To the Media

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Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

Location: Helmholtzstraße 8
89081 Ulm

Innovative Silicon Anodes Increase Lithium-ion Batteries' Energy Density and Sustainability

FACILE project combines fiber, nonwoven, and semiconductor technologies

A new research project involving four partners based in Baden-Württemberg – one being the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) – aims to advance the state of the art in battery technology. Called FACILE, this project seeks to increase lithium-ion batteries' energy content by developing innovative silicon-based anode materials. To this end, the industry and science consortium intends to combine proven paper and nonwoven production processes with sophisticated industrial coating techniques used in semiconductor and photovoltaic engineering. The goal is to boost the practical energy density on the anode side by up to 250 percent as well as to improve batteries' environmental footprint. The Baden-Württemberg Ministry of Economic Affairs, Labor, and Tourism is funding the project with €1.28 million. Launched on July 1, 2025, it will run for 24 months, concluding on June 30, 2027.

"FACILE shows how industry and science in Baden-Württemberg can jointly cover the entire value chain for lithium-ion batteries, from material development to cell production," says Prof. Dr. Markus Hölzle, member of the board and head of the ZSW in Ulm. "The project goes to develop silicon anodes on flexible nonwoven fabric substrates that compensate for significant volume changes in the material. This will result in powerful, durable, and sustainable batteries – and make important contribution to strengthening the region's competitive stance."

Conventional anodes – that is, lithium-ion cells' negative poles – are made of graphite, which can store lithium at up to 370 milliampere hours per gram. Silicon, in contrast, can theoretically store up to 4,200 milliampere hours per gram – more than ten times as much as graphite. While silicon and graphite costs' are comparable, silicon is abundantly available worldwide and thus more sustainable.

Fibers, not fractures: Reinventing silicon anodes

The Baden-Württemberg-based partners in this project are determined to use silicon to increase the anode's actual energy density by at least 250 percent, thereby achieving no less than 1,000 milliampere hours per gram of practical capacity. The great challenge is that silicon's volume changes markedly during charging and discharging. Unless suitable countermeasures are taken, this soon causes cracks and peeling

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on the anode, which can result in battery failure. This is where FACILE enters the picture. It is the first attempt to develop silicon anodes on fiber-based, electrically conductive nonwoven substrates. Their flexible, fiber-based structure is designed to accommodate the volume changes in silicon. The resulting composite material pairs high performance and long service life with sustainability in an innovation that is truly 'made in Baden-Württemberg.'

Building and validating test cells

The ZSW at Ulm started off by trialing in small test cells the fiber-based silicon anodes produced in the project. Next the scientists will analyze, refine, and scale up the production processes for manufacturing large battery cells such as those that power electric vehicles. The institute brings a great deal of expertise to this task: It operates several cell manufacturing pilot plants. One is a factory-like research production line for making large lithium-ion cells with up to 100 ampere hours capacity. It has been up and running since 2014.

ZSW scientists have amassed decades of experience assessing the safety and performance of batteries and prototypes. Set up in 1998, the institute's battery safety and testing center is renowned across Europe.

Baden-Württemberg project spans the entire value chain

The project covers all the key steps involved in manufacturing innovative lithium-ion batteries – new anode materials development, manufacturing processes, plant engineering, material testing, methods development, and battery cell production. The partner organizations draw on their particular technology expertise to help select, develop, and optimize suitable processes.

The project is called Development & Production of Innovative, Fiber- and Silicon-Based Anode Materials for High-Performance and Sustainably Produced Li-Ion Batteries, or FACILE for short. It is coordinated by centrotherm international AG based Blaubeuren. This mechanical engineering company's task within the research project is to develop an innovative high-throughput system for applying silicon coatings to fiber materials. There are several more partners on board: Phoenix NonWoven GmbH & Co. KG in Lenningen is developing and will deliver the specialized nonwoven fabrics. The International Solar Energy Research Center Konstanz (ISC Konstanz e.V.) is investigating the bond between the nonwoven fabric and the copper foil, while the Photovoltaics department at the University of Konstanz is conducting material analyses. Finally, the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) in Ulm is tasked to characterize,

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make, and test the advanced fiber-based anode in full-fledged battery cells.

About the ZSW

The Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) is one of the leading institutes for applied research in the major topics of the energy transition: Photovoltaics, wind energy, batteries, fuel cells, electrolysis, eFuels, circular economy, policy advice and the use of AI for process and system optimisation. Together with industry, we pave the way for new technologies to enter the market. More than 300 colleagues and around 100 scientific and student assistants work at the ZSW locations in Stuttgart and Ulm. The ZSW operates a test field for wind energy and another test field for PV systems. The ZSW is a member of the Baden-Württemberg Innovation Alliance (innBW), an alliance of ten business-related research institutions.

About centrotherm

Thermal production solutions and coating technologies are among centrotherm's core competencies. For more than 70 years, the company has been developing and implementing manufacturing concepts for a steadily growing international customer base. Its innovative solutions serve established growth industries such as semiconductors, microelectronics, and photovoltaics, and figure prominently in emerging sectors such as including fiber and battery manufacturing. As a leading, globally active technology group, centrotherm works closely with partners in industry and research to create valuable competitive advantages for its customers.

About ISC Konstanz

The International Solar Energy Research Center Konstanz e.V. (ISC Konstanz) is an institute devoted to developing solar cells, solar modules, and renewable energy systems, with a strong focus on industry-oriented research and technology transfer. Founded in 2005 as a non-profit association, the center brings together a team of more than 70 scientists, engineers, and students. They collaborate in national and international research projects with leading institutes and companies from across the industry.

About Phoenix Non Woven

An innovative spin-off of the former Scheufelen paper factory in Lenningen, Baden-Württemberg, Phoenix Non Woven GmbH & Co. KG specializes in manufacturing novel wet-laid nonwovens. While the production process is much like conventional paper manufacturing, it draws on a far wider spectrum of fibers, particularly high-performance synthetic materials. This approach enables the company to create advanced nonwovens in exceptional quality, replete with integrated functionalities.

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About the University of Konstanz

One of Germany's eleven Universities of Excellence, the University of Konstanz has received funding from the Excellence Initiative and its successor program, the Excellence Strategy of the Federal Government and the States, since 2007. Its Photovoltaics Division emerged from the Chair of Applied Solid State Physics established in the mid-1970s. Today, the Photovoltaics Division focuses on characterizing materials and components for renewable energy use cases.

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The FACILE project is developing innovative silicon-based anode materials for sustainable and more powerful lithium-ion batteries.
Photo: ZSW