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Materials development for advanced Li ion batteries

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Lithium ion batteries are widely used in many portable applications and are the most promising energy storage systems for future mobility and stationary applications. Worldwide, extensive research efforts focus on the development of high performance, low cost and more sustainable materials for advanced lithium ion batteries. In this presentation, we describe various strategies to increase the energy density of lithium ion batteries by combining high voltage and high capacity cathode materials as nickel rich layered oxides or high voltage spinel type materials with silicon/carbon composites. An alternative approach is the development of cobalt free cathode materials. Co-free, Li-rich $Li_{1+x}Ni_{0.5}Mn_{1.5}O_4$ (0<x<1) compounds are very promising candidates for high energy applications. The lithium-nickel-manganese oxide compounds can be tailored with respect to composition in order to reach high capacities up to 250 mAh g^{-1} with long cycling life. An adapted electrode manufacturing process including a deep understanding of the interactions between powder properties, process parameters and electrochemical performance is essential to get maximum cell performance. In addition, lithium plating can occur during charging, which is a severe ageing mechanism and a potential safety risk. Adapted cathode materials with excess of lithium can be used to compensate irreversible losses of silicon based anode materials and to prolong life time in full cells.

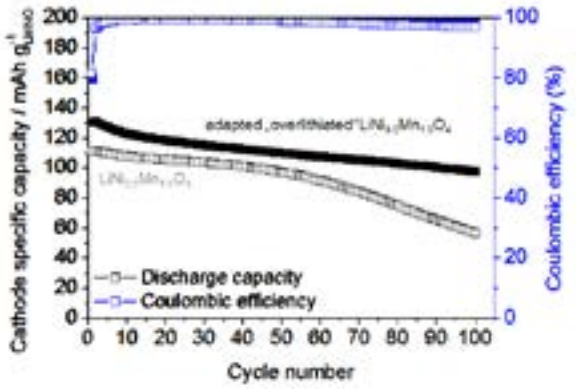

Figure 1: Capacity retention of two Li ion cells Si//$LiNi_{0.5}Mn_{1.5}O_4$ (open squares) and Si//$Li_{1+x}Ni_{0.5}Mn_{1.5}O_4$ with excess lithium adapted to irreversible loss of silicon (black squares); capacity is referred to cathode material.

Recent Publications

1. M Marinaro, M Weinberger and M Wohlfahrt-Mehrens (2016) Toward pre-lithiatied high areal capacity silicon anodes for Lithium-ion batteries, Electrochimica Acta 206:99-107.
2. G Gabrielli, P Axmann, T Diemant, R J Behm and M Wohlfahrt-Mehrens (2016) Combining optimized particle morphology with a niobium-based coating for long cycling-life, high-voltage lithium-ion batteries. ChemSusChem 9(13):1670-1679.
3. M Mancini, G Gabrielli, P Axmann and M Wohlfahrt-Mehrens (2017) Electrochemical performance and phase transitions between 1.5 and 4.9 V of highly-ordered $LiNi_{0.5}Mn_{1.5}O_4$ with tailored morphology: influence of the lithiation method. Journal of the Electrochemical Society 164(1):A6229-A6235.
4. T Waldmann, B I Hogg and M Wohlfahrt-Mehrens (2018) Li plating as unwanted side reaction in commercial Li-ion cells–A review. Journal of Power Sources 384:107-124.

5. G Gabrielli, M Marinaro, M Mancini, P Axmann and M Wohlfahrt-Mehrens (2017) A new approach for compensating the irreversible capacity loss of high-energy Si/C|$LiNi_{0.5}Mn_{1.5}O_4$ lithium-ion batteries. Journal of Power Sources 351:35-44.

Biography

Margret Wohlfahrt-Mehrens is the Head of the Accumulators Materials Research Department (ECM) at ZSW in Ulm, and Head of Materials II (Composite Materials) at the Helmholtz Institute Ulm for Electrochemical Storage (HIU). Her research focuses on new materials for Li-ion, Li-S, metal-air and Na-ion batteries, and process development for electrode and cell production in close collaboration with several industrial companies. Her projects are part of a broad network including large international industrial companies, research organizations and universities. She coordinates the German battery competence center Li-EcoSafe, is member of the board of directors of HIU and member of executive board of the competence network Li-ion batteries (KLIB).

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