Fraunhofer FEP

PRESS RELEASE

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Lithium thin films as pioneer to high energy capacities

The development of resource-efficient manufacturing processes for next-generation battery anodes was the aim of the joint project „nextBatt" funded by the German Federal Ministry of Education and Research (BMBF, funding reference: L1FHG42421). At the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP, new material combinations and efficient production technologies have been realized for this purpose. The Institute will present recent results at SVC TechCon 2022, May 3–5 2022, in Long Beach/USA, at booth No. 436.

The demand for lithium-ion batteries (LIB) is growing rapidly. In 2020, the Fraunhofer Institute for Systems and Innovation Research ISI, among others, estimated that the request for lithium-ion cells will increase by a factor of 20 to 40 until 2030 just for electromobility[1].

To prevent the immeasurably increase for consumption of resources accompanied to the rising demand of LIB's, scientists around the world are working feverishly on innovations.

In 2021 the project "nextBatt" made its individual contribution to mentioned endeavors. In addition to the Fraunhofer FEP, the "nextBatt" consortium was complemented by the capabilities of the Fraunhofer Institutes for Material and Beam Technology IWS, for Solar Energy Systems ISE and for Surface Engineering and Thin Films IST.

"In comparison to commercial systems, the energy capacity of lithium-ion batteries may be increased up to 65%." predicts Dr. Stefan Saager, project manager at Fraunhofer FEP. "This can be reached by replacing conventional graphite anodes with materials based on silicon and in perspective by metallic lithium. With the resource-efficient process technologies at Fraunhofer FEP, we have already succeeded in producing pure metallic lithium coatings and also lithium-silicon compound coatings at production-relevant scales."

Federal Ministry of Education and Research

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[1] Ralph Diermann: Das Rennen um die Batterie der Zukunft. In: Der Spiegel. February , 2020, ISSN 2195-1349 (spiegel.de) and PRNewswire: Global Lithium-Ion Battery Market Size Could Exceed $115 Billion By 2030 as Demand is Booming

Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP
Winterbergstraße 28 | 01277 Dresden, Germany | www.fep.fraunhofer.de

Head of Marketing: Ines Schedwill | Phone +49 351 8823-238 | ines.schedwill@fep.fraunhofer.de

Head of Corporate Communications: Annett Arnold, M.Sc. | Phone +49 351 2586-333 | annett.arnold@fep.fraunhofer.de

Usually, lithium coatings are produced in the form of thin films by roll-to-roll-technologies, which also require the use of lubricants. At Fraunhofer FEP, however, the lithium coatings are produced in a thickness range of 1–20 micrometers by thermal vapor deposition in vacuum without any contaminating substances. This allows very pure and, above all, thin metallic lithium layers to be fabricated in a reproducible manner. In this process, lithium granulate is transferred to vacuum, filled into a crucible, and then heated to temperatures of 500–700°C. The lithium melts and finally it evaporates. Similar to the way water accumulates on lids of cooking pots, the propagating lithium vapor is condensed on a substrate. This substrate is moved in a well-defined manner over the lithium vapor source so that a lithium layer of a given thickness is condensed on it.

A big challenge during the technology development laid not only in setting up the processes, but also in the working environments, because lithium has an extremely high reactivity. Lithium reacts not only with oxygen in the air, but also with nitrogen. Furthermore, in contact with water it forms the strong alkali lithium hydroxide with the release of hydrogen. These reactions are known to be strongly exothermic, which makes them more difficult to handle and hence high standards for health and safety protection are required. Therefore, lithium can only be handled under an inert argon atmosphere. Furthermore, high-purity lithium layers are essential for achieving good battery performance. Fraunhofer FEP's facilities have been prepared adequately for experiments with air-sensitive materials such as lithium.

A major advantage of the technology is that the vapor deposition process can also be used to produce compound films in combination with other materials, such as silicon. To realize this, another vapor source with a different raw material is "easily" installed next to it. The different materials are mixed in the two superimposed vapor streams and a compound layer with the desired composition will condense on the substrate. In this way, very promising material combinations are reachable, which could not be produced in any other manner. In addition, very high deposition rates can be achieved with this process - an important criterion for converting the technology to mass production.

Up to now, the pure lithium coatings produced at Fraunhofer FEP have been investigated at Fraunhofer IWS with regards to their electrochemical properties. It was found that about 80% of the deposited lithium was electrochemically active – i.e. this material is available in a battery for chemical reactions to store energy. A further increase above 90% is reachable by optimizing processing steps. This improvement includes various processes for substrate cleaning and pretreatment, the coating technology itself, and refinement processes through post treatment. The reduction of so-called "dead lithium" is an essential key to increasing efficiency in batteries and this aspect is a currently subject of intensive international research.

At Fraunhofer FEP test and pilot plants are available for this purpose. With those, for example, metallic plates and strips or plastic films can be processed in an efficient roll-to-roll process. Other promising technologies for increasing battery performance are being developed in the project consortium. To name a few: processes for surface coating and processing of powders, metallization of plastic films for light current collectors or plasma processes for the production of alternative electrode materials. Due to the proximity to the partners, among other things, comprehensive characterization capabilities are applicable at the Fraunhofer IWS without having to consider long storage and transportation times of the sensible materials.

The Fraunhofer institutes are already in contact with various partners from academia and industry. The scientists estimate that the coating technology could be transferred the mass production of next-generation batteries within the next five years if research activities are intensified immediately. For this, the "nextBatt" project represents a pioneer.

About the project "nextBatt-resource-efficient production processes for next-generation battery anodes“

Funded by the German Federal Ministry of Education and Research (BMBF) under grant no: L1FHG42421

Duration: 01.02.2021 – 31.12.2021

Partners: Fraunhofer FEP, Fraunhofer IWS, Fraunhofer ISE, Fraunhofer IST

Fraunhofer FEP at SVC 2022 – Society of Vacuum Coaters Annual Technical Conference

Exhibition
May 3 – 4, 2022
Long Beach Convention Center, Long Beach, CA, USA
Exhibit Hall A
Booth No. 436

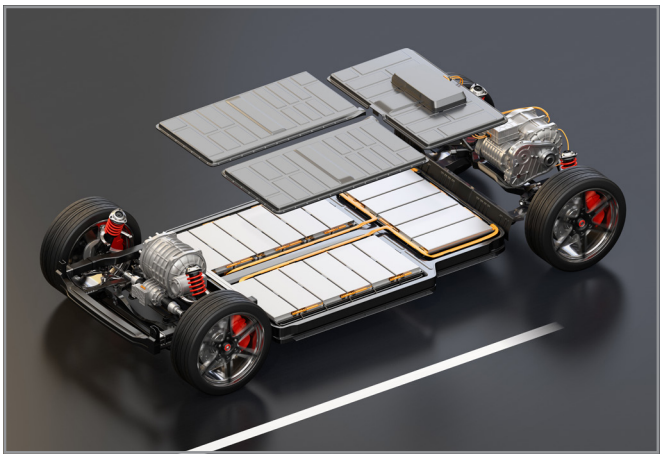
Conference - Technical Program
May 2, 2022, 6.00 p.m.
S. Saager, L. Klose, B. Scheffel, M. Fahland
Plasma-Enhanced Chemical Vapor Deposition of Graphene Layers in a Effective Roll-to-Roll Process
Session Plasma Processing (PP)

May 3, 2022, 12.00 a.m.
J. Szelwicka, J. Rezek, J. Vlcek, M. Fahland
Deposition of thermochromic VO_2 on ultra-thin glass in roll-to-roll process
Session High Power Impulse Magnetron Sputtering HIPIMS (HP)

May 5, 2022, 10.40 a.m.
M. Fahland, M. Top
Time Series Analysis in Vacuum Roll to Roll Coating Technology
Session WebTech Roll-to-Roll Coatings for High-End Applications (WT)

May 5, 2022, 1.20 p.m.
J.-P. Heinß, L. Klose
High-rate sputter etching of substrates using hollow-cathode arc discharge sources
Session Protective, Tribological, and Decorative Coatings (TT)

May 5, 2022, 4.40 p.m.
S. Saager, L. Decker, T. Kopte, B. Scheffel
PVD of Metallic Lithium Layers and Lithiated Silicon Layers for High-Performance Anodes in Lithium Ion Batteries
Session Coatings for Energy Conversion and Related Processes (EN)
https://svctechcon.com/technical-program



The demand for lithium-ion batteries will continue to grow in the future for a wide range of applications
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Lithium in its initial form as granulate and deposited as a thin film as the basis for manufacturing innovative and efficient next-generation batteries
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The **Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP** works on innovative solutions in the fields of vacuum coating, surface treatment as well as organic semiconductors. The core competencies electron beam technologies, roll-to-roll technology, plasma-activated large-area and precision coating as well as technologies for organic electronics and IC design provide a basis for these activities. Thus, Fraunhofer FEP offers a wide range of possibilities for research, development and pilot production, especially for the processing, sterilization, structuring and refining of surfaces as well as OLED microdisplays, sensors, optical filters and flexible OLED lighting. Our aim is to seize the innovation potential of the electron beam, plasma technology and organic electronics for new production processes and devices and to make it available for our customers.