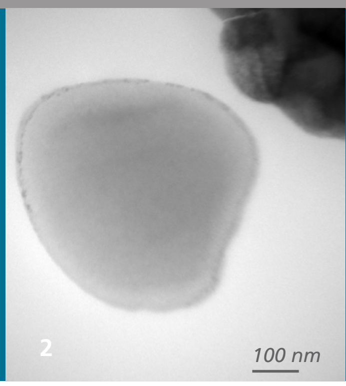
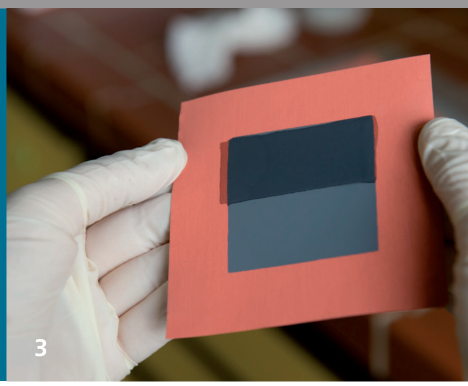
Fraunhofer ISC

FRAUNHOFER INSTITUTE FOR SILICATE RESEARCH ISC





1 *Cathode material $LiCoPO_4$*
2 *SEM picture of a core-shell particle coated with metal oxide*
3 *Electrode partially coated with hybrid polymer electrolyte*
4 *Screening of glass ceramics*

NEW MATERIALS FOR FUTURE BATTERIES

For the realization of pure-electric vehicles (EV, PEV) and stationary applications like the storage of electricity from solar and wind power, a much improved lithium-ion battery needs to be developed. For this purpose, research at the Fraunhofer ISC focuses on new materials which show high energy and power density, a longer cycle life and which are, at the same time, very safe. In an interdisciplinary team new cell components are designed which are adjusted to each other and tested directly in different cell types.

The electrolyte

A great optimization potential, especially with regard to safety, lies in the electrolyte. Properties like high conductivity, low flammability, high mechanical stability, and yet at the same time good compatibility with and processability on the electrode, call for an »all around talent«.

The Fraunhofer ISC believes that the development of hybrid polymer electrolytes can be a way of tackling these partly conflicting requirements.

On the basis of organic-inorganic hybrid polymers, which, compared to other solid polymers, show a high intrinsic conductivity (up to 10^{-4} S/cm and 10^{-3} S/cm as gels), different composites have been developed. For example, adding functional silica or ceramic particles increases the mechanical strength of the electrolyte. Similary, materials can be obtained, which are much less flammable and show significantly higher thermal stability than the liquid plasticizers used as standard electrolytes in commercial batteries. Furthermore by using these hybrid materials the separator can be omitted and the overall resistance can be reduced.

By changing the condensable monomer of the hybrid polymers, the electrolyte can

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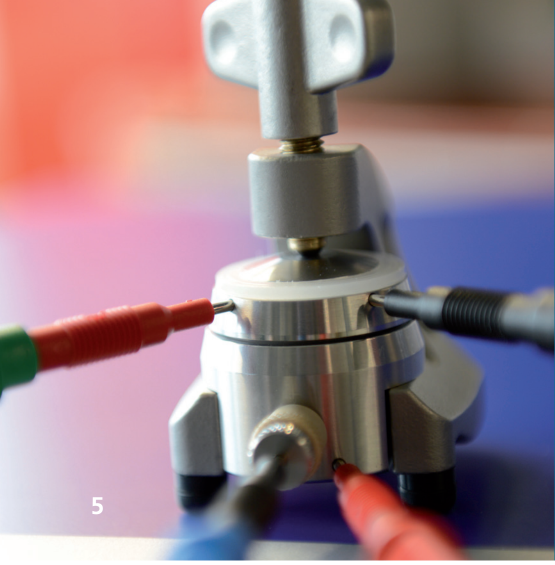

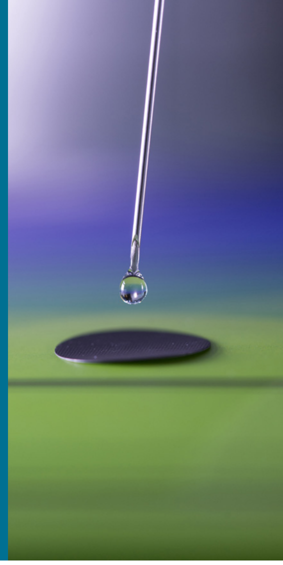

be chemically modified and taillored to its application and specific properties, e.g:

- High conductivity up to 10^{-3} S/cm (gel formulation)
- High mechanical stability (for lithium-metal applications)
- High transparency (application in electrochromic devices)
- High safety (mobile applications)

Besides polymer based electrolytes, the material development of the Center for Applied Electrochemistry focuses on the development of lithium-ion conducting glass ceramics. These materials show very high lithium-ion conductivity, high electrochemical stability and are not flammable. The Fraunhofer ISC has many years of experience in the development of glass ceramics and thus is a competent partner for the development of inorganic solid electrolytes for lithium-ion batteries and alternative battery concepts. Using a fully automized glass screening robot, it is possible to screen and characterize up to six materials a day.

To fulfill the requirements of the whole cell chemistry, newly developed materials are tested in close cooperation with the electrode development. The electrochemical cells are designed and analyzed according to customer specification.

Electrode materials

For the realization of higher energy and power densities for the next generation of lithium-ion batteries, the Fraunhofer ISC follows different technology approaches. New high voltage active materials like Si/C-composites for anode and olivine-structures such as $LiCoPO_4$ or doped lithium-metal phosphate for cathode materials are synthesized and characterized electrochemically. Furthermore, commercially available high power materials like $Li(Mn_xNi_yCo_z)O_2$ are modified by functional coatings with hybrid polymer materials, metal oxides or fluorides to obtain core-shell structures. These show enhanced stability against the electrolyte (high cycling stability) and improved electrical or ionic conductivity. Another research focus is the development of new electrodes for lithium-ion capacitor energy storage systems with fine tuned energy and power densities. By the combination of the powerful double layer capacitor materials with battery materials, which can reach very high energy densities by the intercalation of lithium-ions, new energy storage systems with an improved power density can be obtained.

Our competencies

- Development of adjusted electrolyte and electrode materials
- Building cells according to customer specification (lab cells up to 2.5 cm², pouchbag cells)
- Cyclization under extreme environmental conditions (-20 °C to +80 °C, 0-100% relative humidity)
- Cyclic voltammetry and electrochemical impedance spectroscopy (-20 °C to +120 °C)
- 3D-laser scanning microscopy (LSM) for optical analysis of the electrode surface.
- Scanning electrochemical microscopy (SECM)

In close cooperation with the Center for Applied Analytics ZAA the Fraunhofer ISC can offer further comprehensive characterization of the developed materials, e.g. by

- Electron microscopy: (Cryo-) SEM, four-point-analysis
- Spectroscopy methods (NMR, FT-IR, Raman, XPS)
- X-ray diffraction
- Thermogravimetric analysis with online-mass and IR-spectroscopy as well as differential scanning calorimetry (DSC)

5 Commercially available 3-electrode-cell for electrochemical testing of materials

6 Electrolyte coating on electrode material

7 Production of anode and cathode foils by screen printing