Fraunhofer
BATTERY

Fraunhofer Battery Alliance

Research for next-generation batteries

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Vacuum intensive mixer. ©Fraunhofer IFAM

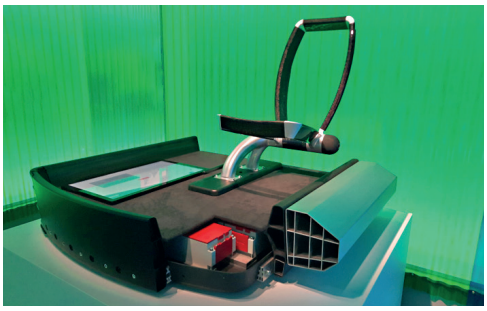
Research for next-generation batteries

The member institutes of the Fraunhofer Battery Alliance develop technical and conceptual solutions along the entire value chain of electrochemical energy storage systems, from materials development to system integration of mobile and stationary storage systems, either on behalf of customers or in public funded projects with industry.

Batteries are a central element for the energy transition and contribute significantly to the defossilization of the energy supply. High-performance batteries are key components in mobile and stationary electrically-powered applications and thus enable security of supply infrastructures in the future, for example in the areas of transportation and logistics, energy grids, self-sufficient industry, private households, communications and health care.

Especially in high energy and power ranges, the durability and reliability of a system must be high, placing significant technical demands on the batteries. Electrical energy storage devices in vehicles must meet a particularly wide range of (sometimes contradictory) requirements, e.g. in terms of cost, energy and power density, cycle stability, temperature range, cycle and calendar life, and safety.

Battery cell formats. ©Fraunhofer ISI, Christoph Neef



Exploded view of the SafEBat battery design with load-dependent heating of cell and module. ©Fraunhofer IWU

Through research in the field of electrochemical energy storage, the Fraunhofer Battery Alliance develops suitable technologies and conceptual solutions to application level. This requires a holistic approach to batteries and optimization along the entire value chain of battery technology. The 26 member institutes of the Fraunhofer Battery Alliance cover the steps and processes along the circular value chain almost completely with specialist knowledge and many years of expertise.

Materials and cells

The member institutes develop, optimize, and characterize customer-specific materials and components for batteries. The work includes the synthesis, development, modification and structuring of materials and components, the development of electrodes, separators and electrolytes as well as their optimization and characterization. Research and development work aims to increase tolerance to external influences and improve the storage properties and intrinsic safety. The focus is on lithium-based cell chemistries such as lithium-ion systems including lithium-sulfur and solid-state batteries. In addition, redox-flow batteries, sodium-based batteries, metal-air batteries and double-layer capacitors are also considered.

Cell production

Our institutes operate special pilot plants for transferring the results obtained in the laboratory to industrial scale. In these facilities, all stages of the production of electrochemical cells can be carried out, especially with regard on sustainable, resource-saving, and cost-effective electrode production. The focus is on the production of electrode suspensions as well as efficient coating and drying of the electrodes at high productivity. Laser processes are highly relevant for cutting electrodes and welding electrode stacks. The systematically developed processes are optimized and upscaled on the production lines and the downstream assembly lines. For good quality management, automation and digitization are taken into account in cell production, and the individual process steps are mapped as a digital twin.

System and integration

Within the Fraunhofer Battery Alliance, single cells based on different technologies are developed for use in customized battery modules and complete battery systems for various applications. The work includes the simulation-based design of the mechanical construction and the cooling system, bonding technologies, safety concepts, the development of battery management systems and the corresponding algorithms for measuring charge and aging, as well as optimized charging and operation management strategies. In addition to the optimization of housing and mounting, innovative integrated sensors can enable the monitoring of operating parameters and are relevant for system reliability, operational stability and safety of the batteries. The interfaces of the modular battery systems are configured to facilitate system integration in terms of both performance and communication.

Simulation

The properties of batteries from the atomic scale to their behavior in a power chain are investigated by the Fraunhofer Battery Alliance using cutting-edge simulation tools. Simulation activities range from quantum chemical methods for material characterrization and physical continuum models for cell design through to realtime-capable battery models for integration into battery management systems, test stands or battery simulations in hardware-in-the-loop (HIL) systems. The member institutes are also involved in the generation of detailed and analogous models for strength analysis as well as the optimization of cell structures with regard to operational and crash safety. The analysis and application-oriented dimensioning of the energy storage system including the energy management system and the determination of optimal circuit variants of individual cells, the development of the battery management system for monitoring the battery status and for the diagnosis of storage modules are also integral parts of the work of the member institutes.

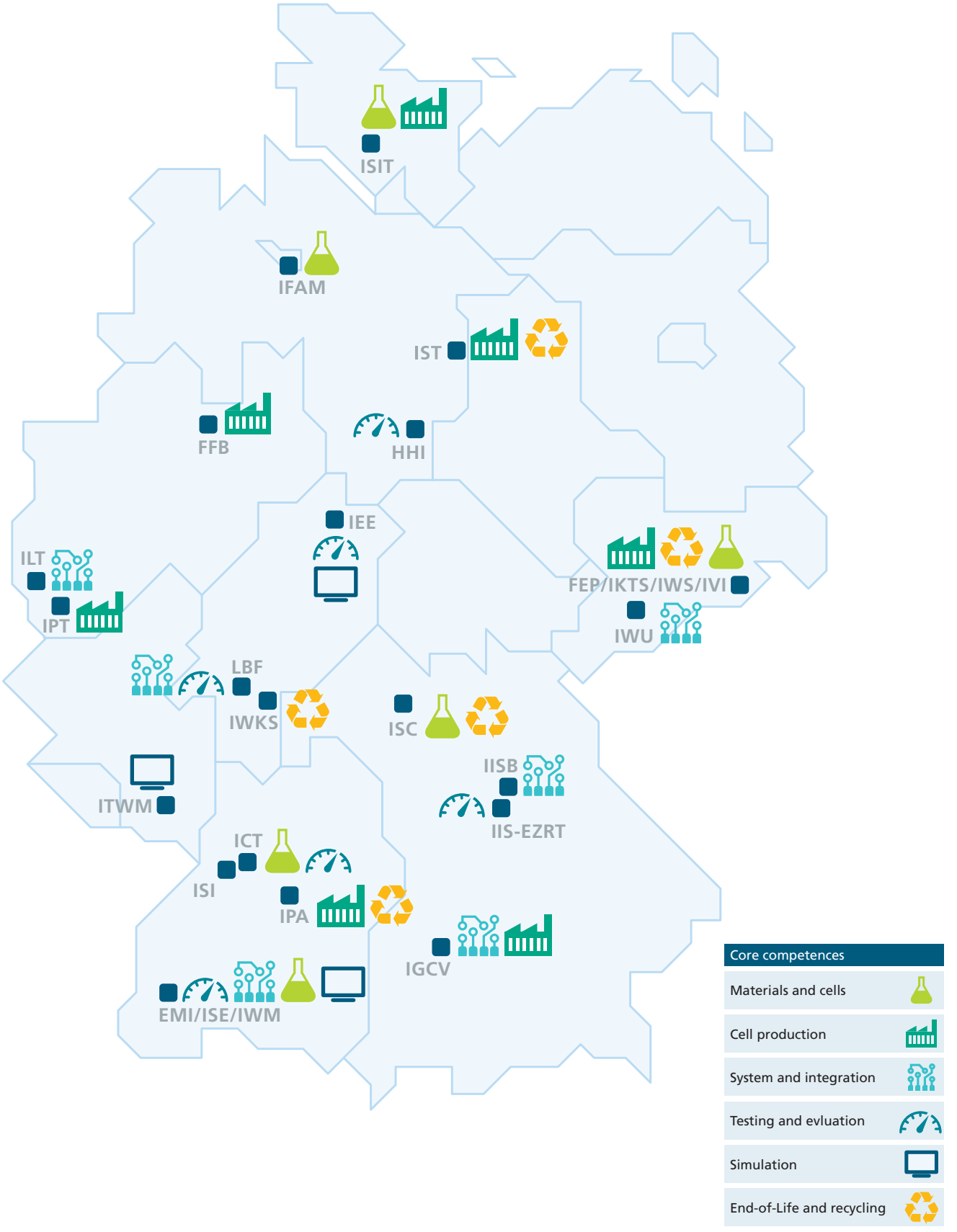
Testing and evaluation

The testing and evaluation of energy storage devices is an important step in the development chain for automotive applications. Batteries are tested in electrical, thermal, and mechanical tests according to common norms and standards as well as in customer-specific tests. This includes material characterization, performance tests, analysis, and evaluation of service life under various environmental conditions, determination of operational stability and system reliability in operation, and testing of battery behavior under accident conditions. For this purpose, the member institutes have various test facilities for safety tests with time-resolved analysis of released substances, for crash research and material characterization as well as for stress and load tests. Depending on the requirements, the tests are carried out at cell, module, or system level.

End-of-Life and battery recycling

The member institutes have many years of experience in evaluating product and process technologies along the entire value chain of battery technology, from raw materials extraction to the product and recycling. In the development of new battery technologies and optimization of existing systems, the limited use of critical raw materials, dismantling- and recycling-friendly design, as well as intelligent, resource-saving, and efficient recycling are crucial. In addition, the institutes of the Fraunhofer Battery Alliance are involved in the development of life cycle analyses, the determination of remaining useful life and second life models, as well as the demonstration of reconditioning processes for batteries under market conditions.

Member institutes of the Fraunhofer Battery Alliance



26 Member Institutes

The Fraunhofer Battery Alliance combines the expertise and many years of experience of the 26 member institutes with around 700 employees in the field of battery technology.

Fraunhofer EMI | Investigation of strain-rate-dependent effects under mechanical abuse up to module level, and crash modeling of cells and modules.

Fraunhofer FEP | Development of through-put-optimized vacuum thin film technologies in a roll-to-roll modus for current collectors, cathodes, anodes, electrolytes and separators.

Fraunhofer FFB | Large-scale production infrastructure for industry and for research to promote and accelerate innovations for economical and ecological battery cell production and for transfer to market maturity.

Fraunhofer HHI | Development of new safety concepts for batteries based on photonic sensor technology with the objective of cost-effective production and integration in lithium-ion batteries for a wide variety of applications.

Fraunhofer ICT | Safety and ageing tests up to module level, gas analysis and other special (operando) analysis methods at cell and system level, development of new batteries such as solid-state, redox flow and Na batteries as well as research and test data management.

Fraunhofer IEE | Physical-electrochemical simulation of batteries for stationary and automotive applications, identification of parameters for arbitrary battery simulation models, development and testing of battery HiL systems, aging simulations for batteries.

Fraunhofer IFAM | Material and process development for future battery technologies such as nanostructured electrodes for lithium-ion batteries, composites for all-solid-state batteries and metal air batteries.

Fraunhofer IGCV | Materials and process research for conventional lithium-ion and solid-state batteries, as well as development and testing of cell, module and storage systems in the target format.

Fraunhofer IIS-EZRT | Non-destructive monitoring based on X-ray technology, optics and magnetic resonance methods as well as unique testing equipment for the development and production of energy storage systems.

Fraunhofer IISB | Development of battery systems with a battery management system (foxBMS® is used as a free, open and flexible development environment) and integrated power electronics for mobile and stationary applications.

Fraunhofer IKTS | Battery development based on ceramic materials and processes with an emphasis on lithium and sodium systems, conventional cell concepts and solid-state approaches.

Fraunhofer ILT | Laser-based production technology from cell up to pack level, such as drying and functionalization of layers, structuring, manufacturing and connection of electrodes, bonding technology for module production and the investigation of thin-film or solid-state batteries.

Fraunhofer IPA | Development of production processes and technologies for the manufacture of design- and format-flexible cylindrical cells batteries, including of Industry 4.0 technologies and automated disassembly.

Fraunhofer IPT | Innovative and sustainable process and machine development for the production of batteries with quality improvement through digitalization measures.

Fraunhofer ISC | Research on sustainable energy storage technologies – material and process development, testing and intelligent recycling of lithium-ion, solid-state and lead-acid batteries.

Fraunhofer ISE | Material development, cell production, module and system development, battery tests according to common standards and quality assurance for energy storage plants.

Fraunhofer ISI | International monitoring of technology and market developments and development of the framework conditions for energy storage devices for electromobility, stationary and (small) mobile applications, as well as national roadmapping for the strategic support of research, industry and politics.

Fraunhofer ISIT | Customer-specific development and manufacture of secondary batteries for special requirements up to system level, based on lithium-ion technology, the development and optimization of manufacturing processes and the development of new secondary batteries such as magnesium sulfur, lithium-sulfur and calcium-ion batteries.

Fraunhofer IST | Development of scalable production processes for next-generation energy storage devices under consideration of the entire product life cycle – from raw materials extraction to recycling.

Fraunhofer ITWM | Development and application of physical models for the simulation of batteries from micrometer scale up to cell scale, with a focus on lithium-ion cells.

Fraunhofer IVI | User-oriented battery characterization, remote monitoring and predictive aging diagnostics, from the cell through to the vehicle fleet for current and future battery technologies.

Fraunhofer IWKS | Focus topics are dismantling, (hydro-)mechanical and hydrometallurgical recycling of the black mass as well as direct recycling, accompanied by comprehensive material analysis, LCA, LCC and process optimization.

Fraunhofer IWM | Simulation of battery materials on atomistic and quantum chemical level, as well as simulation of the crash behavior of battery systems.

Fraunhofer IWS | Material, surface and laser technologies along the process chain for the development of new battery cells, with current focus on lithium-sulfur and solid-state batteries.

Fraunhofer IWU | Development of lightweight construction and thermal management for vehicle batteries and their circular economy.

Fraunhofer LBF | Multiphysical testing of traction batteries for electric vehicles according to mechanical, thermal, and electrical criteria as well as evaluation of system reliability and quantification of insecurity in electromobility.

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Cover photo:
Smart cell battery module with impedance measurement and contactless, capacitively coupled communication interface based on the open source BMS development platform foxBMS®.

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