Laser ablation mechanism for modification of composite electrodes with improved electrolyte wetting behaviour

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Lithium-ion pouch cells consist of stacked layers of tape-casted composite electrodes and separators. The electrodes exhibit typical film thicknesses in the range of 50 - 100 µm. Nevertheless, thick composite films suffer from insufficient wetting behaviour with liquid electrolyte due to an increase in electrolyte penetration depth and therefore, poor cycling performance at high charging and discharging currents. These drawbacks can be overcome by recently developed laser process strategies.
Laser structuring of selected composite electrode materials was performed using Q-switched ytterbium-doped fiber laser radiation with a wavelength of 1064 nm and pulse duration of 200 ns. The thermal impact of the laser ablation process into the positive active material was investigated using X-ray diffraction analysis as well as focused ion beam sample preparation technique for cross sectional analysis of melted surface layers. Furthermore, the heat impact zone was estimated by a numerical calculation and the results were in good agreement with those obtained from experimental studies.
It could be shown that vaporization of the binder matrix within the laser interaction zone maintains the ablation process and therefore, the removal of the composite electrode material down to the current collector. The application of laser structuring technique enabled the formation of capillary structures directly into the composite electrode accompanied by rapid and efficient electrolyte wetting. Furthermore, it was shown that lithium-ion cells composed of laser structured electrodes revealed significantly improved reliability and capacity retention at high charging and discharging currents for several thousands of cycles.