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FRAUNHOFER INSTITUTE FOR SILICATE RESEARCH ISC


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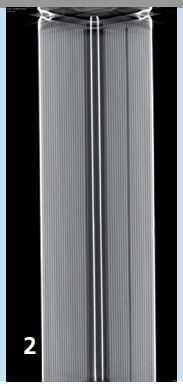
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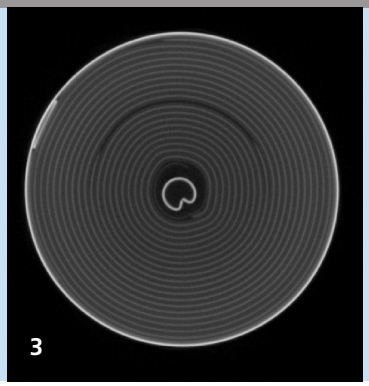
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1 - 3 *Opening a cell in an inert gas atmosphere and CT image of a standard lithium-ion battery*

AGEING AND POST-MORTEM ANALYSIS

In order to develop new lithium-based batteries with higher storage densities, which at the same time guarantee outstanding reliability and safety, it is essential to improve our understanding of aging processes and the mechanisms that cause aging effects. Fraunhofer ISC offers a full range of relevant services.

The Institute can manufacture laboratory-scale cells to customer requirements for the testing of various cell components. Alternatively, tests can be carried out on existing cells. The cells undergo cycle testing on the basis of industry-standard test scenarios. If necessary, the test procedures can be adapted to the customer's specific needs. Accelerated aging tests are an efficient and reliable means of studying degradation mechanisms. These tests are conducted under extreme environmental conditions and thus provide additional information on the robustness of the cell technology in question.

Nondestructive methods such as computed tomography (CT) can be used to detect manufacturing defects as well as short circuits due to particle agglomeration and winding defects. Aging effects such as delamination and contacting problems are also detected.

Impedance analysis allows the cell to be examined from an »electrochemical point of view«. More detailed information on the cell can be obtained using a wide variety of physical and chemical methods after it has been opened in an inert gas atmosphere.

Such methods permit the locally resolved detection of changes in the material. An ion beam is used to expose successive layers of the electrode, which are then analyzed using XPS or EDX. Changes in the crystalline structure can be revealed by means of X-ray diffraction analysis, and microscopic mechanical defects can be detected by scanning electron microscopy.

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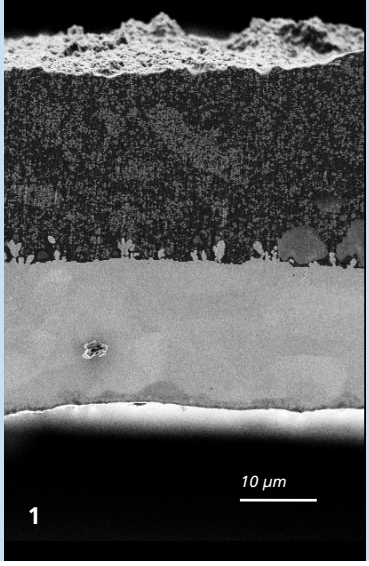

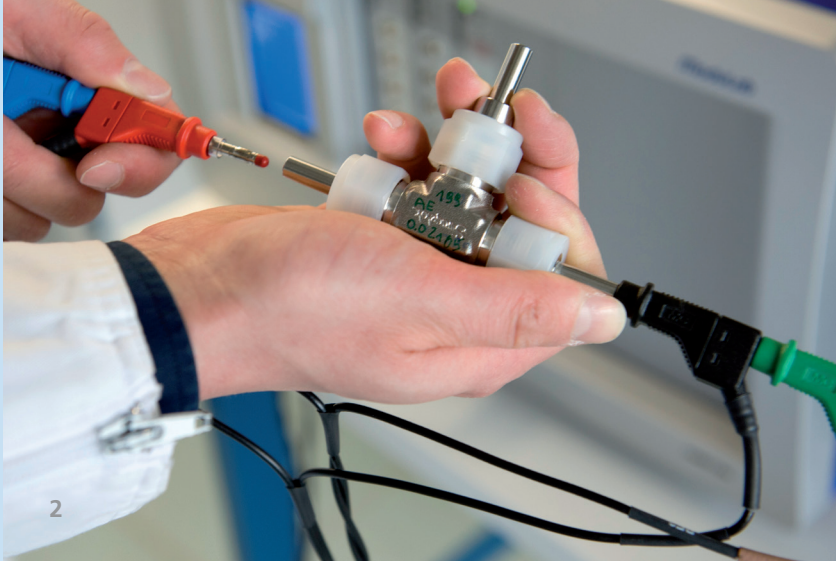

The presence of degradation products inside the cell can be determined using various chemical analysis methods (e. g. ICP-OES).

The resulting information helps to determine material-specific aging mechanisms and the aging effects of different environmental factors. On request, we can develop suitable coatings based on this information and adapt processes so as to reduce degradation in the next generation of cells.

Our Services

- Assembly of test cell (pouch bag, laboratory-scale cell up to 2.5 cm^2 from discrete components
- Accelerated aging tests (maximum capacity 5 Ah)
- Cycling tests under extreme environmental conditions (-20 °C to + 80 °C, 100 % relative humidity)
- Nondestructive analysis by means of impedance spectroscopy and computed tomography; detection of defects (delamination, internal short circuits, cracks, variations in density)
- Opening of cells in an inert gas atmosphere and subsequent characterization
- Comparative measurements before and after cell aging
- Preparation of samples for artifact-free characterization

Our fully equipped laboratories can provide almost every analysis method required for a comprehensive characterization.

The chemical analysis methods include:

- ICP-OES for quantitative analysis of the distribution of lithium in the system
- Scanning electrochemical microscopy (SECM)
- Thermogravimetric analysis with online mass spectrometer and infrared spectrometer (TGA-FTIR-MS)
- Differential scanning calorimetry (DSC)

Selection of physical analysis methods

- Electron microscopy: (cryo-)SEM, TEM, 4-point analysis
- Depth profiling (TOF-SIMS, FIB/EDX)
- (Stereo) microscopy
- 3-D laser scanning microscopy
- Spectroscopic methods (XPS, µ-Raman, IR)
- X-ray diffraction (XRD)
- Computed tomography (CT)

The results are documented in the most commonly used file formats, enabling them to be imported directly to your presentations and reports. Computed tomography images, for example, can be supplied in TIFF or JPG format. Our unique setup – offering applied electrochemistry research facilities and a certified analysis laboratory under the same roof – gives you rapid access to a complete range of top-quality scientific services dealing with aging processes and cell defects.

In addition to its many years of experience, Fraunhofer ISC can provide access to a multitude of more specialized services through its membership in professional networks and its many contacts inside and outside the Fraunhofer Gesellschaft. These include cell safety testing and tests to ascertain the structural durability and reliability of battery systems for use in applications subject to strict quality requirements.

1 CSP image of a coated anode

2 A laboratory-scale cell connected to a potentiostat for electrochemical characterization