3rd Issue
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NEWS

Sintbat

Silicon based materials and new processing technologies for improved lithium-ion

Sintbat

improved lithium-ion batteries

In this Issue

Introduction

According to the European Energy Storage Technology Development Roadmap towards 2030 (EASE/EERA) energy storage will be of the greatest importance for the European climate energy objectives.

The Sintbat project aims at the development of a cheap energy efficient and effectively maintenance free lithium-ion based energy storage system offering in-service time of 20 to 25 years. Sintbat will use innovate approaches to address these aims. These include, the latest generation of anode materials based on silicon as well as a prelithiation process for lifetime enhancement will be implemented in the cell manufacturing process. Insights gained from ad-vanced in-situ and in-operando analysis methods will be used for multi scale modelling target-ing on the simulation of aging mechanisms for a reliable life-time prediction and enhancement.

The implementation of high energy materials combined with a low cost and environmental benign aqueous cathode manufacturing process will lead to remarkable cell costs reduction down to 130 € per kWh. This will enable battery based storage system for an economic reasonable price of less than 400 € per kWh (CAPEX) and will lower the OPEX down to less than 0.09 € per stored kWh for the targeted in-service time of 20 to 25 years (10,000 cycles).

The technical developments will be supported by the set-up of a relevant roadmap as well as a catalogue for good practice. To guarantee the highest possible impact for the European economy the Sinbat consortium installed an Industrial Advisory Board including various European battery material suppliers, cell manufacturer and end-users whereby the whole value added chain in this way is completed within the Sintbat project.

This strong interaction of the Sintbat consortium with relevant stakeholders in the European energy economy will assure that battery based energy storage systems are becoming an economic self-sustaining technology.

Sintbat

improved lithium-ion batteries

Project Progress

The Sintbat project approaches the one third mark and is in full swing. We are glad to give you a brief outline of the recent findings in this newsletter.

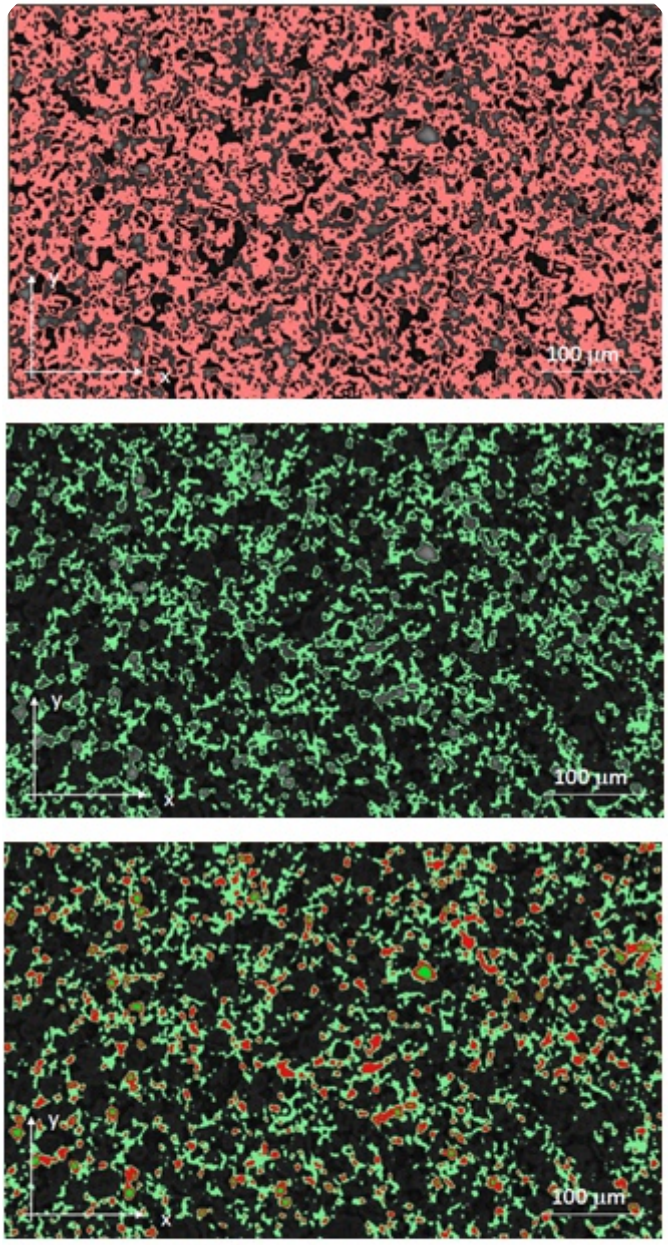
Project Management (WP 1):

After almost one and a half first year, the partners made good progress regarding the use of resources and corresponding work. For the preparation of the periodic report (technical as well as financial report after 18 month) active contributary work is provided. There are no identifiable risks or deficits. Nevertheless, as a principle of good management an independent body is commissioned for review.

Research and Development:
Cell Benchmark, Advanced Electrode Development and Balancing (WP 2):

The cell benchmark has been successfully completed. Only long-time cycling studies are ongoing now. For risk minimization, two different approaches have been chosen for advanced silicon based negative electrodes. One with a lower silicon content, capacity and a long cycle life and one with silicon or silicon composite as active material with higher capacities and high energy. To increase the overall energy density of the cell a thickness reduction of the electrode by calendering is necessary.

In the electrochemical measurements no negative influence, caused by the calendering, was obvious. The Sintbat cell – by increasing the Si amount by factor 3 – performed competitive and showed a significant enhancement of the anode charge density compared to benchmark. The obtained electrode materials are now used for prelithiation by a coating process to create different prelithiation levels and reversible capacities. Their properties will be evaluated thoroughly in a pouch bag cell. At the same time the development of an aqueous processed positive electrode is driven forward.



Picture: XCT Slice image: x-y plane-segmentation of different phases

Project Progress

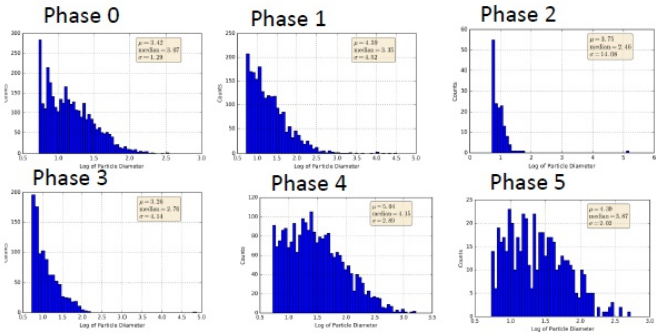
Aging Mechanisms and Tailoring of Electrolytes (WP3):

In order to overcome the shortcoming of Li-ion batteries novel materials and processes will be developed. In this context especially the microstructure of the electrode material and its impact on the performance of the battery is important. Therefore, experimental methods which include 2D and 3D from the electrode material over the mm to the nm scale as well as accurate image analyzing algorithm are necessary.

Sintbat develops just now a characterization toolbox suitable to analyze the micro structure of pristine Si-based anode material which is relevant for future Li-ion batteries used in industrial related storage solutions. This comprises the measurement of the microstructure by using focused ion beam-scanning electron microscopy (FIB-SEM) and X-ray computed tomography (XCT) to cover the length scales from mm to nm including 2D and 3D information, the development of suitable image analysis algorithm to obtain accurate results regarding the microstructure of the electrode and the validation of the data by comparing FIB-SEM and XCT results.

The active region of the sample is basically defined by a graphite matrix, a binder and the distributed Si particles within the graphite/binder matrix. The electrode material is manufactured by mixing the components directly and cast them for instance on a copper foil. Samples are then prepared for the individual methods. In addition we compare different samples having different weight percentage of the Si phase.

The XCT system gives the possibility to measure for these particular samples a Voxel size V down to about 700 nm – leading to 3D information between the mm to the µm scale. For the µm to the nm scale we use FIB-SEM.



Picture: 3D Analysis - Size distribution

The 2D and 3D structural data are further analyzed (e.g. the thickness, the porosity, graphite and binder content, the Si particle volume and size distribution, the maximum and minimum distance between the center of mass of the particles) to provide guidelines for the optimum electrode configuration.

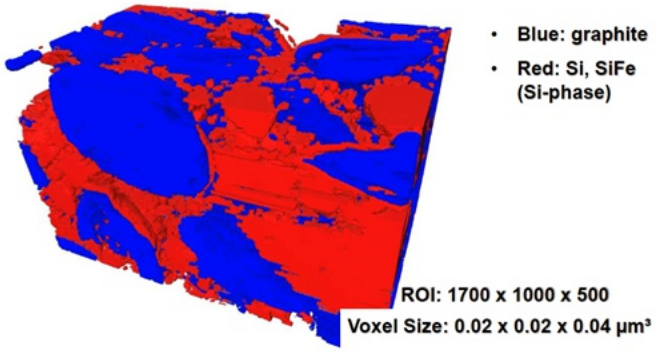
The findings shall give information of how the Si-particles are distributed within the active material for a certain production process. Further studies to relate the findings of the micro-analysis to the storage capacity are planned for the future.

Modelling, Simulation and experimental validation (WP4):

The aim is to develop a computational model to study mechanical deformation of the anode and a electrochemical model to investigate the voltage response of the cell. Silicon particles offer promising means for capacity enhancement of Li-ion batteries.

Project Progress

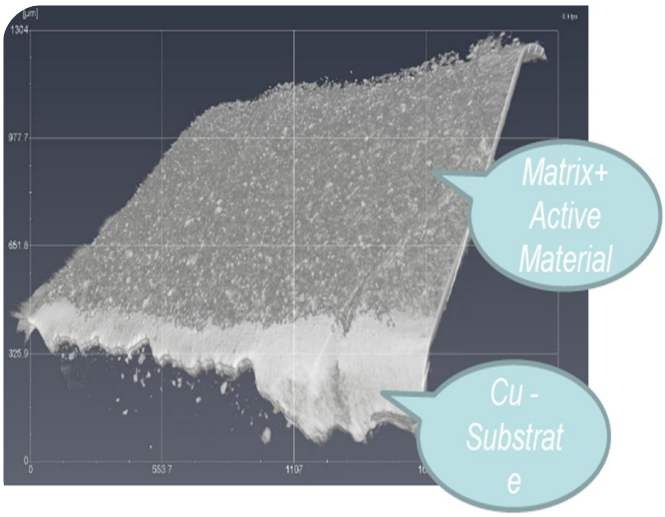
Extreme volumetric expansion of Si during lithiation and mechanical constraints from the surrounding material lead to mechanical stress, which can cause failure of the anode and the capacity fade of the battery. As observed experimentally, mechanical stress can change the kinetics of the chemical reaction between Si and Li even up to the reaction arrest. UoW could show that the chemical reaction kinetics qualitatively differs from the linear elastic case and the factors affecting the reaction front velocity and stress relaxation behind the reaction front are studied. This approach will be extended to a 3D finite-element model of the Li-ion battery anode.



Picture: FIB-Tomography-3D result

Conventional Electrochemical-based models for Lithium-ion batteries are not applicable with Si-enriched materials. Due to volume changes the diffusion dynamic in the lithiation /delitiation process changes considerably, and therefore the voltage response of the battery.

Present work concentrates on the formulation of a Single Particle Model (SPM) for Lithium-ion Batteries taking volume expansions/contractions and the electrolyte dynamic (concentration, overpotential) into account.



The new method finds approximate continuous solutions of differential boundary value problems. UoW was able to illustrate, via dynamic simulations for low C-rates, the volume changes of a silicon particle, its lithium-ion concentration, overpotential in the electrolyte and in the solid particle, as well as the voltage response of the battery in comparison with the traditional SPM.

Implementation, Cell Development, Analysis and Safety Tests (WP5):

This work package deals with the transfer of the materials and processes developed within Sintbat into the agreed cell design on a industrial scale. It builds on Sintbat output and has commenced integrating silicon containing materials to gain an improved cell capacity.

First results showed that the project target could be achieved. Volume expansion and resulting material stress during cycling are expected issues and are analyzed closely.

Project Progress

Prototyping and Demonstration (WP6):

Has its its main work in the later stages of the project, performing cell manufacturing based on the developed cell design and chemistry, module assembly and the development of an advanced battery and energy management system.

Nevertheless, preparations were begun to obtain cell models for state estimation algorithms. Besides an initial module design including thermal management concept was realized. First results were presented to the Industrial Advisory Board and further collaboration options regarding the exploitation of the results were discussed.

Life Cycle and Health Risk Assessment (WP 7):

Within WP 7, a product design accompanying LCA according to ISO EN 14040 / 44 analysing the environmental impacts associated with all stages of the products life from cradle to grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling) are planned.

Those studies are performed in parallel to the ongoing project internal development process in order to provide decision support towards the most environmentally benign concepts. In this way, the consideration of a variety of alternatives gives valuable decision support, points out current environmental hot-spots and highlights the most promising application scenarios.

As a first step, a several reference model will be developed which reflects a commercial battery energy storage system. For this, the battery cells 18650 with a life time of approx. 8000 cycles have been selected. The reference modules were modelled using the software GaBi and based on data sets available in the Ecoinvent database and literature. As opposed to this, the SintBat model requires specific data from the industrial project partners.

Dissemination, Exploitation and Business Plan (WP 8):

With the project work well underway the Sintbat partners increasingly present their results at conferences in european & non-european countries as well as in written form.

The first steps towards a Market Analysis as a foundation for a Sintbat Business Model have been taken.

These efforts are flanked by information exchange with different european associations/platforms to better implement a Sintbat roadmap across different existing (European) roadmaps.

The Industrial Advisory Board has taken up it's work last autuum and is well integrated as the participation during the last General Assembly shows. The cooperation extends across the whole value chain within the scope of Sintbat. The IAB is still growing - additional members are desirable.

General Assembly Meeting

Date: 26th-27th April 2017 Location: Uppsala, Sweden

From the 27th to the 28th September 2017, the project consortium met for the second biannual meeting of the project "Sintbat" at Uppsala, Sweden. Our host Uppsala University is a research university and the oldest university in Sweden and all of the Nordic countries still in operation, founded in 1477. It ranks among the world's 100 best universities in several high-profile international rankings.

The meeting started with a welcome by the host, Daniel Brandell, who gave a brief overview of the University's history and current appearance and wished for an interesting and fruitful meeting.

Irrespective of several work package meetings the consortium was keen to learn about the project progress within each work package in detail in its entirety. Accordingly, presentations were given by the work package leaders specifying the results already achieved, issues tackled and the work planning for the future. There was sufficient time to discuss the outcomes in-depth, respond to questions specifically, tagging essential work steps and coordinate the concerted efforts.

A meeting with the (growing) Industrial Advisory Board (IAB) was part of the officia General Assembly. It started with a welcome by Martin Krebs (VMB) and a short introduction round of all partners. Then, the Sintbat partners involved in material development, aging and modelling presented their work. Afterwards, the IAB members shared their opinion and made suggestions for future collaboration.

At the end of this exciting event, project coordinator Martin Krebs summarised the outcome of the lively meeting thanking all partners for their active cooperation and contributions during the first year of the project by underlining the good standard of work performed in the project. By keeping this up, the project is on a very good path to reach its goals.

All project partners are looking forward meeting again on the 10th - 11th October 2017 at Ellwangen, Germany.

Newsflash

TerraE is preparing to set up major lithium-ion battery cell production facilities in Germany

Led by a company called TerraE Holding GmbH, the group aims to target customers in the transport and industrial sectors who want to achieve "strategic delivery security" and to participate in the project.

TerraE-Holding GmbH has composed 17 major companies and research institutions to a consortium to handle planning for building large-scale lithium ion battery cell manufacturing in Germany. The consortium includes companies from throughout the supply chain, such as infrastructure manufacturing planners, material producers, machine engineering companies, cell manufacturers, and industrial consumers.

Large-scale series production is planned to be established at two German locations. The factories will be operated as “foundries,” meaning that TerraE Holding GmbH will build and operate the factories, where lithium ion cell customers can have products produced to their specifications. Production start is expected with 2170 battery cells which are about to supersede the international standard18650.

With 34 GWh the TerraE factory shall exceed the production capacity of Litarion (500MWh) by far and at first glance be comparable to Tesla’s Giga Factory. But, whereas Tesla aims to reach it’s 35 GWh in 2018 the newcomer is expected to provide 5 GWh from 2020 on.

One have to bear in mind that TerraE will start from scratch and will not rely on mayor players such as Panasonic as a technology partner for Tesla. Nevertheless, TerraE will in all likelihood employ NMC 8:1:1 to achieve cell competitiveness. NMC 8:1:1 is at present not introduced in mass production with any other cell manufacturer.

The news comes as pressure ramps up on Germany's traditional auto giants to speed up their transition to electric mobility, against a background of rising concern about air quality problems and limited manufacturing capacities – at least in the vicinity of car factories. The scarcity of lithium-ion cells worldwide prompted the big players to make long-term contracts with suppliers (e.g. BMW signing a 15y-contract with Samsung SDI) leaving smaller companies empty-handed.

So a lot of arguments speak speak in favour of TerraE but the established suppliers are well aware of the situation: Samsung SDI responds by switching to Li-ion cell production in a plant at Budapest, LG Chem builds a new plant in Wroclaw with a estimated capacity of 15 GWh (Samsung) and 10GWh (LG) from 2019 on.

TERRA E

Event Watch

The remaining months in 2017 are replete with top-class events. Do not miss the opportunities! For example, the 2nd Dresden Battery Days, dedicated to the exchange of knowledge between international electrochemical energy storage experts on the specific topics of Status of R&D of solid-state batteries, Manufacturing issues, Aspects of future system integration. Or the Batteries Event, a meeting place of technologies (lead, Li-ion, Post Li-ion), applications (micro/macro) and of the value chain.

Dresden Battery Days
(Volkswagen Sachsen GmbH, DIE GLÄSERNE MANUFAKTUR)
18.09. - 20.09.2017 Dresden, Germany

22nd International Congress for Battery Recycling ICBR 2017
20.09. - 22.09.2017 Lisbon, Portugal

Batteries Event – The international Energy & Power Supply Conference and Exhibition
03.10. - 06.10.2017 Nice Acropolis, France

Battery+Storage / World of Energy Solutions
09.10. - 11.10.2017 Stuttgart, Germany

5th E-Mobile Production Day
11.10.2017 Aachen (RWTH Aachen), Germany

4th Ruhr-Symposium (functional materials for batteries)
12.10.2017 Duisburg (Fraunhofer), Germany

4th international Energy Symposium
18.10.2017 Aachen, Germany

13th Lithium Battery Materials & Chemistries
31.10. - 01.11.2017 Hyatt Centric Arlington, Virginia, USA

8th Annual Battery Safety
02.11. - 03.11.2017 Hyatt Centric Arlington, Virginia, USA

ICEnSM – The First International Conference on Energy Storage Materials
18.11. - 21.11.2017 Tsinghua University Shenzen, China

Battery Forum Germany Conference
24.01. - 26.01.2018 Berlin, Germany

Consortium

VARTA Microbattery GmbH

VARTA Microbattery (VMB) is an internationally leading and globally active manufacturer of retail and OEM batteries and has been operating for more than 125 years. VMB employs nearly 750 persons in Germany and approx. 2,000 worldwide. The company headquarter is located in Ellwangen in the southern part of Germany where the entire research, engineering and production of the electrochemical cells are done. 150 VARTA employees work in the Innovation Tower at our headquarters in Ellwangen.
This central Research and Development department focuses on developing new products and optimizing existing solutions. Particular attention is paid to material and structural research, converting and storing energy (light, heat, vibration, etc.), and nanotechnologies, fuel cells, and printed batteries.

Uppsala Universitet

Uppsala Universitet (UU), founded in 1477, is the oldest University in the Nordic countries. In all different ranking lists UU is among the top 100 universities in the world. Today, it trains more than 43,000 students, and employs 6,000 people. There are about 2,500 active graduate students; 44% of these are women. Each year, the University awards some 270 doctoral degrees.
The Ångstrom Advanced Battery Centre (ÅABC) is an integral part of the Department of Chemistry – Ångström Laboratory, Uppsala University; it is housed within the Ångström Laboratory – one of Europe's best equipped Materials Research Laboratories. The Centre involves the full-time activities of 35-40 researchers, of whom 8 are Senior Staff and research engineers; the remainders are PhD students and postdocs. It is the leading basic research environments for the development of electrochemical storage materials and advanced battery technology in the Nordic countries. It is publishing more than 20 battery research papers per year. It is a member of ALISTORE-ERI a network of excellence for battery research started more than 10 years ago within FP6. It is a member of SHC (The Swedish Hybrid Vehicle Centre) and of several existing and former FP7 programs.

Consortium

Varta Storage GmbH

The VARTA Storage GmbH (VS) is a developer and manufacturer of stationary battery storage systems. The company has substantial know-how in the field of energy storage by using long-life lithium-ion batteries and conducts in the context of innovative research and development activities. The first commercial product from VARTA Storage is the ENGION Family, a modular storage system which allows the storage of PV-Energy in order to increase the self-consumption of private households up to 70%. With the development of novel large-sized storage systems the company addresses new applications like the efficient use of renewable energies and the support of grid stability.

Commissariat à l'énergie atomique et aux énergies alternatives

CEA is a French government-funded technological research organization. With more than 15,000 researchers and co-workers, its activities cover four main areas: Energy, Defence & security, Health & information technologies, and Fundamental research. Two Institutes from CEA both located on the CEA Grenoble centre are involved in the Sintbat project. CEA-INAC is a fundamental research institute (420 people) involved in nanoscience, while CEA-LITEN is a technological research institute (1,000 people) specialized on energy R&D (fuel cell, batteries, biomass, and solar application).

CEA-INAC develops expertise in advanced characterization on the Nanocharacterisation platform, a large facility devoted to up-to-date electron microscopy, spectroscopy and NMR on the Minatec campus of Grenoble. INAC also manages X-rays beam line at ESRF facility and ILL neutron reactor. For many years, CEA-INAC has developed strong knowledge in LIB investigation and in particular for Si based electrodes. The Nanocharacterisation facility not only provides access to high tech equipment with experienced staff, but also develops new characterisation methods to add to its portfolio.

The Laboratory for Innovation in New Energy Technologies and Nanomaterials (CEA-LITEN) has a unit dedicated to energy for transport application (Department of Electricity, Hydrogen and Transport, DEHT) which has more than 15 years experiences in new materials for Li-ion batteries. Today, this entity is equipped with a dry room of 300 m^2 dedicated to Li-ion batteries prototyping from the electrode material up to the cell and more than 600 m^2 dedicated to Li-ion module and pack system development. CEA-LITEN intellectual properties portfolio on Li-ion batteries is more than 100 on the topics of material synthesis, battery architecture, and BMS.

Consortium

WMG, University of Warwick

The University of Warwick is one of the UK's great success stories. In less than fifty years since being founded the University has become one of the UK's best universities, consistently at the top of UK league tables and rapidly climbing the international league tables of world class universities. Warwick is globally connected, forward-looking and entrepreneurial. At its heart Warwick is about creating new ways of thinking and achieving: making us stand out from our competitors and the more 'traditional universities' and creating an inspiring place to study and undertake research.
As one of the largest academic departments at the University, WMG is able to make a real impact on industry through collaborative R&D and top class education. UK government reviews have cited WMG as an international role model for university and business collaboration. What makes it unique is a multidisciplinary approach to innovation; pushing the boundaries for science and technology and enabling the transfer of knowledge into new areas. Working at the forefront of emerging technologies, and across diverse projects and industry sectors, WMG tackles real world challenges in an environment that inspires confidence and creativity.

MCL Leoben

The Materials Center Leoben Forschung GmbH (MCL) is the leading Austrian institution in the field of applied materials science with around 150 employees. In particular, it is operating the Comet K2 Center on Integrated Research in Materials, Processing and Product Engineering (MPPE) which is the largest competence center in the field of research on application of materials in Austria. The research focuses on Integrated research in materials, processing and product engineering and covers the entire supply chain from material synthesis via materials processing and manufacturing and is also including the behavior of components in service till their deployment. About 50 scientific institutions and about 90 companies are collaborating in this network on material based innovations in the fields of (a) new materials and novel material solutions for future applications like energy storage and harvesting, (b) new and optimized processes and process chains, (c) new design concepts, (d) innovative material driven products, and (d) reliability of products in service.
The MCL has modern Lab equipment suitable for cutting edge failure characterization and material characterization.

Consortium

VARTA Micro Innovation GmbH

VARTA Micro Innovation GmbH (VMI), with registered office in Graz (AUT), is a joint venture between the battery manufacturer VARTA Microbattery (Ellwangen, DE) and Graz University of Technology (AUT). The business purpose of VARTA Micro Innovation GmbH is R&D in the area of electrochemical energy storage systems. Within VARTA Micro Innovation both, the industrial fabrication know how from VARTA Microbattery and the basic research know how from Graz University of Technology for various electrochemical energy storage systems are merged together. This unique configuration enables VARTA Micro Innovation to perform a fast transfer of newly developed technologies into production state. The R&D activities of VMI are divided in three main research areas:

Lithium Power - Improvement of specific energy (Wh*kg-1) and energy density (Wh*l-1)
Heat Power – Enlargement of the temperature operation range
Rapid Power – Improvement of the rate capability

VARTA Micro Innovation is highly experienced in research, reverse engineering and ordered analysis in the area of lifetime prediction and reliability of Li-Ion Batteries for different application fields (e.g. EV, storage etc.). VARTA Micro Innovation has also many years of experience in working with high capacity negative electrode materials for lithium ion batteries. This work includes on the one hand basic research of high capacity electrode materials as well as electrode fabrication and construction of batteries with these materials on prototype level.

EurA AG

EurA AG has been established in 1999. As an innovation service provider, EurA advises more than 800 mainly medium-sized companies in Germany, covering all industrial sectors. EurA mainly focuses on consulting and assisting companies in national and European R&D projects. This comprises the entire innovation process, including the generation of promising ideas, the search for suitable partners, the establishment of the project consortium, the technical and administrative coordination of the project as well as the project controlling.

Consortium

Uniwersytet Warszawski

University of Warsaw (UW) was founded in 1816. The University brings together scholars from a variety of disciplines. It is the place of a diversity of scientific research. Nearly 60,000 people study at the University of Warsaw every year. The candidates are offered a very broad range of courses in the fields of humanities, social sciences and natural sciences, as well as many interdisciplinary courses combining knowledge and skills of many disciplines. The University offers undergraduate and doctoral studies, organizes summer schools, postgraduate studies and vocational courses, initiates interdisciplinary programmes and introduces new teaching techniques.
The Faculty of Chemistry, University of Warsaw, is a large research and teaching centre. There are fully developed programs in analytical chemistry, biochemistry, inorganic, nuclear, organic, and physical chemistry as well as in chemical physics. The faculty has been regarded as one of the top chemistry departments in the country for decades, and it attracts outstanding faculty and students. Many faculty members have distinguished themselves both nationally and internationally.

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EurA AG
Max-Eyth-Str. 2
73479 Ellwangen, Germany
Phone: +49 7961 9256-229

Project Coordinator:

VARTA Microbattery GmbH
Daimlerstr. 1
73479 Ellwangen, Germany

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