Fraunhofer EMI

Fraunhofer Institute for High-Speed Dynamics,
Ernst Mach Institute, EMI

Ensuring the safety of new battery systems

Comprehensive expertise for the safe integration of batteries

In-depth and innovative battery research under one roof

For over ten years Fraunhofer EMI has specialized in making battery systems safer. By the **interaction between experiment and simulation**, your battery system can be efficiently understood, optimized and further developed.

Benefit from many advantages:

In-depth experience
Over 10 years of battery safety research for major manufacturers. Main focus on battery abuse testing of lithium-ion batteries.

Highly instrumented testing
Battery misuse tests tailored precisely to the question for maximum significance.

For complete electric car batteries
Test facility for large lithium-ion batteries under abuse conditions. Experimental bunker up to 50 kWh.

Research and development
The institute not only tests, but also supports product development for future standards. A comprehensive research network can be activated.

Validated simulation models
Based on a comprehensive understanding of the system, simulation models are developed for different load cases.

Security and confidentiality
Employees are used to dealing with sensitive projects and receive regular training.

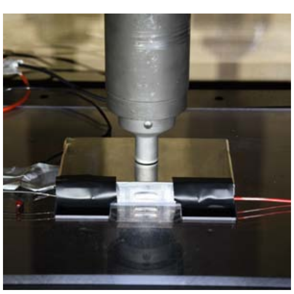
Comprehensive research approach
A team of experts has been assembled from various disciplines to ensure comprehensive research.

Everything in one institute
From the bunker to the test laboratory to CT, high-speed X-ray and simulation.

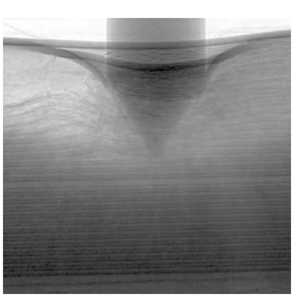
In focus: comprehensive tests for detailed system understanding

Fraunhofer EMI offers analysis, evaluation and optimization of safety at the level of cells, modules and overall systems. A research facility was built specifically for electric cars. This allows entire vehicle batteries to be tested under abuse conditions.

The battery testing center works for numerous leading companies and brands.



Mechanical cell characterization
Testing of all common designs (prismatic, cylindrical, pouch) against intrusion with different punch geometries. The critical forces and intrusion depths that lead to an internal short circuit are determined through a series of tests. In addition, testing can also be carried out at high test speeds with precisely limited intrusion depths, even on charged cells.



In-situ X-ray video
Using in-house developed high-speed X-ray technology, the cell's internal dynamics can be recorded during thermal runaway. These processes have so far remained hidden. X-ray technology now allows manufacturers to develop cells and batteries with greater safety.

Test chamber for destructive battery tests Extensive measurement technology enables a detailed analysis of the battery behavior during thermal runaway: e.g. determination of the chamber pressure, the temperature on the cell and the gas volume during degassing.

Propagation testing
The institute carries out propagation tests on battery modules and systems in a fire- and explosion-proof bunker. For example, in new housing concepts, the resistance to internal battery fire and the effectiveness of propagation-inhibiting measures can be assessed.

Crash tests of modules and HV storage systems
The institute has a battery crash accelerator to assess the crash safety of charged modules and HV storage devices. In conjunction with simulations, battery systems can be comprehensively described and researched.

Simulation and virtual prototypes

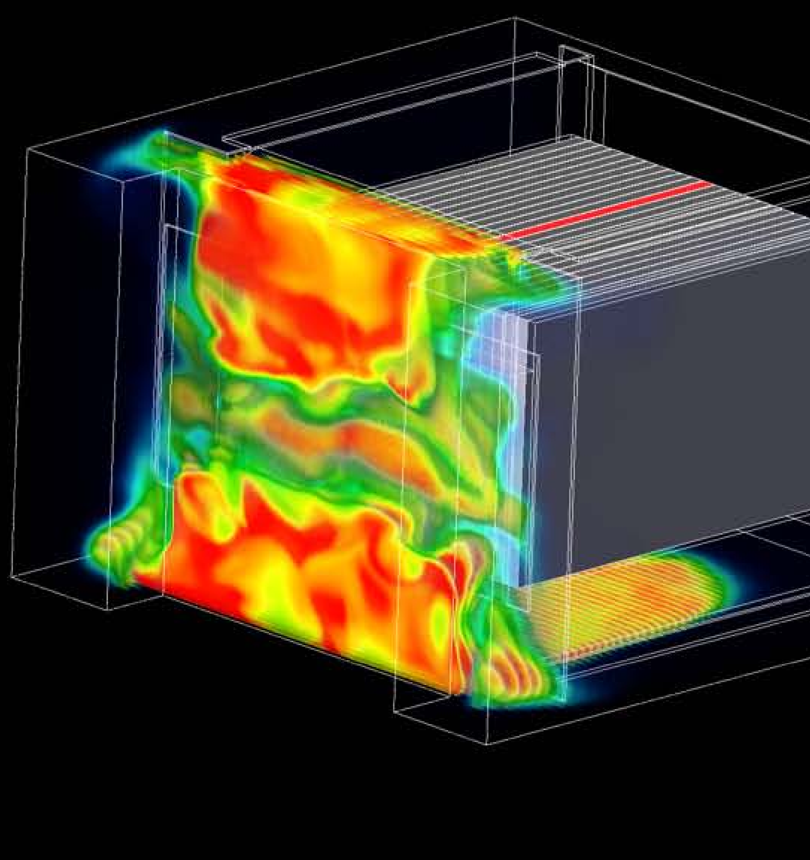
Simulation methods enable detailed insights into the deformation behavior of batteries and the phenomenology of thermal runaway.

Efficient way to a safe battery system
In close conjunction with tests in the battery test center, realistic simulation models are created that optimize battery systems more efficiently and cost-effectively than pure experiments.

Assessment of mechanical deformations
Detailed structural mechanical models realistically depict mechanical deformations of batteries that occur in crashes. This includes individual cells, battery modules and housings.

Flow simulations for thermal runaway
Flow simulations enable the simulation of gas propagation and chemical reactions during thermal runaway. The basis for this is careful testing and knowledge of the existing cell chemistry. Sound modeling of thermal runaway also requires the consideration of the released particles, since they transport a significant proportion of the heat.

Effects of thermal runaway
To prevent the spread of thermal runaway, it is important that adjacent components maintain their structural integrity. A comprehensive safety assessment therefore requires not only the simulation of the fire, but also sound modeling of the thermomechanical material behavior of the surrounding structures.



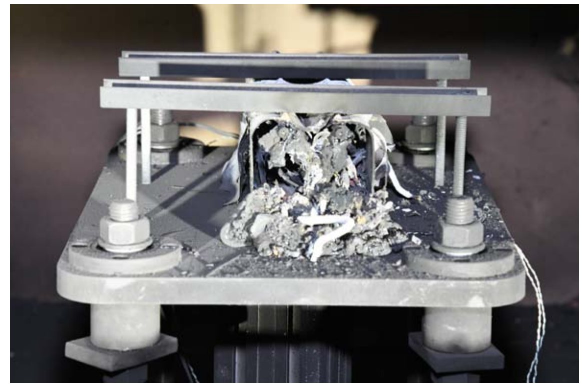
Exemplary flow simulation of the venting of a battery cell in the module
Geometry kindly provided by RCT Power GmbH.

Case study: Safety of a battery housing against thermal runaway

Protection strategies to prevent the spread of thermal runaway to other cells are based on a nested integration of the batteries.

The individual cells are installed in modules, which again are surrounded by a housing. So far, corresponding protection concepts have been tested through complex experiments on prototypes at module and system level.

A possible alternative is a simulation-based approach in which the heat transport in the housing is predicted using a validated model. In this way, critical points are identified early in development and appropriate protective measures can be implemented.



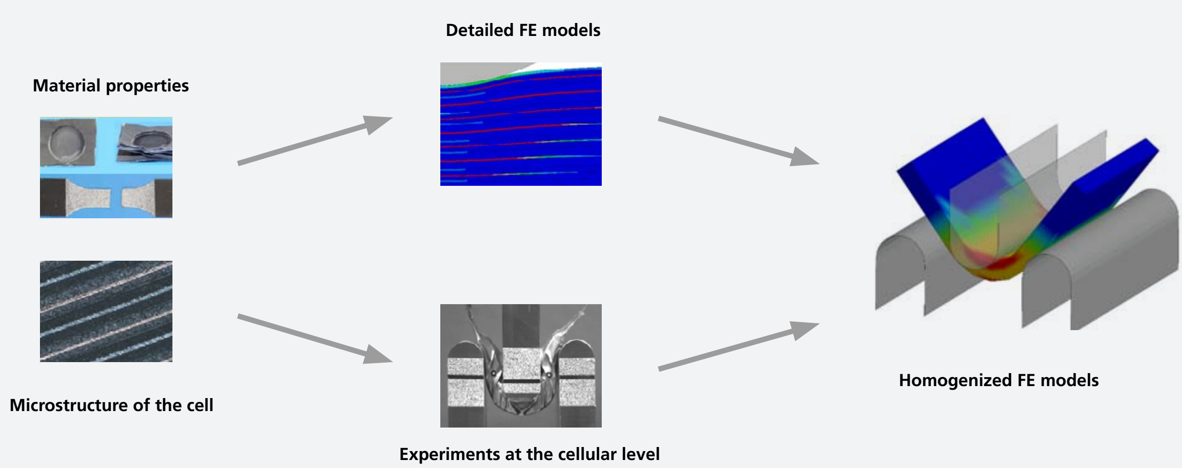
Burnt battery of an e-bike
As part of a propagation test, the thermal runaway of the cells was specifically provoked.

Accurate mechanical simulation models

Full vehicle simulations are an essential component for evaluating the crash safety of vehicles. A key challenge with electric cars is that each individual cell is responsible for vehicle safety.

Failure of each separator layer can cause an internal short circuit and thus thermal runaway. The diagram shows how Fraunhofer EMI develops these mechanical simulation models.

Diagram: Development of mechanical cell models to investigate crash safety.
Procedure from the BATTmobil project, collaboration between Fraunhofer EMI and Fraunhofer IWM.
Sponsored by the Baden-Württemberg Ministry of Economic Affairs



Secure system integration

The safe integration of batteries is crucial for the development of battery-powered vehicles, aircraft, and energy storage. This requires safe enclosures, efficient cooling systems, and intelligent control software.

Fraunhofer EMI offers its expertise in six application fields as shown on the right.

Automotive

Crash safety of electric vehicles, designing batteries against thermal runaway

Aviation

Risk of personal electronic devices in the aircraft cabin,
drone impact on aircraft structures

Stationary storage

Security concepts for home storage, effectiveness of fire protection measures

Defense

Safe use of lithium-ion batteries, military technical loads (e.g. shelling)

E-bike, e-scooter

Battery fire investigation

Special applications

Transfer of existing know-how to any application and installation situation

Infrastructure

Fraunhofer EMI has a comprehensive infrastructure for characterizing the safety-relevant behavior of lithium-ion batteries. The test facilities allow tests to be carried out safely, even on fully charged test items.

Battery crash system
Impact tests at up to 22 m/s with forces up to 1 MN, shock tests up to 100 g acceleration.

Quasi-static mechanical cell test bench
High-precision testing from 10 µm/s to 10 mm/s, event-dependent interactive test sequences.

Dynamic mechanical cell test bench
Crush and intrusion tests up to 5 m/s to determine load rate-dependent failure limits.

In-situ X-ray technology
Radiography and CT with the highest time resolution to image cell-internal failure processes.

Cell and module cycler
For preparing the test item under defined environmental conditions, charging current up to 1000 A.

Gas analysis
Diagnostics for time-resolved concentration measurement of released gases during the experimental procedure.

High-speed measurement technology
Recording of relevant measured variables such as voltages, temperatures, pressures, forces.
Video and infrared video.

This is how you can cooperate with us:

Research and development mandate

The classic cooperation: orders for the characterization of individual cells or entire batteries including an analysis of the test results, development and adaptation of simulation models for specific applications and load cases.

Strategic partnerships

Long-term collaboration to develop new technologies. The development of test procedures and simulation methods as well as support in the integration of new types of materials are possible.

Joint publicly funded projects

For a joint project idea, we will apply for public research funding with you. The projects are usually designed to last three years.

Promotions

A doctoral student conducts research at Fraunhofer EMI on a topic related to your company.

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Fraunhofer Institute for High-Speed Dynamics, Ernst Mach Institute, EMI

Fraunhofer EMI is a world-leading research institute in high-speed dynamics.

The institute conducts research on fast processes through experiments and simulations, with a focus on enhancing safety and resilience.

Specifically, the research focuses on processes which occur within fractions of a second, such as car crash, battery explosion, or collision in space. Based on the observations, enhanced safety concepts are developed

Fields of research include safe mobility, battery safety, building protection, aircraft safety, satellite development, research for the German Armed Forces, safety in urban systems, and resilience of infrastructure networks.

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