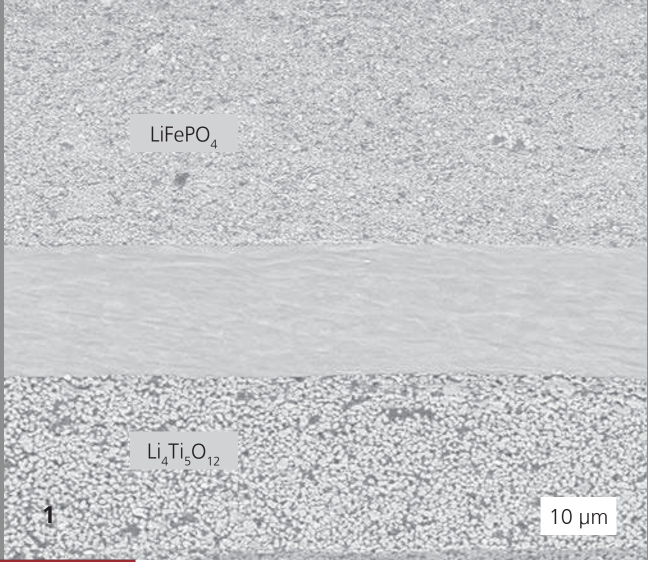

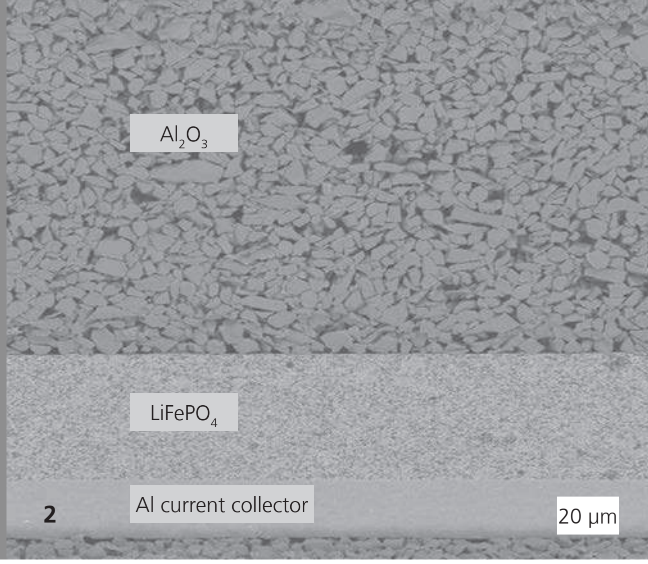

EMBATT BIPOLAR BATTERY: NEW BATTERY DESIGN FOR HIGHER ENERGY DENSITY

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Availability of low-cost battery systems and energy densities higher than 450 Wh/L are prerequisites for wide-scale market penetration of electric vehicles. To meet these requirements, the established monopolar Li-ion cell technology employs active materials with increased energy densities or optimized cell and system packaging. With the EMBATT battery design, Fraunhofer IKTS and partners IAV GmbH and ThyssenKrupp System Engineering GmbH are taking a new approach. The consortium jointly develops large-scale lithium bipolar batteries as well as the associated manufacturing technologies and concepts for direct integration into vehicle chassis. The EMBATT bipolar battery consists of stacked cells, in which the current collector of the negative electrode of one cell is in contact with the positive electrode of the next cell. Thus, two electrochemical cells connected in series share one current collector – one side of the bipolar electrode serves as the anode in one cell and the other side as the cathode in the next cell.

Through this simple stacking of cells, the bipolar battery design does away with complex cell packaging and delivers a stack voltage resulting from the number of single cells in the stack. The advantages of this design are numerous: low internal resistance in the stack, the option to use very large electrode areas, and elimination of the need for extensive cell connections as are found in conventional battery systems. The EMBATT design thus transfers the high energy density from the cell level directly to the battery system.

In the first step of the recently started project, the partners developed a cell design optimized for subsequent manufacturing and vehicle integration. Fraunhofer IKTS developed the design of the bipolar electrode as well as suitable environmentally friendly and efficient production processes.

Based on the results of studies conducted to determine the optimal electrode balancing, bipolar electrodes were prepared with $Li_4Ti_5O_{12}$ (LTO) as the anode and $LiFePO_4$ (LFP) as the cathode material. Use of $LiNi_{0.5}Mn_{1.5}O_4$ (LNMO) on the cathode side in the future will allow for a further increase in the cell voltage and hence the energy density of the stack. Studies on the optimal synthesis conditions of this so-called high-voltage cathode material are currently underway.

Technologies aimed at simplifying future cell production by enabling a ceramic separator to be applied directly to the electrode are also being developed. This will eliminate the need for an additional separator component for the bipolar battery.

In initial tests, bipolar stacks achieved the expected performance with the prepared electrodes and separators.

1 *Bipolar LTO/LFP electrode.*
2 *Ceramic separator directly coated on LFP cathode using water-based process.*

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