

Program, Speakers, Preparatory Reading


Energy Storage in Batteries

Materials, Systems, and Manufacturing

SCCER Summer School | 11-15 July 2016 | Möschberg | Switzerland

In cooperation with the CTI

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Swiss Competence Centres for Energy Research

 Schweizerische Eidgenossenschaft
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Welcome

We are looking forward to welcoming you soon at our SCCER summer school [Energy Storage in Batteries: Materials, Systems, and Manufacturing](#) from 11 to 15 July 2016 in Möschi, Switzerland.

Energy storage devices are key components in current energy systems and will be even more important in the near future, in particular for electric mobility and renewable energy storage. Both stand for a climate-friendly energy future and rely to a great extent on the availability of durable, inexpensive, and safe electricity storage systems. Current challenges for battery research, development, and manufacturing include higher energy density, safety issues, as well as cost reduction and durability of state of the art battery systems resulting in an improved driving range for mobility and more cost-effective storage systems or energy application.

The [Swiss Competence Centers for Energy Research](#) Heat and Electricity Storage (SCCER HAE) and Efficient Technologies and Systems for

Mobility (SCCER Mobility) engage more than 200 researchers at leading Swiss universities, research institutions, and universities of applied sciences who work on technical, social, and political solutions for a reliable and sustainable energy supply system and improved energy efficiency. This includes the development of new battery materials and systems for storage and transport technologies.

Our summer school offers you the unique opportunity to meet [17 speakers from academia, industry, and public administration](#) and to get a profound overview of battery research, from basic electrochemistry and material science to the management of battery systems and key application issues in the automotive and the electricity industry. We thank our speakers for contributing to an attractive and rich course program.

In this booklet, you will find short background [information about the speakers](#), a [program overview](#), and a [list of preparatory reading](#) covering the topics addressed at the summer school.

Michael Bürgi, Fiorella Meyer, Petr Novák, Gloria Romera, Jürg Roth, and Andrea Vezzini



Speakers

Dr. Donat Adams

Donat Adams completed his PhD thesis at the Laboratory of Crystallography at the Department of Materials, ETH Zurich in 2007. After stays at the CEA and the Ecole Polytechnique in Paris he joined the Reliability Science and Technology Laboratory at the Swiss Federal Laboratories for Materials Science and Technology (Empa) in 2010.

Prof. Dr. Wolfgang Bessler

Since 2012, Wolfgang Bessler has been a full professor for process simulation at the Department of Mechanical and Process Engineering at the Offenburg University of Applied Sciences. He has spent several months at Stanford University and the California Institute of Technology and is a member of the Institute of Energy System Technology (INES) at Offenburg University. The central research theme of Wolfgang Bessler is computational battery and fuel cell technology. He and his group develop and apply multi-scale and multi-physics mathematical models in order to understand and improve batteries and fuel cells.

Dr. Olaf Böse

After completing his PhD at Humboldt-University, Olaf Böse worked for Solvay Fluor GmbH and Continental AG. In 2014, he joined the Center for Solar Energy and Hydrogen Research Baden-Württemberg ZSW. His work focuses on nickel-metal hydride (NiMH) cell development and electric double-layer capacitors.

Dr. Daniel Brand

Daniel Brand completed his PhD at ETH Zurich in 2005 on modeling and simulation of performance and emission of internal combustion engines. After six years as development engineer and eventually head of turbocharging systems at ABB Turbo Systems, he joined BKW Energie AG where he has been head of the BKW Technology Center since 2015.

Prof. Dr. Axel Fuerst

Axel Fuerst is professor for engine dynamics at the Bern University of Applied Science BFH and head of the Manufacturing Technologies Group at the BFH-CSEM Energy Storage Research Center ESReC. He worked for ABB, Rüttschi Fluid AG and Alstom. His current research activities include manufacturing processes of electrodes, cells and packs for large-format batteries.

Marcel Gauch

In 1999 Marcel Gauch joined the Technology and Society Laboratory of the Federal Laboratories for Materials Science and Technology (Empa). In his research, Marcel Gauch focuses on mobility related life cycle assessments (LCA), in particular of biofuels and electric vehicles.

Dr. Pascal Häring

After completing his PhD thesis at the Paul Scherrer Institute (PSI) and the University of Bern, Pascal Häring joined Oerlikon Stationary Batteries AG as head of the Laboratory for Innovation and Test. Since 2008 he has been head R&D at Renata AG.

Marcel Held

Marcel Held received the engineer degree for communication technology and informatics at the Zurich University of Applied Science in Winterthur. Since 1998, he has been a senior engineer at the Reliability Science and Technology Laboratory of the Federal Laboratories for Materials Science and Technology (Empa) and a lecturer on reliability at ETH Zurich. His most recent research focuses on aging of Li-Ion batteries.

Christian Köbel

Christian Köbel is an electrical engineer and holds a Bachelor of Business Administration. He joined Bombardier Transportation in 2001 where he has been director Primove product management since 2011. Primove is Bombardier's complete e-mobility portfolio and it includes inductive power transmission, high performance Li-Ion battery technology and propulsion systems for electric rail and road vehicles.

Prof. Dr. Maksym Kovalenko

Maksym Kovalenko has been an assistant professor (tenure track) of inorganic functional materials at the Laboratory of Inorganic Chemistry, Department of Chemistry and Applied Biosciences at ETH Zurich since 2011. He is also affiliated with the Swiss Federal Laboratories for Materials Science and Technology (Empa). The research activities of Maksym Kovalenko cover various aspects of chemical synthesis, surface functionalization, self-assembly and applications of colloidal nanostructures. His goals are to develop novel functional materials for energy supplying and energy storing purposes.

Prof. Dr. Petr Novák

Petr Novák, Fellow of the International Society of Electrochemistry, is head of the electrochemical energy storage section of the Paul Scherrer Institute (PSI). He has been working in the field of electrochemical energy storage (focusing on batteries, mainly lithium-based) since 1983, first at the J. Heyrovský Institute, Prague, later as Alexander von Humboldt-Fellow at the University of Bonn, and since 1991 at the Paul Scherrer Institute. Petr Novák has been a lecturer at the Department of Chemistry and Applied Biosciences at ETH Zurich since 2002 and an adjunct professor at the Laboratory of Inorganic Chemistry since 2009.

Dr. Timothy Patey

Timothy Patey is an engineer dedicated to renewable power integration and sustainable mobility via energy storage devices. He is currently senior scientist in the applied physics group of ABB Corporate Research in Switzerland, where he has been since 2010. In this time, he has worked directly with battery integration technology for electric buses, substations, and residential energy storage. Prior to ABB, Dr. Patey researched lithium-ion battery materials and electrodes at Umicore Corporate Research, ETH Zurich, the Paul Scherrer Institute, and the Tokyo Institute of Technology. His broader technology interests include electrochemical energy storage, sustainable technology, and atmospheric CO₂ capture.

Martin Pulfer

Martin Pulfer is head of the Accumulators and Super-capacitors Research Program of the Swiss Federal Office of Energy SFOE.

Florian Ringbeck

Florian Ringbeck received his Master of Science in Electrical Engineering from RWTH Aachen University, Germany in 2014. From 2014 to 2015 he has been a scientist at the Institute for Power Electronics and Electrical Drives of RWTH Aachen. He is now deputy head of the section for storage systems technology and vehicle integration and is pursuing his PhD. His research includes battery pack design, battery diagnostics and battery management systems.

Dr. Gerhard Rizzo

Gerhard Rizzo has been a senior research engineer at the Institute for the Development of Mechatronic Systems, University of Applied Sciences and Technology Buchs NTB since 2014. Before, he worked for the private companies Cofely Refrigeration and AXIMA Refrigeration. His research interests include thermal management of lithium-ion batteries.

Prof. Dr. Andrea Vezzini

Andrea Vezzini has been professor for industrial electronics at the Bern University of Applied Sciences since 1996. He is a co-founder of drivetek ag and Integrated Power Systems AG. Andrea Vezzini holds the position of head of the BFH-CSEM Energy Storage Research Center and deputy head of the Swiss Competence Center for Energy Research (SCCER) Mobility. In 2015 he became a member of the Federal Energy Research Commission (CORE).

Dr. Claire Villevieille

Claire Villevieille completed her PhD thesis on the electrochemistry of lithium-ion batteries at the Physics and Chemistry Department of the University of Montpellier, France, in 2009. She joined the electrochemical energy storage section at the Paul Scherrer Institute (PSI) in 2010 where she has been head of the battery materials group since 2014. In her research Claire Villevieille studies the reaction mechanisms of battery systems such as Li-ion, Na-ion, Li-S, and recently all-solid-state cells by means of various operando techniques.

Program

Monday 11 July 2016

11.00 - 12.00 | Welcome and Introduction

13.30 - 15.15 | Prof. Dr. Petr Novák

Basics of Battery Electrochemistry

The very first module of the course will introduce the definitions and expressions relevant to technical electrochemistry. Then, the basics of battery electrochemistry will be discussed including both thermodynamics (electrode potential, cell voltage) and kinetics (ohmic, charge transfer, and concentration overpotential). Finally, the application of this basic knowledge to porous electrodes will be shown.

15.45 - 17.30 | Prof. Dr. Maksym Kovalenko

Basics of Materials Science

This lecture will cover the structure, synthesis and characterization of materials used in rechargeable lithium-ion batteries and in closely related battery technologies. First, the major intercalation-type cathode and anode materials will be addressed. Then the advantages and shortcomings of going to "nano" (down-sizing) and "smart engineering" of electrode materials will be discussed. Finally, materials aspects of post-Li chemistries will be briefly reviewed.

Tuesday 12 July 2016

8.30 - 10.15 | Dr. Claire Villevieille

Characterization of Cell Components

The goal of this lesson is to get insight into a battery during cycling, using advanced characterization techniques and combining information from the bulk, the interface and the surface. We will thus review characterization techniques existing through various examples looking at cell components (electrodes, electrolytes, separators etc.).

10.45 - 12.30 | Dr. Donat Adams

Ageing and Safety of Cell

In this module we will study the different causes of aging of rechargeable batteries (SEI layer formation, electrode dissolution, etc.), and the influence of operational parameters (depth of discharge, temperature, currents and current ripples) for the most important cell chemistries. The difference between the capacity fade due to calendar life vs. cycle life is addressed. Finally, the contribution of each component to battery safety and the selection criteria for types of rechargeable batteries regarding costs, safety and capacity fading is discussed in this lecture.

13.30 - 15.15 | Prof. Dr. Wolfgang Bessler

Physicochemical Modeling and Simulation

Physicochemical models are being widely used to understand the properties of lithium-ion batteries, to support electrode and cell design, and to reduce development costs. This class includes a first overview of modeling approaches (Newman-type models, micro-structure-resolved models, multi-scale models). Then governing processes and model equations, simulation software and implementation as well as challenge model parameterization will be discussed. The lecture closes with application examples: lithium-ion battery lifetime prediction, metal-air battery chemistry.

Wednesday 13 July 2016

15.45 - 17.30 | Florian Ringbeck

Battery Management System: Functions & Algorithms

The online estimation of a battery's SOC and SOH is a crucial function of a vehicle's battery management system (BMS). There are several approaches for improving the algorithms and hardware involved in the battery cell surveillance. These improvements are for example the usage of active impedance measurement techniques to obtain battery data or the implementation of physical-chemical models on BMS. This class concentrates on state of the art BMS functions and the above-described trends in their further development.

19.30 - 20.30 | Martin Pulfer | Evening Talk

SFOE Accumulators and Supercapacitors Research

The Swiss Federal Office of Energy (SFOE) actively promotes research aimed at improving electrochemical and electrostatic energy storage. Martin Pulfer will give an overview of the SFOE Accumulators and Supercapacitors Research Program and present a selection of projects (in German).

8.30 - 10.15 | Dr. Gerhard Rizzo

Thermal Modeling and Management

Thermal management is a major issue, especially for lithium-ion batteries. Too high as well as too low temperatures cause accelerated degradation. In addition, the temperature distribution inside a lithium-ion cell and between different cells of a battery system should be as homogeneous as possible. To achieve this requirement, adequate thermal management is needed, which has to be integrated into the superordinate system.

**10.45 - 12.30 | Prof. Dr. Axel Fuerst
Dr. Pascal Häring**

Lithium Battery Design and Production

The implementation of electro-chemical energy storage is demanding as some of the used materials are quite reactive. This lecture gives an insight of principal lithium battery design and production processes. In a second part, a closer look at the development process, from design to production release, will be taken.

13.30 - 15.15 | Dr. Olaf Böse

Modeling Characterization and Tests on Battery Packs

Single cells are integrated to battery packs to increase voltage and/or current level. Extensive testing of battery packs is required to verify if the design values of battery packs are reached to fulfill requirements of customers, standards and legislations. Detailed descriptions of the current state-of-the-art testing routines with respect to electrical, mechanical, thermal and safety characteristics are presented with focus on automotive batteries based on Li-Ion cells.

Thursday 14 July 2016

8.30 - 10.15 | Prof. Dr. Andrea Vezzini

Battery System Components

For a complete battery system, additional hardware is required. The battery management system (BMS) monitors the operating values (voltages, currents and temperatures) and protects the battery cells from being used outside their safe region. The hardware and software structure of such a BMS must meet certain requirements regarding low power consumption, safety critical behavior and accuracy.

The current interrupting devices (CID) as well as fuses and current sensors should be carefully designed and their sizing depends on the application of the battery system.

10.45 - 12.30 | Dr. Timothy Patey

BESS Technology for Public Transportation and Green Power Grid

This lesson begins with business cases for "new" applications. The technology of dimensioning and cooling lithium-ion batteries in electric buses, home energy storage, and sub-stations is discussed. A semi-empirical battery model will be introduced, followed by a discussion on the implications and limitations of this approach. Finally, a brief discussion on future electrochemical technologies will be held (time permitting).

13.30 - 15.15 | Marcel Held

Reliability and Safety

Reliability and safety are basic requirements for cells and battery systems, in addition to performance, life cycle costs and ecological considerations. The cost-effective design and operation of a battery is intimately related to the reliability and safety of its components. In this module, the basic failure mechanism of cells and their effects are explained and illustrated. Safety features from cell to battery level, the influence of environmental and operational conditions, safety testing and analysis methods are presented in order to support the design of reliable and safe batteries.

15.45 - 17.30 | Marcel Gauch

Life Cycle Assessment and Environmental Aspects

It is commonly known that the environmental friendliness of electric mobility depends on the source of the electricity driving the vehicles. But how detrimental is the construction and use of the batteries used for mobility? Huge differences exist between public perception and the scientific facts in this instance. In this contribution, research results using life cycle assessment methodologies will be presented.

Friday 15 July 2016

8.30 - 10.15 | Christian Köbel

Application Key Issues I

Battery lifetime is the major cost driver of e-mobility solutions today. By choosing the right battery size together with the right charging strategy, the optimum for the application can be found. But variations in the application parameters often define a different optimum in battery size in the eyes of the customers.

10.45 - 12.30 | Dr. Daniel Brand

Application Key Issues II

Control over flexibility, such as dispatchable power plants, demand side management, storage and (related) grid reinforcement, has always been a prerequisite for utilities in order to provide a stable and reliable energy supply. In the framework of the energy transition, the characteristics of energy production and consumption change dramatically, which calls for both, new concepts of control and integration of new types of storage. The BKW Technology Center assesses the potential of emerging technologies for future business and identifies the need for innovation.

12.30 | Farewell lunch (optional)

Preparatory Reading

For preparatory reading, we recommend the articles and book chapters below. Please note that the copies attached to this program booklet are for your personal use only.

P. Novák: Future of lithium batteries: a personal opinion

Booklet of BASF SE: The Research Network Electrochemistry and Batteries, 2013. p. 77-79.

C. Villevieille: Electrochemical characterization of rechargeable lithium batteries

Rechargeable Lithium Batteries. From Fundamentals to Applications, Amsterdam 2015, p 183–232.

J. Vetter et al.: Ageing mechanisms in lithium-ion batteries

Journal of Power Sources 147 (2005), p. 269–281.

B. Weissnar and W. Bessler: Model-based degradation assessment of lithium-ion batteries in a smart microgrid

Proceedings of ICSGCE 2015/IWCSG 2015, Offenburg, Germany, 20-23 October 2015, p. 234-238.

G. Rizzo and M. Stöck: Thermal modelling and management

B. Löffel et al: Manufacturing technologies and production methods for battery cells

SCCER Heat & Electricity Storage Annual Report 2015, p. 13.

S. Abada et al.: Safety focused modeling of lithium-ion batteries: A review

Journal of Power Sources, 306 (2016), p. 178-192.

S. Boyd: Electric motors / A. Vezzini: Battery management systems in EVs

IEA: System optimization and vehicle integration for enhanced overall vehicle performance, final report, Vienna 2015, p. 93-122.

Xinfan Lin et al: A lumped-parameter electro-thermal model for cylindrical batteries

Journal of Power Sources 257 (2014), p. 1-11.

M. Held and U. Sennhauser: Stress-induced ageing of lithium-ion batteries

Chimia 69 (2015), p. 737–740.

D. Notter et al: Contribution of li-ion batteries to the environmental impact of electric vehicles

Environmental Science & Technology 44 (2010), p. 6550–6556.

AGORA Energiewende: Stromspeicher in der Energiewende

Untersuchung zum Bedarf an neuen Stromspeichern in Deutschland für den Erzeugungsausgleich, Systemdienstleistungen und im Verteilnetz, 2014, Kapitel 1, p. 11-24.

BFE / KEMA: Energiespeicher in der Schweiz – Bedarf, Wirtschaftlichkeit und Rahmenbedingungen im Kontext der Energiestrategie 2050

Kurzfassung des Berichts und Kapitel 5.2 (Szenarien), p. 1-13, 83-84.



SCCER HaE and SCCER Mobility

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