
1

CUTTING OF ELECTRODE MATERIALS WITH SHORT PULSE LASERS

THE TASK

Electro-mobility represents a central development focus for the global automotive industry. Electric vehicles drive emission free and thus embody the future of our mobility. Achieving this goal requires overcoming many challenges. An example is the need for cost-effective high-volume manufacturing technologies to produce the required energy storage devices. A partial aspect of the development work addresses the cutting of the sheet materials for the three elementary components of lithium ion cells: the cathode, the anode and the separator. The active electrodes are built from multilayer metal foil (aluminum or copper) stacks, which are coated on both sides with graphite or lithium metal oxide. This combination of different materials causes challenges for the cutting process.

The state-of-the-art electrode materials cutting processes are highly productive stamping technologies. Their primary disadvantage lies in the low flexibility of static tools and permanent tool wear caused by the cutting of ceramic materials. The quality of the cutting edges continually decreases. Laser beam cutting is a contact and wear free technique and thus presents an alternative. This laser technology is also highly flexible in particular if varying cutting contours are required. However, so far there has been one critical disadvantage of this technology and that is the higher cycle times.

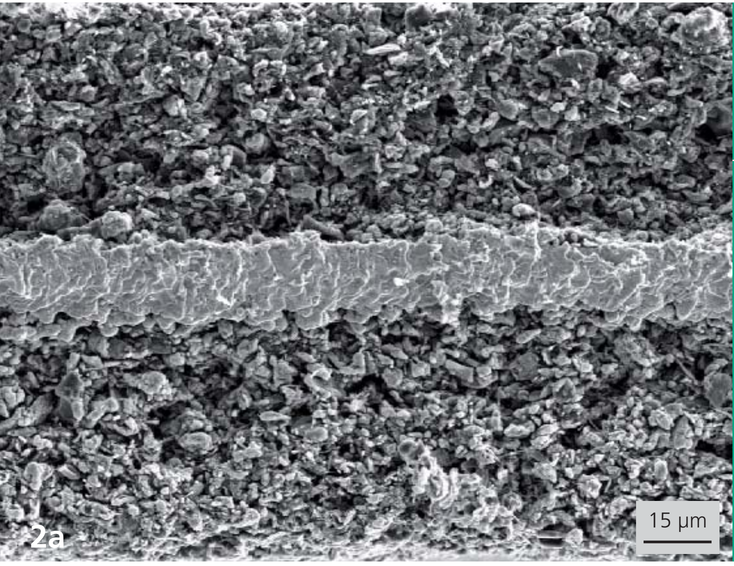
This project aims at overcoming this limitation. The concept is the utilization of laser beam sources of highest beam quality in combination with dynamic remote cutting processes.

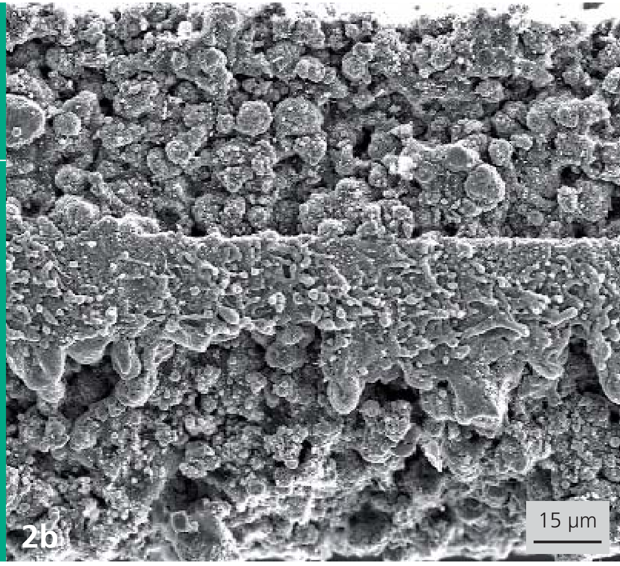
OUR SOLUTION

The laser remote cutting with dynamic beam scanning allows very high path velocities. This process purposely avoids process gases as used in conventional laser beam cutting. Therefore the laser beam can be scanned quickly over the surface using galvanometer scanners following the desired cutting contour. The use of laser sources with high quality beams achieves in particular for pulsed lasers very high intensities in the processing spot. Under such conditions the cutting occurs as material ablation in vapor form.

The service life of the lithium ion cells depends on the quality of the cuts. The cutting process has to avoid heat dissipation into the sheet material to suppress undesired ablation and to avoid the modification of the active coating material along the cutting edges. Another concern is the redeposition of ablated material, which could cause electrical shorts in the cell.

Fraunhofer IWS engineers performed numerous experiments to develop and optimize cutting processes for anode and cathode materials. Key process parameters were analyzed such as the pulse length and how it affects the cut quality.





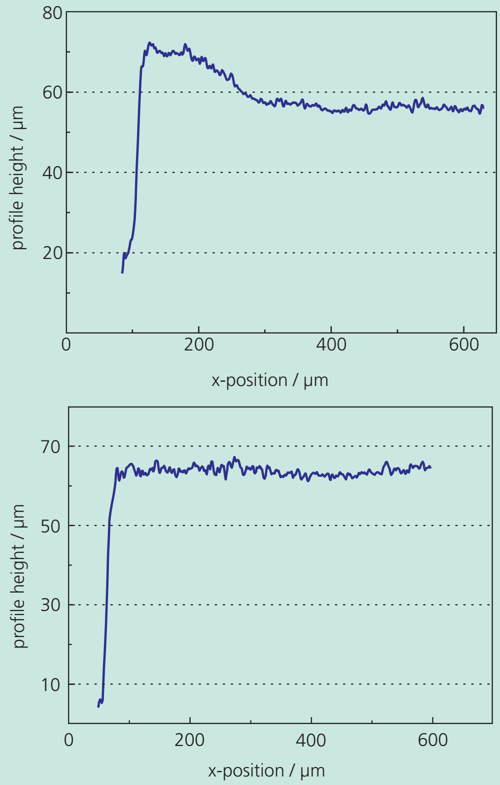
RESULTS

Figures 2a and 2b show SEM pictures of the typical cutting-edge during processing with short pulse solid-state lasers. The size and amount of particles that remained on the surfaces is so little that they do not present any limitation to further processing. Anode and cathode foils could be separated with high quality under identical conditions (40 W average power, wavelength 1 µm, spot diameter 25 µm). The influence of two pulse lengths (30 ns and 10 ps) on the processing results was studied. Both pulse lengths lead to almost identical cutting speeds up to 30 m min^{-1} when using equal power. Cutting speeds on the order of 60 m min^{-1} require laser powers exceeding 100 W.

The focus diameter and intensity or pulse energy was optimized to minimize the removal of active coating material from the metallic carrier foils along the cut edge. Transitioning to ultra short laser pulses has a measurable influence on the impact of heat dissipation and redeposition along the separated edge surface. The surface profiles shown in Figure 3 clearly show this for the anode material, which can increase in volume due to heating. Due to the minimal interaction time during ps pulses there is no thermal effect visible.

These results were obtained as part of a BMBF funded project DeLIZ (02PO2640; 02PK2641/2642). This project also addressed the test of high power cw fiber lasers for cutting such electrodes with speeds of up to 700 m min^{-1}.

Comparison of surface profiles of cut edges:
a measurable increase in surface height due to heat impact is observed for the process using nanosecond pulses (upper graph);
in the case of picosecond pulses (lower graph) the profile remains flat and does not show measurable thermal effects.



3

1 Example electric car

2 SEM image of the cut edge of a laser cut electrode

a) cathode

b) anode

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