**Upscaling of the laser structuring of lithium-ion battery electrodes - process development and electrochemical properties as a function of design patterns**

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Structuring of electrodes for lithium-ion batteries by using ultrashort pulsed laser ablation is a quite promising approach to significantly increase the electrochemical performance of lithium-ion batteries. The main impact of such 3D electrodes is due to shortening of lithium-ion diffusion pathways and improving the electrolyte wetting of composite electrodes The latter is reducing the electrolyte filling process time and saving the need for warm aging in the manufacturing process. The 3D electrode concept, in combination with an increase in electrode layer thickness, facilitates an increase in energy and power density of batteries at the same time. To implement the laser structuring process in industrial cell manufacturing, an adaptation of the ultrafast laser technology to the coating speed has to be established.

In the presented study, the use of an ultrashort pulsed laser system of high power up to 300 W and high repetition rate in the MHz regime was evaluated regarding processing speed for patterning of graphite and silicon/graphite anodes. For composite graphite anodes (film thickness > 76 µm) with an areal capacity of about 2.5 – 4.0 mAh/cm$^2$ and a thick-film silicon/graphite anode with 5 wt.% silicon content (film thickness 80 µm, areal capacity 4.3 mAh/cm$^2$) the laser and process parameters and processing speed were evaluated and optimized. Furthermore, different structure patterns including hole, grid and line pattern, were studied regarding upscaling in roll-to-roll processing. The different types of patterns were evaluated with respect to accessible electrochemical properties. Prior to cell assembly and during post-mortem studies, the quality of structured electrodes was examined by profilometry and scanning electron microscopy. Debris formation and a thermal impact to active material and current collector could be avoided. To evaluate the electrochemical properties such as high rate capability, cell impedance, and cell lifetime, coin cells and pouch cells were manufactured. For this purpose, NMC 622 cathodes were prepared as the respective counter-electrodes and a cell balancing in the range of 1.1-1.2 was ensured.