including no tool wear, flexible cut pattern, improved edge quality, increased precision, and lower cost of operation.

Foil slitting: during the foil slitting step a wide roll of battery foil is cut along the length of the roll into narrow strips as required by the cell design. An infrared pulsed laser works well for foil slitting. It can cut through coated metal foil electrodes at a high speed with good quality. If a narrower cut width or higher quality is desired, a pulsed green or ultraviolet (UV) laser can also be used for foil slitting.

Foil cutting: during this step anode and cathode foil strips are cut to a desired pattern as required by the cell design. Depending on the cell design and whether the entire width of the foil roll is coated or not, during this step the laser needs to cut through coated foils or just the metal foil. Lasers used for foil slitting also work well for this process.

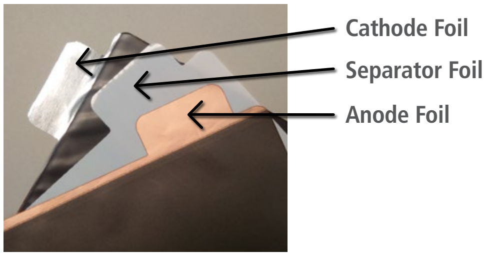

Figure 1. Three Li-ion battery cell electrode and separator foils.

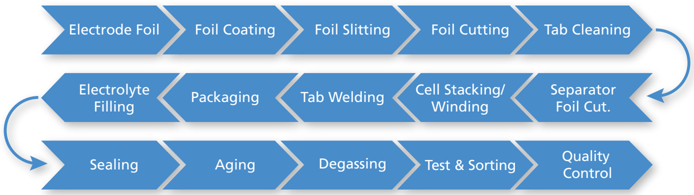

Figure 2. Schematic of steps involved in roll-to-cell Li-ion battery cell manufacturing process.

Tab cleaning: depending on the battery foil structure and cell design, in some cases removal of graphite and lithium-metal-oxide is necessary to expose bare copper and aluminum foil tabs. The key during this process step is to remove the coating material without harming the metal foil underneath. Pulsed IR lasers seem to work well for this step and provide the needed selectivity in removing coating without harming the metal foil.

Separator foil cutting: similar to foil cutting, separator foil are also cut to a desired pattern as required by the cell design. Since separator foils are made of organic material a pulsed UV laser is best suited for this process step.

Spectra Physics® provides a variety of lasers covering infrared to UV wavelength range for Li-ion battery processing. We have successfully demonstrated all four processes described above using our infrared pulsed fiber laser, VGEN-QS-HE-100, and green and UV lasers from the Talon® and Quasar® laser families.

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PRODUCTS: *VGEN-QS-HE-100, TALON 355-30, TALON 532-40, QUASAR 355-60, QUASAR 532-95*

	VGEN-QS-HE-100	Talon 355-30	Talon 532-40	Quasar 355-60	Quasar 532-95
Wavelength	1060–1080 nm	355 nm	532 nm	355 nm	532 nm
Power	100 W	30 W @ 100 kHz	40 W @ 100 kHz	>60 W @ 200 kHz, 10 ns >60 W @ 300 kHz, 10 ns	>95 W @ 200 kHz, 10 ns
Repetition Rate	20–140 kHz	0–500 kHz		0–3.5 MHz	
Pulse Width	125±25 ns	<25 ns @ 100 kHz		<2 ns to >100 ns	

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