Battery Show North America | October 9th, 2024

Fraunhofer USA

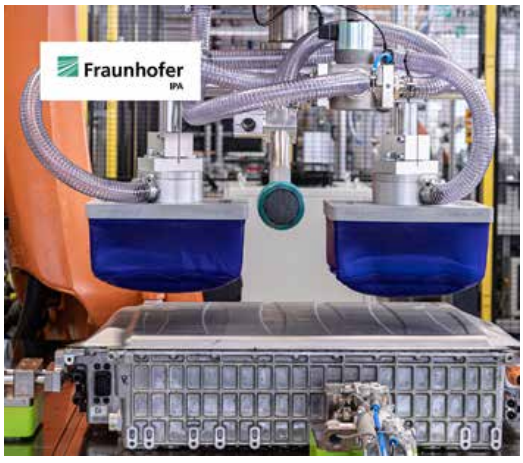
Battery Disassembling, Recycling Processes and Recovering of Critical Raw Materials

Closing the Loop of Battery Life Cycle

Fraunhofer is advancing automated disassembly systems, which are key to enhancing the efficiency and effectiveness of recycling, especially for batteries with different designs and chemistries. Besides political regulations, high scrap rates along the entire value chain make a profound recycling concept indispensable for every stakeholder. Fraunhofer develops tailored processes for the (direct) recycling of lithium-ion and sodium-ion batteries, including the purification and regeneration of recycled battery materials and process water treatment.

Automated Battery Disassembling

Our cutting-edge automated process specializes in the efficient disassembly of traction batteries down to the module and cell level. Its primary focus is on opening battery systems and dismantling internal components. A key objective is to create technology-independent solutions compatible with various battery types. Our robot concepts are characterized by their flexibility, allowing industrial companies to choose customized sub-concepts that address their specific challenges and seamlessly integrate them into their production processes.



© Fraunhofer IPA: Format-flexible gripping with suction pads.

© Fraunhofer IKTS: Holistic recycling solutions on a pilot plant scale for the recovery of battery-grade lithium carbonate (> 99,5 %).

Battery Recycling

We work on holistic, raw material-independent recycling approaches to increase recovery and recycling rates. At the same time, the purity and quality of the recycled products are to be increased. Our recycling strategies include:

- Direct recycling strategies
- Efficient combination of mechanical, chemical or thermal treatment methods according to their intended use and requirements on sustainability.
- Chemical circularity
- Wastewater treatment

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Rapid Prototyping and Cell Characterization in Battery Cell Development

Next Generation Battery Development

In the fast-evolving world of battery technology, achieving a competitive edge requires a streamlined and adaptable approach to development. Our focus is on accelerating battery cell development: From rapid prototyping up to small batch production for various chemistries and cell formats. Emphasizing production-related processing paths, innovative test and analysis methods, data-driven diagnostics and AI for quality and battery health management.

Cell Manufacturing Line

Our production platform is designed to accelerate the validation of innovative battery designs, formats, and chemistries for both research and industry partners. We achieve this through a dedicated cell manufacturing line operating in mini-environments, which provide variable production atmospheres for every process step from mixing to cell assembly.

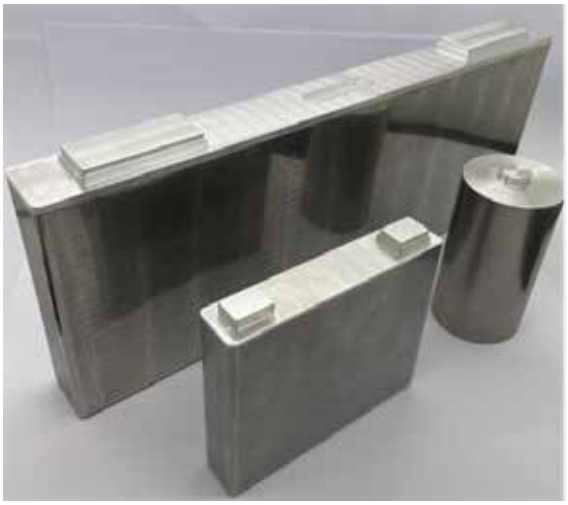

Fig. 1: © Fraunhofer IGCV
Rapid prototyping of battery cell casings of varying size and formats printed with selective laser melting.

Fig. 2: © Fraunhofer IFAM

Additionally, we offer additive manufacturing for customized cell casings (Fig. 1), in-house pack assembly and testing facilities to streamline the entire process.

BATTERIEdigital®

BATTERIEdigital® is a comprehensive digitalization strategy that accelerates and optimizes the development of new battery technologies using artificial intelligence and real-time data analysis.

- Feature-Rich Data Analysis: Extraction and processing of high-quality data, enabling precise, scalable, and automated assessments of battery health and performance.
- AI-Driven Optimization: Reduces development time and enhances performance predictability by providing actionable insights across the entire value chain.
- Faster Development Cycles: Clients experience accelerated timelines for bringing products to market while supporting their sustainability goals.

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Shaping the Future of Dry Battery Electrode Processing

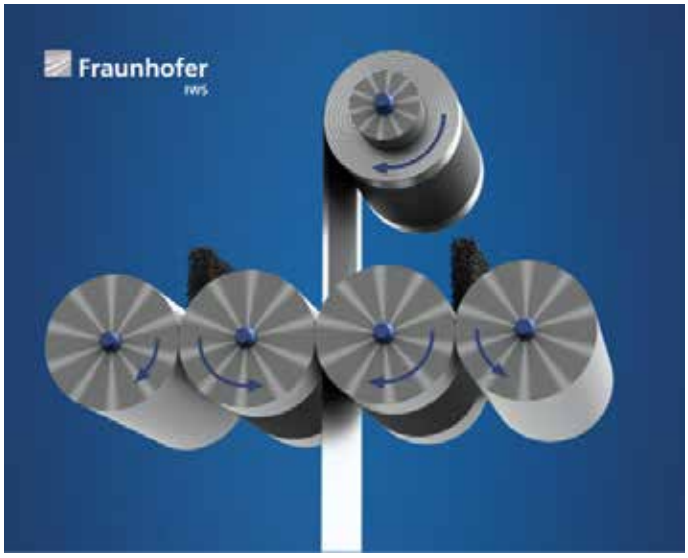
Cutting-Edge Electrode Processing

Traditional solvent-based electrode coating processes are space- and energy-intensive. Fraunhofer's innovative dry coating technologies eliminate the need for solvents, while keeping a high process speed and providing scalability. Dry-coating technologies also support the production of high-loaded / thicker electrodes, enabling new fields of application and resulting all in all in a significant cost saving as well as a reduced environmental impact.

© Fraunhofer ISIT: Brush coating.

DRYtraec®

With more than 10 years of experience in dry coating, Fraunhofer has long-term experts providing R&D along the value chain. The unique dry coating infrastructure at Fraunhofer allows small scale material development as well as fast transfer into roll-to-roll processes on prototype coating lines coupled with dedicated analytics infrastructure. Due to our broad patent portfolio for dry battery electrode (DBE) coating, a collaboration with Fraunhofer IWS assures freedom-to-operate to our clients and opens the door for licensing the technology. As key player in the DBE field, Fraunhofer IWS has access to a strong network and can act as connector between industries and partners.



© Fraunhofer IWS: Process scheme for simultaneous, double-sided coating of battery electrodes with DRYtraec®

- Roller-based dryfilm production
- Broad patent portfolio for process, electrodes and equipment
- Dedicated dry coating lab for R&D along the value chain between TRL-1 and TRL-6
- Up to 10 m/min double sided coating on 200 mm width
- Strong characterization capabilities, including prototype pouch cell testing

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Innovative Laser Processes in Battery Module Packaging, Manufacturing and Application Monitoring

Advancements in battery technology necessitate innovations in module packaging and manufacturing processes to enhance performance and efficiency. Fraunhofer uses highly efficient laser processes for the construction of battery modules or battery packs. New types of materials and the systematic incorporation of test and field data represent significant strides in modern battery module packaging and manufacturing. Moreover, the comprehensive monitoring, collection and evaluation of process as well as application data promotes circularity and facilitates compliance with public regulations such as the Battery Passport requirements.

Laser Processes

To make battery cells competitive in the mass market, significantly reducing production costs is essential, and highly efficient laser processes are key to achieving this. Their applications throughout the value chain include:

- **Thin-film processes**: drying and sintering.
- **Laser cutting and separation** of electrodes.
- **Laser micro welding,** which joins battery cells into modules and packs, ensuring long-term stability and low electrical resistance.

©Fraunhofer ILT: Laser micro welding allows precise and rapid connection of batteries.

Development of Advanced Battery Cases and Validation Methods

Multi-physical and multi-axal eMAST testing surpasses traditional uniaxial methods in assessing pack durability and reliability.
It considers real-world multi-physical loads and associated vibration dynamics experienced during service life. This leads to improved pack characterization, early detection of system-level issues, and a deeper understanding of vibration impacts.

Fleet Monitoring

For the successful operation of hybrid and electric vehicles in freight shipping and public transport, the condition and disposability of the vehicles—particularly the batteries—are critical factors. The IVImon system plays a vital role in this by accurately assessing key state parameters of the battery storage unit. It processes this data and presents it in a user-friendly format, enabling operators to make informed decisions about battery management and vehicle performance.

©Fraunhofer LBF: Multi-physical and multi-axial eMAST testing.

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How Pilot Lines Drive Battery Technology Advancements

From Lab to Large Scale

Scaling processes, from laboratory conditions to industrial standards, is a central challenge of modern production technology. Many innovations or factory ramp-ups fail along the scaling process, as larger-scale effects that were not observed in the laboratory often come into play.

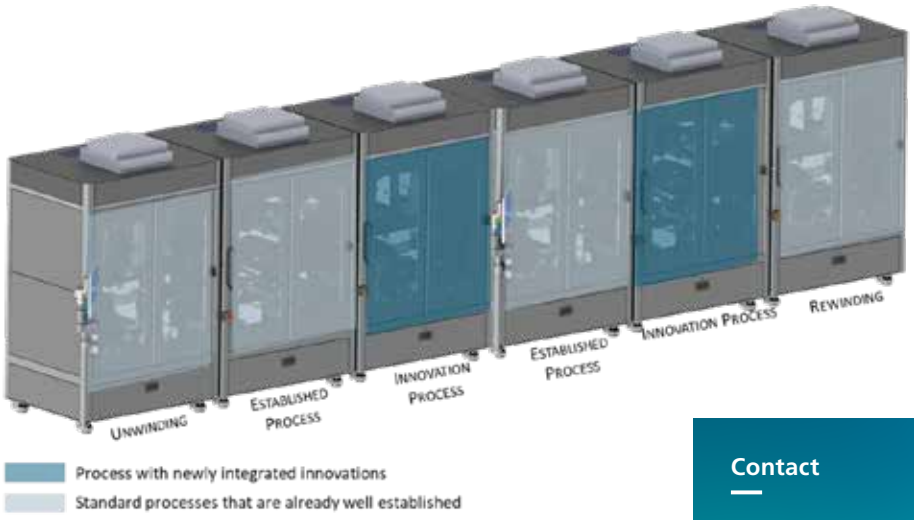
Our approach to battery manufacturing focuses on flexible and modular pilot-line production, enabling companies to test and optimize their technologies, to scale innovations (from lab to fab), ramp-up and validate new cell concepts, or produce cells for niche applications. Furthermore, by integrating automation and digitalization, we enhance efficiency and precision throughout the battery manufacturing process.

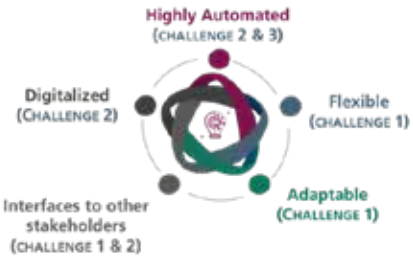
Our Solution

Flexible plug-and-produce small to medium-scale production equipment.

- Enabling Battery Innovations
- Enabling Efficient Production Scaling
- Enabling Serial Production for Small- to Mid-scale applications

We have developed a new modular machine architecture that leverages years of innovative experience across multiple industries. Utilizing a roll-to-roll (R2R) development system, this architecture offers remarkable flexibility. With extensive experience in establishing pilot lines, including those at Fraunhofer FFB, our turnkey capabilities enable us to create specialized machinery for next-generation cell technologies, all built on our advanced architecture.





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