Interface formation and properties in a Na_xCoO_2/Nasicon/Na all-solid-state battery

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While liquid electrolytes allow good contact, and thus an efficient ionic pathway through the interfaces with the electrodes, a key challenge for solid-state electrolytes is their poor interface properties due reaction layer formation and low contact area caused by the granular microstructure. In this contribution we present results on the performance and interface properties of all-solid sodium batteries based on a solid electrolyte $Na_{3.4}Sc_{0.4}Zr_{1.6}(SiO_4)_2(PO_4)$ and thin-film P2-Na_xCoO_2 electrodes. The used solid electrolyte $Na_{3.4}Sc_{0.4}Zr_{1.6}(SiO_4)_2(PO_4)$ of a Na super ionic conductor (Nasicon) type with an ionic conductivity as high as $4x10^{-3}$ S/cm, low interface resistance of 365 **Ω** cm², and no chemical reactions with metallic sodium within a voltage range up to 6 V is considered for all-solid sodium-based batteries [1].

Upon deposition of P2-Na_xCoO_2 on the Nasicon electrolyte, we observe by X-ray photoelectron spectroscopy changes in the electrolyte surface region and the formation of a thin interlayer. We find that this interlayer causes small but significant cell overpotential in relation to the conductivity of the solid electrolyte [2]. In a P2-Na_xCoO_2/Nasicon/Na all-solid-state battery with a thin-film cathode grown by pulsed laser deposition, we achieved capacities of 123 mAh/g, with a capacity fading of 6% over 500 cycles. We present an electrochemical impedance study on the evolution of the inner cell resistance under operational conditions between 2.0 and 4.2 V. The interface resistance of the Nasicon solid electrolyte in contact with a P2-Na_xCoO_2 cathode was found to be dependent on the P2-Na_xCoO_2 film growth conditions. The influence of post-annealing on the crystal- and microstructure of the P2-Na_xCoO_2 cathode and its impact on the interface resistance is correlated with the electrochemical performance of the sodium all-solid-state battery at room-temperature.

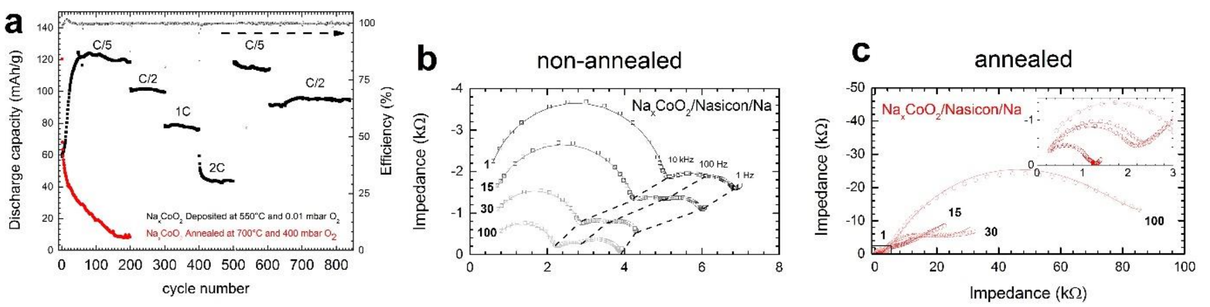

Fig. 1a, discharge capacity and efficiency of P2-Na_xCoO_2/Nasicon/Na batteries with as-grown (black) and annealed (red) P2-Na_xCoO_2 cathode at the cycling rates between C/5 and 2C. Impedance spectra of a P2-Na_xCoO_2/Nasicon/Na battery with (b) not-annealed and (c) annealed cathode between 1 and 100 cycles.

Acknowledgements: The work was financially supported by the DFG HA 6128/2-1 and KO 4093/2-1.

References:

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