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ELECTROLYTE DEVELOPMENT – FROM LIQUID TO SOLID STATE CONCEPTS

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LIQUID ELECTROLYTE

Motivation
- Electrolyte filling is a bottle neck in cell production
- Optimizing components for faster electrolyte filling
- Safety aspect: Application of a protecting Al_2O_3 layer
- Al_2O_3 coating on electrode can replace classical separator

Challenges
- Improvement of wetting properties of cell components

Research areas at Fraunhofer IKTS
- Basic understanding of the electrolyte wetting process in state-of-the-art Li-ion technology
- Optimization of electrolyte filling by surface modification of separators and electrodes

Work Topics
- Investigation of wetting properties of commercial separators
- Development of ceramic separator coatings
- Free standing separator foils

POLYMER ELECTROLYTE

Motivation
- Flexible cell design
- Building of bipolar battery concepts
- Production method similar to classical LIBs
- Safety aspects: no liquid organic solvents in the battery

Challenges
- Increase Li-ion conductivity at room temperature
- Minimization of electrolyte thickness for application relevance

Research areas at Fraunhofer IKTS
- Integration of ion conducting polymer electrolytes into cell manufacturing process
- Lithium stability tests and incorporation of ceramic particles

Work Topics
- Polymer electrolyte infiltrated electrodes
- Novel cell concepts using polymer electrolytes

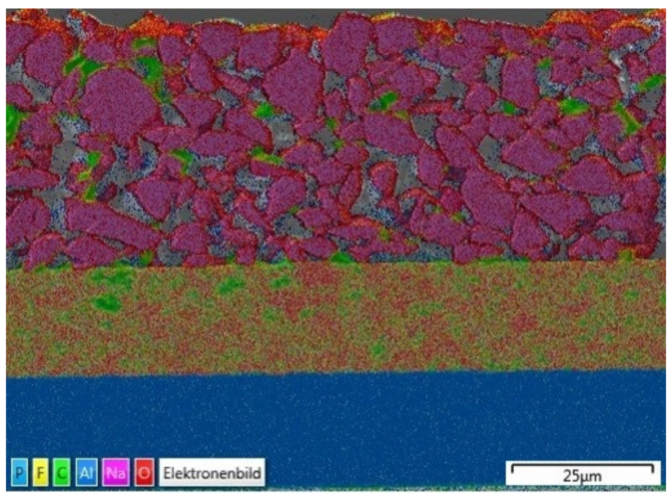
CERAMIC ALL SOLID STATE

Motivation
- Usage of specialized Li-ion conductive oxide materials
- Li-metal as anode possible for certain materials
- Bipolar cell concepts with higher energy density
- Application of established ceramic process technology

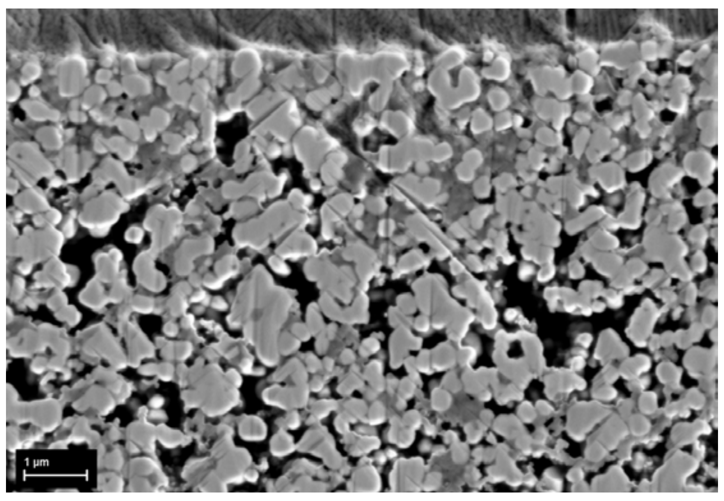
Challenges
- Increase Li-ion conductivity and compatibility under room temperature
- Establish process technology for scale up

Research Areas at Fraunhofer IKTS
- Synthesis of ceramic electrolytes
- Processing of electrolyte-separators and composite cathodes
- Building all solid state test cells

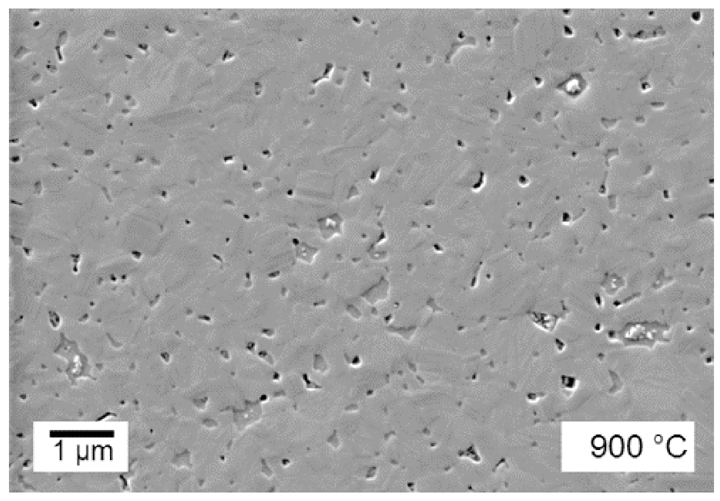
Work Topics
- Tapes of sintered ceramic of Li-ion conductive powder
- New Li-ion conductive ceramics



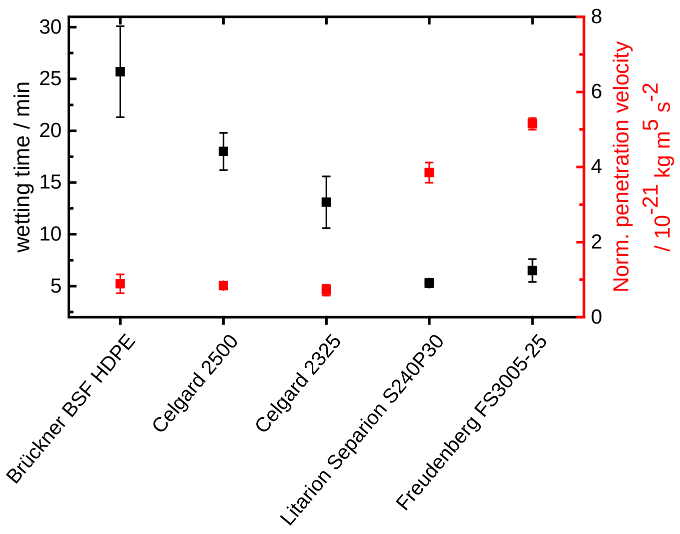
Pic 1: EDX mapping of Al_2O_3 based separator on top of LTO electrode.



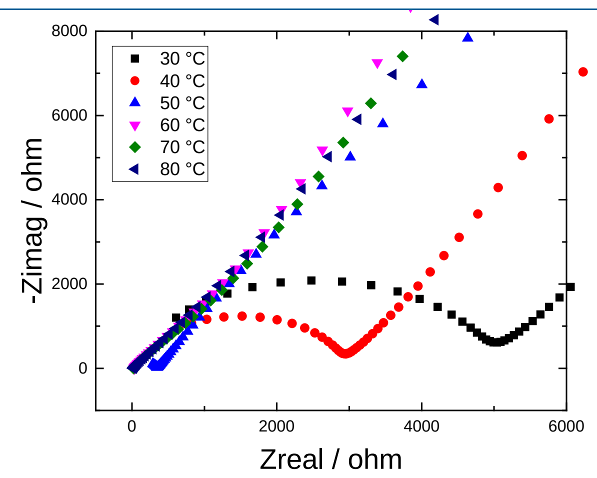
Pic 2: FESEM cut of PEO infiltrated LTO anode.



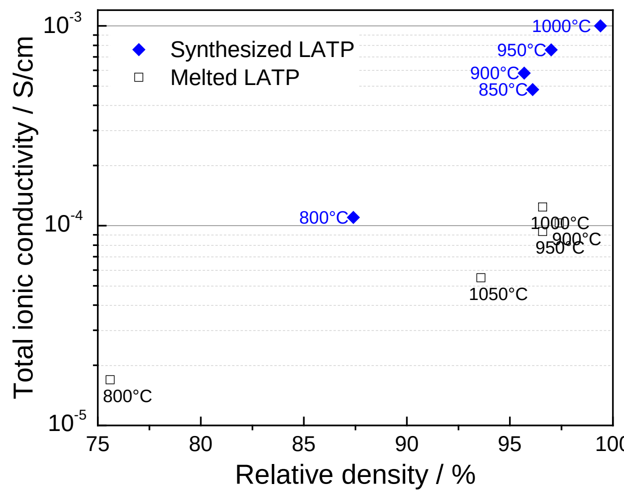
Pic 3: LATP Ceramic electrolyte made of synthesized and milled powder.



Pic 4: Comparison of measured electrolyte wetting times for different separators.



Pic 5: Impedance of free standing PEO electrolytes with Li salt; decreasing bulk resistance with higher temperatures proved; Ionic conductivity at 80 °C: ≈1 10-4 S/cm.



Pic 6: Ionic conductivity of synthesized LATP material at different temperatures with different densities.

ELECTROCHEMICAL CHARACTERIZATION

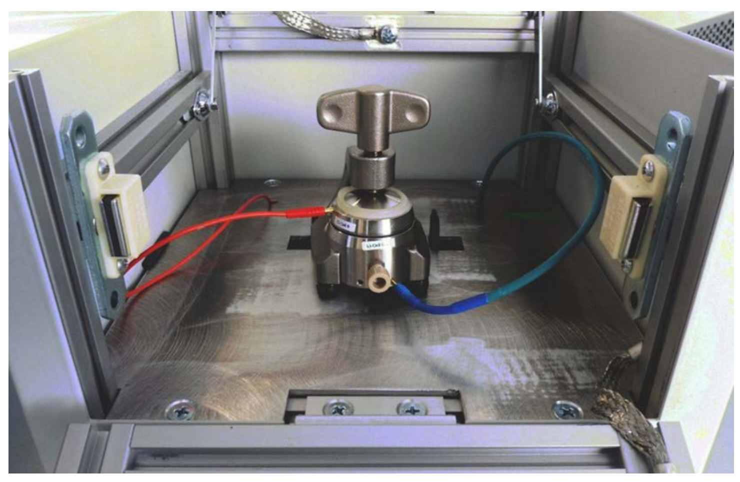
Impedance
- Symmetrical measurement with gold or graphite contacts
- Potentiostatic or galvanostatic EIS between -40 °C and 140 °C
- Equivalent circuit fitting with different tools
- Biologic and Gamry potentiostates - Frequency: 10^{-1} - 10^{6} Hz

DC-ionic conductivity
- Measurement with two lithium electrodes
- Impressing of voltage steps to sample (e.g. -5 to 5 V)
- Accurate measurement of current
- Calculation of conductivity from resistance and sample geometry

Hebb Wagner method
- Solid electrolyte sample contacted with gold and lithium
- Highly sensitive current measurement in faraday cage
- Detection of non-ionic currents and processes
- Calculation method similar to DC ionic conductivity

Pic 7: Climate chamber for temperature dependent impedance measurement.

Pic 8: Keithley high precision electrometer with faraday cage and El-Cell.



Pic 9: El-Cell in faraday cage; detection of currents below nA possible.

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