Fraunhofer BATTERY

Fraunhofer Battery Alliance

Soild-state ion conductor (© Fraunhofer IWM)

Simulation and modeling

The 26 member institutes of the Fraunhofer Battery Alliance develop technical and conceptual solutions along the entire value chain of electrochemical energy storage systems up to the application level on behalf of customers or in publicly funded projects together with industry. Our expertise and many years of experience range from materials development to system integration of mobile and stationary storage systems.

Competences and field of work

Computer-aided simulations allow cost-effective, reproducible investigations at different levels of detail and thus accelerate the development of battery storage systems. Simulation activities range from quantum chemical methods for material characterization and physical continuum models for cell design up to realtime-capable battery models for integration into battery management systems or battery simulations in hardware-in-the-loop (HIL) systems.

Quantum chemical methods provide insights into the mode of operation of materials that cannot be obtained experimentally. This information deepens the understanding of properties of new materials and processes, for example those arising during the charging and discharging of a battery system. Macroscopic parameters, which define the efficiency of materials, can be determined using modern multi-scale processes. In addition, numerical simulation on the nano-scale offers the possibility to improve qualitative understanding of the basic processes involved.

At the cell level, geometric factors play an important role in battery behavior in addition to material properties. Based on the physical processes of ion, charge and heat transportation, models have been developed to enable one- and three-dimensional predictive simulations of battery cells. The influence of the electrode microstructure (for example particle size and topology), and the influence of the macroscopic cell layout can also be investigated using a simulation model. Detailed local information about the conditions inside the virtual cell furthermore improve understanding of specific cell properties.

Numerical simulations provide an essential contribution in predicting the failure of cells, for example, short circuit under crash load and its consequences. In addition to compression and bending tests on cells, extreme scenarios such as perforation

can be analyzed, and the cell structure or protective casing can be optimized. For these simulations it is particularly important to use material models suitable for describing the behavior of the materials under high dynamic loads. Specialized material characterization provides the basic data required for simulation models. An important component here is the close coupling with experimental tests for the generation of suitable failure and hazard criteria.

Target-oriented and efficient simulation models are essential for the design of the entire battery system. Based on the experimental analysis of battery cells or detailed computer models, simulation models are available that accurately and quickly describe the electrical and thermal operating behavior or the aging of cells, so that they provide a basis for the design of battery systems. This enables better analysis and an application-oriented dimensioning of the energy storage cooling and battery management systems. Real-time simulations even enable the use of virtual batteries in HIL systems. In order to configure the models for electrical and thermal behavior, a highly flexible experimental testing infrastructure is available with modular power electronics, highly accurate measurement systems and a wide temperature range on both the cell and the system level.

Please feel free to contact us – with many years of experience and expertise, we will collaborate with you to develop customized solutions tailored to your needs.

Contact

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Our offer

- Physical model development from the quantum mechanical level to the whole battery
- Analysis of the influence of nanostructures on material parameters
- Virtual cell design
- Generation of detailed and analogous models for strength analysis or crash simulation with failure modeling
- Optimization of cell structures regarding operational and crash safety
- Analysis and application-oriented dimensioning of energy storage systems, including optimal energy management
- Development of a battery management system for monitoring state of charge (SOC), aging (SOH), interior cell temperature and for diagnosis of storage modules
- Integration of real-time capable battery simulations as virtual batteries in HiL systems
- Measurement of optimal interconnection of single cells in modules and design and operation strategy of balancing setups
- Testing and evaluation of on-board-systems, battery management systems or holistic systems such as electric vehicles with virtual batteries

Products

- **BEST – Battery and Electrochemistry Simulation Tool** is used for cell design and performance analysis on the microscopic (material) and on the macroscopic (cell) scale and is based on a continuum description of battery transportation processes.
  → www.itwm.fraunhofer.de/best
- **BaSiS – Battery Simulation Studio** dynamically simulates all relevant electrochemical processes in Li-ion and lead-acid cells and batteries under various operating conditions (U, I, T, SOC, SOH) and their aging. Through an interface with Simulink®, the software has been successfully deployed in the automotive industry. A real-time variant for hardware-in-the-loop test systems is available.
  → www.iee.fraunhofer.de/basis
- **foxBMS – The Most Advanced Open Source BMS Platform** is a flexible research and development environment of battery management systems and aims to control modern as well as complex electrical energy storage systems and lithium-ion battery packs. foxBMS is suitable and adaptable for current and future rechargeable energy storage systems. → https://foxbms.org/