The Effect of Different Cut-off Voltages and Elevated Temperature in the Formation Procedure on the Electrochemical Performance in SiC Based Li-ion Cells

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The influence of different upper cut-off voltages in the formation cycle in NCM/SiC Li-ion cells (571 mAh/g theo. capacity of the anode) using 1 M $LiPF_6$ in EC : DEC (30 : 70) + 2.5wt.-% FEC + 2.5wt.-% VC as electrolyte was investigated in the framework of the contribution to the SEI enhancement and the coherent effect on the electrochemical performance.[1,2] Furthermore, the application of elevated temperature in the formation procedure was used to increase the Coulombic efficiency in the formation cycle.[3,4]

The different formation procedures included each one charge cycle to a different cut-off voltage and one discharge cycle to 3 V. Charge and discharge occurred with 0.1C with respect to the theoretical capacity of the cathode (160 mAh/g). Upper cut-off voltages of 3.6 V, 3.8 V, 4.0 V, and 4.2 V in the formation cycle were compared. The electrochemical performance was analyzed by constant current constant voltage cycling (CCCV) in coin cells. The cycling was carried out with cut-off voltages at 4.2 V and 3.0 V and with a C-rate of 1.0C. Upper cut-off voltages during formation of 3.6 V or 3.8 V, respectively, increased the initial (119 mAh/g and 118 mAh/g) and the overall specific discharge capacities (80 mAh/g after 100 cycles) in comparison to the formation procedures with 4.0 V or 4.2 V (74 mAh/g after 100 cycles) as upper cut-off voltages. The discharge capacity retention however, was slightly decreased (3.6 V: 67% 4.2 V: 68%). Scanning electron microscopy images exhibited that the shape of the SEI after formation with cut-off voltages at 3.6 V or 3.8 V is similar and differs from the shape after formation with 4.0 V or 4.2 V. Applying 40 °C during the overall formation procedure led to a large decrease in the initial specific discharge capacity (81 mAh/g) and thus in the overall discharge capacity at 1.0C (61 mAh/g after 100 cycles) and at room temperature. However, an increase in the capacity retention was observed. Using elevated temperatures only in the charge process in the formation cycle increased the loss of lithium as the electrolyte decomposition on the anode surface was accelerated. However, the application only in the discharge process led to an enhancement in the initial specific discharge capacity at 1.0C. The combination of the cut-off voltages 3.6 V or 3.8 V and the application of 40 °C in the discharge of the formation cycle lead to the best ongoing electrochemical performance in the NCM/SiC Li-ion cells.

References:

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