Fraunhofer IKTS

EMBATT Chassis-embedded Energy

MATERIAL AND PROCESS DEVELOPMENT FOR LITHIUM BIPOLAR BATTERIES

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INTRODUCTION

Conventional monopolar lithium batteries are limited in energy density due to the high share of inactive components and limited volume utilization on cell as well as on system level. The EMBATT bipolar battery concept (fig. 1) reduces the amount of inactive components and leads to improved integration properties for automotive applications.

Main challenges which have been identified concern:

- Technological solutions for electrode and system manufacturing
- Material innovations for active material, electrolyte and current collector

Fraunhofer IKTS is addressing these topics in the projects EMBATT1.0 (manufacturing technology) and EMBATT2.0 (material innovations) as summarized in table 1.

Table 1: Comparison of the generations of the EMBATT bipolar battery

	EMBATT1.0	EMBATT2.0
Materials	Commercial LFP and LTO	High voltage system LTO/LNMO with optimized particle morphology
	Liquid electrolyte	Polymer electrolyte
	Al-current collector	Polymer current collector
Energy density on battery system level	> 200 Wh/l	> 450 Wh/l

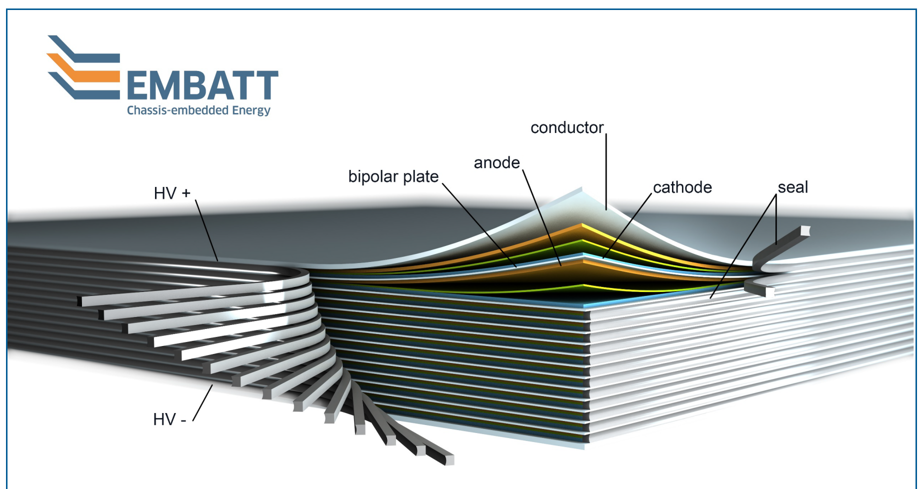


Figure 1: Schematic representation of the EMBATT concept.

WATER BASED ELECTRODES

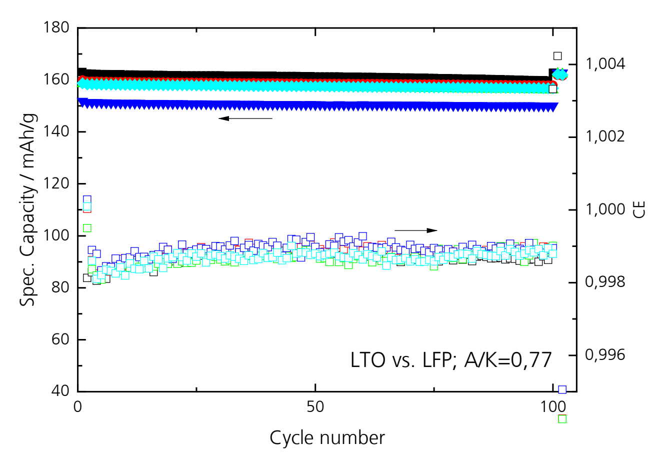
Slurry development

Water based slurry recipes have been developed for LTO and LFP. Then, electrodes were manufactured on pilot scale coating equipment.
Plot 1 shows the results of LTO limited coin cells.

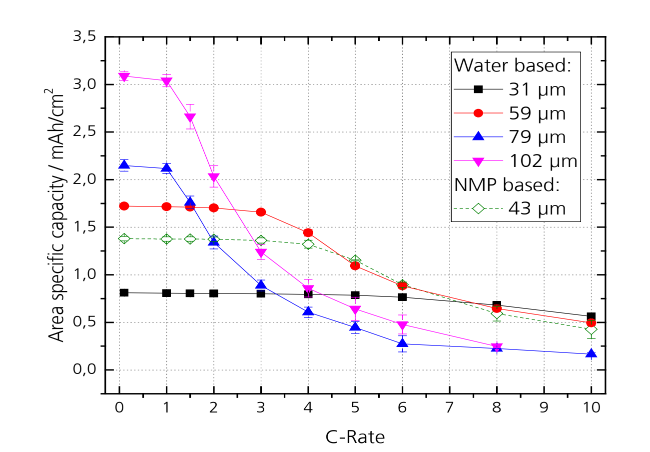
Increasing electrode thickness

The slurry recipes and coating parameters were optimized with the goal of increasing electrode thickness. Plots 2 and 3 show the area specific capacity and the normalized capacity, respectively. An NMP based electrode is added for comparison.

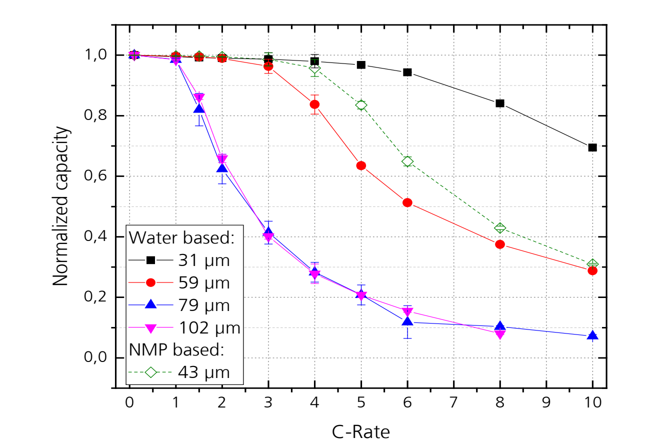
Plot 1: Cycling test for 5 coin cells, LTO/LFP, 1C/1C, 25 °C



Plot 2: Rate capability for water based LTO electrodes



Plot 3: Norm. capacity for water based LTO electrodes



BIPOLAR CELLS AND STACKS

Test cells

Dedicated bipolar test cells have been developed. They consist of electrodes coated on an Aluminum current collector. One side is coated with LFP and the other one with LTO. The electrode are is 5 x 5 cm². An insulator is used to electrically separate the adjacent current collectors and for mechanical stability.

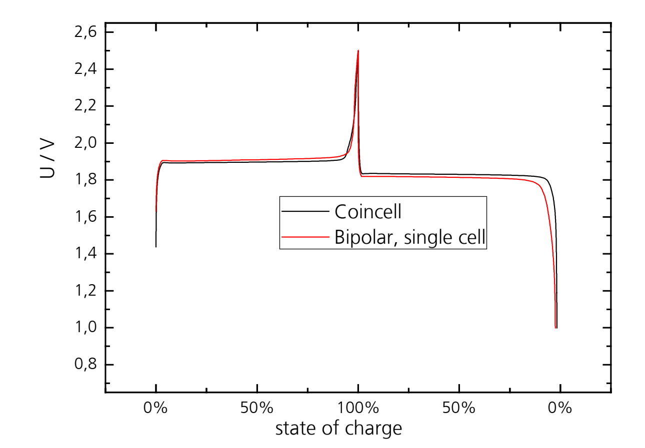
Electrolyte filling and assembly

Two capillaries are inserted between the electrodes (Fig. 3). Different filling strategies have been evaluated inside an Ar-filled glovebox.

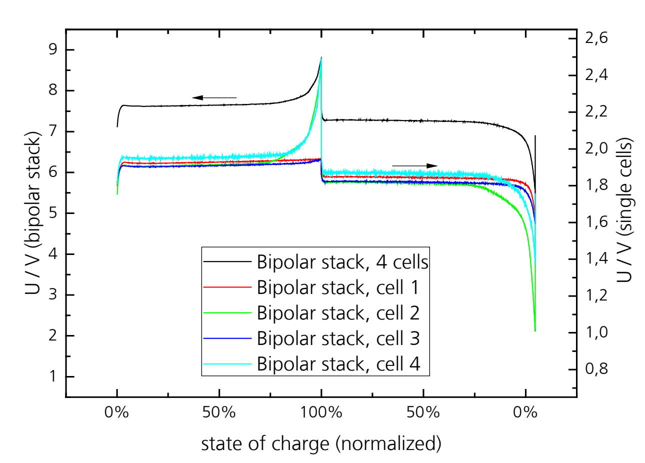
Electrochemical characterization

First, the performance of the electrodes in the bipolar test setup (Fig. 3) have been verified by comparing with the performance in coin cells (Plot 4).
Then, bipolar stacks consisting of 4 single cells have been manufactured. In plot 5 the stack voltage as well as the sing cell voltages are shown.

Plot 4: Comparison of coin cell and bipolar single cell



Plot 5: Bipolar stack voltage and single cell voltages



SEPARATOR COATING

Replacement of additional separators

With the aim of omitting a conventional separator, which has to be placed in the cell during the manufacturing process, a technology was developed to apply a separator directly on the electrode.
In figure 2, an Al_2O_3 based separator was coated directly on the LFP cathode. By optimizing the coating process, thicknesses of approx. 30 µm could be achieved.
In EMBATT2.0, a solid polymeric electrolyte will be applied simultaneously.

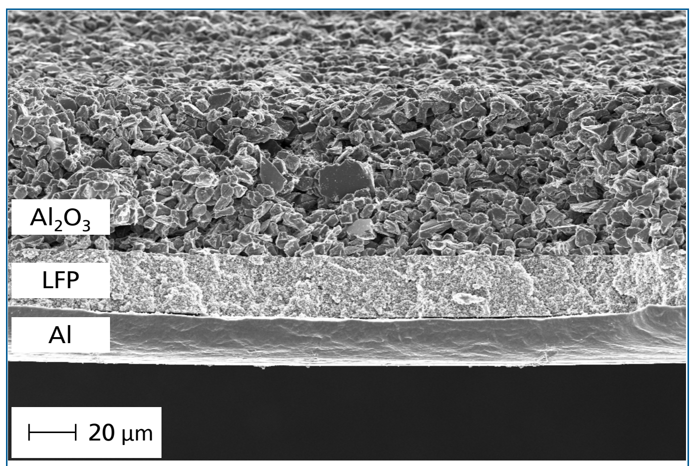


Figure 2: Al_2O_3 layer coated on LFP based cathode.

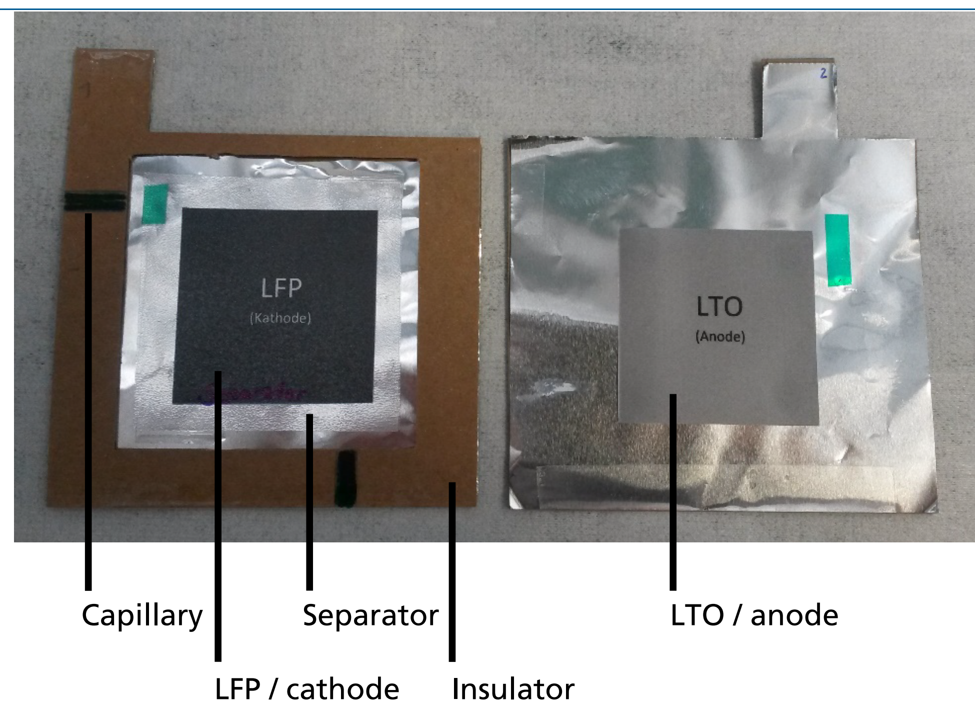


Figure 3: Components of the bipolar stack. Cathode (left) with separator, electrolyte filling capillary and insulator and Anode (right). To form a bipolar test battery several of the shown components are stacked and the single cells are filled with electrolyte.

CONCLUSIONS AND OUTLOOK

Several technological solutions for the manufacturing of large bipolar batteries have been developed in EMBATT1.0: water based processes for thick electrodes, bipolar electrodes, separators coated on the electrodes and electrolyte filling strategies.

In the recently started project EMBATT2.0 material innovations such as dedicated active materials, polymeric electrolytes and polymer based current collectors will increase energy densities up to 450 Wh/l on system level.

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Europäische Union

Europa fördert Sachsen.
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thyssenkrupp

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