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3rd International Conference on

Battery and Fuel Cell Technology

September 10-11, 2018 | London, UK

Scientific Tracks & Abstracts

Day 1

Day-1

SESSIONS

New Battery Technologies | Lithium Batteries | Battery Management System | Super Capacitors | Advanced Energy Materials

Chair: **Margret Wohlfahrt-Mehrens,** ZSW, Germany

SESSION INTRODUCTION

Title: **Materials development for advanced Li ion batteries**
Margret Wohlfahrt-Mehrens, ZSW, Germany

Title: **Electrolyte chemistry of Mg rechargeable batteries**
Tianbiao Leo Liu, Utah State University, USA

Title: **Current challenges in fabrication and operation of oxide-based all-solid-state Li-batteries**
Martin Finsterbusch, Forschungszentrum Juelich GmbH, Germany

Title: **MOBICUS project: Battery ageing testing, modelling, and strategies for improved durability**
Philippe Gyan, Groupe RENAULT, France

Title: **Study on the test platform of the battery management system for the large-scale lithium battery energy storage**
Changhee Cho, KERI, South Korea

Title: **Current situation of spent lithium-ion battery recycling in China**
Fu-Shen Zhang, University of Chinese Academy of Sciences, China

Title: **Lattice elastic and plastic deformation restoring stability in silicon carbide film anode of secondary lithium battery**
Zhang Hongtao, Hubei University of Technology, China

Title: **Defect and interface induced Li/Na-ion storage in nano-engineered electrodes**
Vinodkumar Etacheri, IMDEA Materials Institute, Spain

Title: **The role of atomic bond strengths and structural disorder in cathode materials for rechargeable ion-batteries**
Wojciech Olszewski, ALBA Synchrotron Light Facility, Spain

Title: **Developing, testing and analyzing new Li-Ion battery solutions using an integrated R&D infrastructure**
Alexandru Ciocan, ICSI, Romania

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Margret Wohlfahrt-Mehrens, J Fundam Renewable Energy Appl 2018, Volume 8
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Materials development for advanced Li ion batteries

Margret Wohlfahrt-Mehrens
ZSW, Germany

Lithium ion batteries are widely used in many portable applications and are the most promising energy storage systems for future mobility and stationary applications. Worldwide, extensive research efforts focus on the development of high performance, low cost and more sustainable materials for advanced lithium ion batteries. In this presentation, we describe various strategies to increase the energy density of lithium ion batteries by combining high voltage and high capacity cathode materials as nickel rich layered oxides or high voltage spinel type materials with silicon/carbon composites. An alternative approach is the development of cobalt free cathode materials. Co-free, Li-rich $Li_{1+x}Ni_{0.5}Mn_{1.5}O_4$ ($0<x<1$) compounds are very promising candidates for high energy applications. The lithium-nickel-manganese oxide compounds can be tailored with respect to composition in order to reach high capacities up to 250 mAh g^{-1} with long cycling life. An adapted electrode manufacturing process including a deep understanding of the interactions between powder properties, process parameters and electrochemical performance is essential to get maximum cell performance. In addition, lithium plating can occur during charging, which is a severe ageing mechanism and a potential safety risk. Adapted cathode materials with excess of lithium can be used to compensate irreversible losses of silicon based anode materials and to prolong life time in full cells.

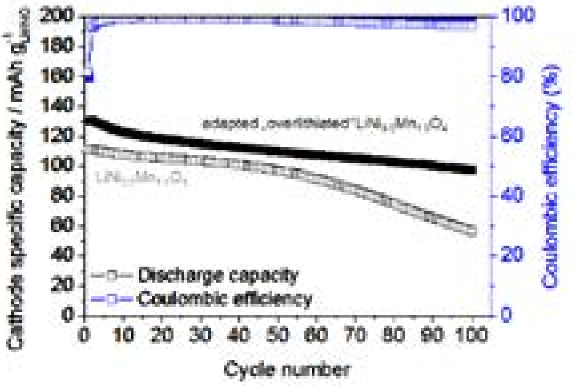

Figure 1: Capacity retention of two Li ion cells Si//$LiNi_{0.5}Mn_{1.5}O_4$ (open squares) and Si//$Li_{1+x}Ni_{0.5}Mn_{1.5}O_4$ with excess lithium adapted to irreversible loss of silicon (black squares); capacity is referred to cathode material.

Recent Publications

1. M Marinaro, M Weinberger and M Wohlfahrt-Mehrens (2016) Toward pre-lithiatied high areal capacity silicon anodes for Lithium-ion batteries, Electrochimica Acta 206:99-107.
2. G Gabrielli, P Axmann, T Diemant, R J Behm and M Wohlfahrt-Mehrens (2016) Combining optimized particle morphology with a niobium-based coating for long cycling-life, high-voltage lithium-ion batteries. ChemSusChem 9(13):1670-1679.
3. M Mancini, G Gabrielli, P Axmann and M Wohlfahrt-Mehrens (2017) Electrochemical performance and phase transitions between 1.5 and 4.9 V of highly-ordered $LiNi_{0.5}Mn_{1.5}O_4$ with tailored morphology: influence of the lithiation method. Journal of the Electrochemical Society 164(1):A6229-A6235.
4. T Waldmann, B I Hogg and M Wohlfahrt-Mehrens (2018) Li plating as unwanted side reaction in commercial Li-ion cells–A review. Journal of Power Sources 384:107-124.

5. G Gabrielli, M Marinaro, M Mancini, P Axmann and M Wohlfahrt-Mehrens (2017) A new approach for compensating the irreversible capacity loss of high-energy Si/C|$LiNi_{0.5}Mn_{1.5}O_4$ lithium-ion batteries. Journal of Power Sources 351:35-44.

Biography

Margret Wohlfahrt-Mehrens is the Head of the Accumulators Materials Research Department (ECM) at ZSW in Ulm, and Head of Materials II (Composite Materials) at the Helmholtz Institute Ulm for Electrochemical Storage (HIU). Her research focuses on new materials for Li-ion, Li-S, metal-air and Na-ion batteries, and process development for electrode and cell production in close collaboration with several industrial companies. Her projects are part of a broad network including large international industrial companies, research organizations and universities. She coordinates the German battery competence center Li-EcoSafe, is member of the board of directors of HIU and member of executive board of the competence network Li-ion batteries (KLIB).

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Electrolyte chemistry of Mg rechargeable batteries

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Utah State University, USA

Mg is earth abundant and low-cost (ca. 24 times cheaper than Li), and as an anode material, Mg is safe to use without dendrite formation (vs. Li, Li-ion, or Na-ion batteries). Its high gravimetric capacity (2,333 Ah/kg) and high reduction potential (-2.37 V vs. SHE) allow the assembly of high-energy density batteries. However, despite rapid research progress, the lack of high performance Mg^{2+} conductive electrolytes still presents a primary technical hurdle for developing practical Mg batteries. The presentation will cover our research efforts in developing high performance Mg electrolytes for Mg rechargeable batteries. Specifically, we will present the synthesis and electrochemical performance of ternary $Mg/MgCl_2/AlCl_3$ (MMAC) electrolytes and other Mg electrolytes. For example, the MMAC electrolyte in DME exhibit 100% Coulombic efficiency, and 164 mV ovpotenail for Mg deposition, and 3.7 V vs. Mg anodic stability. Solution and interfacial chemistry of the presented Mg electrolytes will be discussed in detail. In addition, we will share our results on applying advanced Mg electrolytes in developing high energy density Mg rechargeable batteries. Our preliminary data showed that Mg/S batteries using the MMAC electrolyte could deliver 800 mAh/g capacity at a rate of 100 mAh/g.

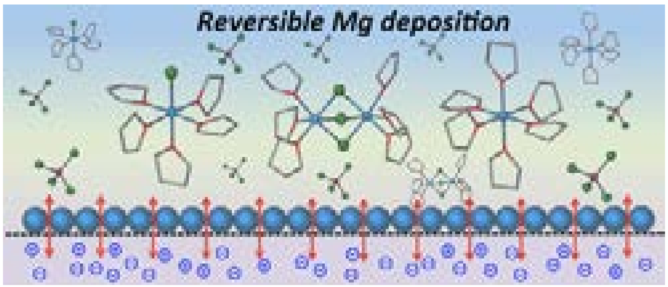

Figure 1

Recent Publications

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3. He S, Neilson K V, Luo J and Liu T L (2017) Recent advances on $MgCl_2$ based electrolytes for rechargeable Mg batteries. Energy Storage Material 8:184-188.
4. Liu T, Cox J, Hu D, Deng X, Hu J, Hu M, Xiao J, Shao Y, Tang K and Liu J (2015) A fundamental study on the [(u-Cl)3Mg2(THF)6]+ dimer electrolytes for rechargeable mg batteries. Chemical Communications 51:2312-2315.
5. Liu, T, Shao Y, Li G, Gu M, Hu J, Xu S, Nie Z, Chen X, Wang C and Liu J (2014) A facile approach using MgCl2 to formulate high performance Mg2+ electrolytes for rechargeable Mg batteries. Journal of Materials Chemistry A 2:3430-3438.

Biography

Tianbiao Leo Liu has received his PhD from Texas A&M University in 2009, served as Staff Scientist at Pacific Northwest National Laboratory from 2013 to 2015, and is currently an Assistant Professor at Utah State University. His research is broadly spread on energy and green chemistry including electrocatalysis, electrochemical energy storage, and environmentally benign chemical transformations.

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Current challenges in fabrication and operation of oxide-based all-solid-state Li-batteries

Martin Finsterbusch, Chih-Long Tsai, Anna Windmüller, Yulia Arinicheva, Hao Zheng, Sven Uhlenbruck, Dina Fattakhova-Rohlfing and **Oliver Guillon**
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All-solid-state Li-batteries (Li-ASBs) promise to alleviate many issues related to the use of organic liquid electrolytes in conventional Li-Ion Batteries since they have the potential to simultaneously increase the energy and power density while offering intrinsic safety and low degradation. They are thus intensely researched worldwide and are of high interest to automotive and portable electronics applications. However, of the many materials and cell chemistries that are explored in fundamental research, successful demonstrations on larger scales are still missing. Of all concepts, oxide based solid electrolytes like the garnet structured $Li_7La_3Zr_2O_{12}$ (LLZ) in combination with Li-metal anodes and thick mixed cathodes promise the highest theoretical energy densities. To demonstrate functionality in larger cells, two main challenges are currently faced during fabrication and one during operation of such large cells using a Li metal anode. For fabrication, scalable synthesis methods for of LLZ itself and processing technologies for large area cell components need to be investigated. While LLZ can be produced with a variety of methods on lab scale, the authors developed a process that allows for large quantities of high quality powder to be synthesized using an industrial established process. Subsequent fabrication of high capacity mixed cathodes requires not just electrochemical stability of the materials used, but also chemical stability at the elevated processing temperatures of ASBs. Secondary phase formation at the electrolyte/cathode interface thus poses further challenges in cell manufacturing. During operation of full all-solid-state cells using Li metal anodes, the difficulty of suppressing the growth of Li dendrites is the main challenge. It is thus essential to understand dendrite formation in LLZ on a fundamental level in order to find mitigation strategies, like the application of interlayers a concept successfully invented by the authors.

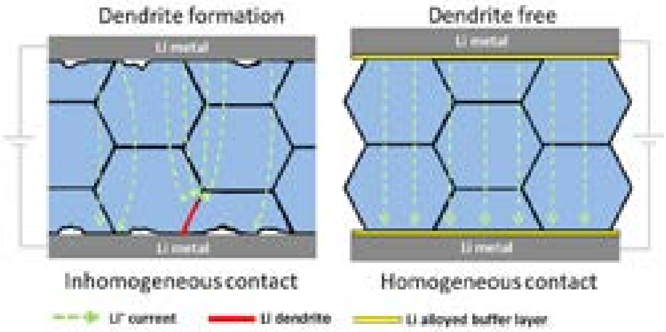

Figure 1: Li dendrite formation in LLZ and suppression via buffer layer.

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5. Tsai C L, Dashjav E, Hammer E M, Finsterbusch M, Tietz F, Uhlenbruck S and Buchkremer H P (2015) High conductivity of mixed phase Al-substituted $Li_7La_3Zr_2O_{12}$. Journal of Electroceramics 352:25-32.

Biography

Martin Finsterbusch has his expertise in developing ceramic based cells and components for future electrochemical energy conversion and storage. Majoring in Physics and Material Sciences, he pursued his PhD in the field of solid oxide fuel cells, investigating the degradation behavior via synchrotron based analysis methods. Translating the knowledge of ceramic based synthesis and manufacturing into the all solid state batteries field, concepts are investigated to increase the energy and power density as well as develop scalable synthesis and manufacturing routes in order to enable this technology for commercial application. Starting at new materials and components development and going all the way to full battery cell manufacturing, conventional an in-house developed ceramic synthesis and processing methods are used.

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MOBICUS project: Battery ageing testing, modelling, and strategies for improved durability

Philippe Gyan
Groupe RENAULT, France

The development of the market of electrified vehicles brings a response to environmental concerns, with sustainable mobility and the use of clean energy sources. The performances of electric energy storage system have improved with new generations of lithium-ion batteries, and their high energy density. Still, during the life of the vehicle, these batteries may undergo some degradation, with a capacity loss, and internal resistance increase through the effect of usage and time. Car fleet owners, car manufacturers want to ensure the profitability of their economic models, and cover the warranty costs, in case these batteries need to be replaced. Therefore, reliable battery ageing models, able to represent vehicle real usage scenarios are required. The French National collaborative project MOBICUS (2013-2017) aims at designing and validating strategies enabling to improve battery durability with vehicle usage and recharge, from experimental measurements, models and validations. Previous projects SIMSTOCK (2007-2011) and SIMCAL (2009-2012), focused respectively on cycling ageing and on calendar ageing. The new approaches developed in MOBICUS bring: The non-linear strong coupling between calendar and cycling ageing; the validation on extended domains of state of charge and temperature; the application of dynamic thermal models and; measurements on cells and packs. Various usage strategies have been tested on packs; thermal strategies have been evaluated, with applications to fast charging. The battery ageing models can now be used for first and second life batteries, and be relevant for smart grids, and smart charging applications.

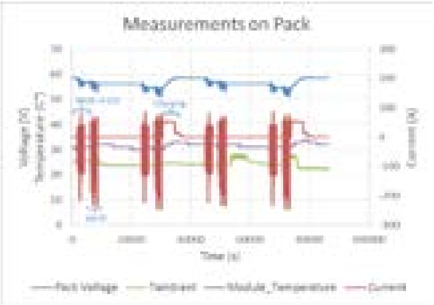

Figure 1: Pattern for ageing measurements on a battery pack.

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2. Baghdadi, O. Briat, A. Eddaech, J.M. Vinassa, P. Gyan (2015) Electro-thermal model of lithium-ion batteries for electrified vehicles applications. Industrial Electronics (ISIE), 2015 IEEE 24th International Symposium on.
3. Grolleau, Baghdadi, Gyan, Ben Marzouk, Duclaud (2016): Capacity fade of lithium-ion batteries upon mixed calendar/cycling aging protocol. EVS29 Montreal.
4. Baghdadi, R. Mathieu, O. Briat, J.M. Vinassa (2017) Lithium-Ion Battery Ageing Assessment Based on a Reduced Design of Experiments 2017 IEEE Vehicle Power and Propulsion Conference (VPPC).

Biography

Philippe Gyan has graduated in 1998 from the Ecole Centrale de Lyon, with a PhD in Mechanical Engineering, Thermal and Energy Management. He has been working for the past 10 years in Renault Research Department for the Electric Vehicle Division. Through contributions to French National and European Projects, he has developed battery ageing models applied to real usage scenarios.

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Study on the test platform of the battery management system for the large-scale lithium battery energy storage

Changhee Cho[1], **Chulwoo Kim**[1], **Jinwook Kim**[1], **Jin-hong Jeon**[1] and **Sungshin Kim**[2]
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[2]PNU, Korea (South)

As the exponential deployment of the sustainable energy sources like photovoltaic and wind generators, electrical energy storages (EES) are also being installed globally to compensate the unstable renewables. Lithium-ion battery (LiB) is the most popular type of rechargeable battery in EES. However, LiB has safety problems such as fire, explosion or the damage of the battery itself unless it is within the proper operating range. The hazards are more critical than other secondary batteries because it has much higher energy and power density. The Battery Management System (BMS) is an essential and critical component to keep the safety of the EES. Because of these risks, there are many testing standards in various applications to provide functional safety requirements of the LiB. Some of them describe the system level requirements including BMS but it is limited and cannot fully support the test of BMS functions. The purpose of the study is to develop the test platform and procedures of the BMS that can give in-depth test of BMS. The test platform is based on the HILS (Hardware in the Loop Simulation) technology with real-time battery simulation. Inside the platform, the LiB is simulated as the electricity equivalent circuit model, and the simulated signals such as voltage, temperature, currents are provided to BMS via hardwire signals. To test BMS for the large-scale EES some signals are transferred via communication because the hardware interfaces are limited. Test procedures and scenario to verify the functions of BMS include measurement accuracy, sensor/IO fault, protections, performance and so forth. With this test platform and test procedure, it is expected to develop more reliable BMS which conclusively supports safer EES.

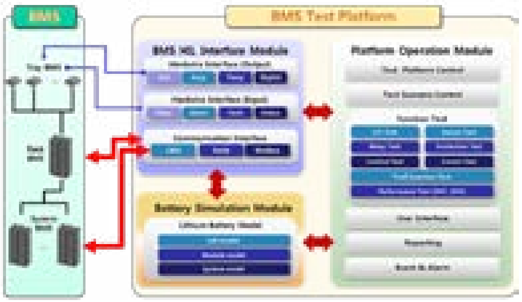

Figure 1 BMS test setup with BMS test platform for the large-scale Battery Energy Storage

Recent Publications

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2. Y-S. Kim, C-S Hwang, E-S Kim, C. Cho , "State of Charge-Based Active Power Sharing Method in a Standalone Microgrid with High Penetration Level of Renewable Energy Sources", Energies MDPI AG , 2016.
3. C. Cho, "Voltage And Frequency Stability Enhancement Of The Islanded Microgrid Using Battery Energy Storage", CIRED 2011.

Biography

Changhee Cho received his B.S. and M.S. degrees from Seoul National University, Seoul, Korea and PhD degree from Pusan National University, Busan, Korea all in Electrical Engineering. Currently, he is a principal researcher of Smart Distribution Research Center in KERI (Korea Electotechnology Research Institute). He is a POC (Point of Contact) and a national expert of Korea in IEA ISGAN (International Smart Grid Action Network) A5 (SIRFN). His research interests are the control and management of distributed energy resources, new & renewable generators, network communications and the energy optimization in the microgrid.

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Current situation of spent lithium-ion battery recycling in China

Fu-Shen Zhang, Meng-Meng Wang and **Kai He**
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In recent years, with the rapid upgrade and replacement of new energy vehicle, as well as electronic devices, huge amounts of spent lithium-ion batteries (LIBs) are generated worldwide. In view of the growing interest in environmental protection and resources sustainable use, recovery of spent LIBs is becoming increasingly important. The Chinese government uses the term new energy vehicles (NEVs) to designate plug-in electric vehicles. There are battery electric vehicles and hybrid electric vehicles inducing purchase incentives. The fleet of NEVs in China is the second largest in the world after the United States, with cumulative sales of around 300,000 plug-in cars sold since 2011 through March 2016. China is creating a favorable environment to foster quicker growth in the NEV sector through intense government-led promotion. The guideline set the target of 200,000 units of new energy buses and 100,000 new energy taxes and city logistics delivery vehicles by 2020 to encourage the production and purchase of NEVs. For post-consumer new energy battery recycling, an environmental benign process namely mechanochemical approach was developed for cobalt and lithium recovery from spent LIBs in the current study. The main merit of the process is that neither corrosive acid nor strong oxidant was used. In the proposed process, lithium cobalt oxide (obtained from spent LIBs) was co-grinded with various additives in a hermetic ball milling system, followed by a water leaching procedure. Experiment results indicated that EDTA was the most suitable co-grinding reagent, and 98% of Co and 99% of Li were respectively recovered under optimum conditions: $LiCoO_2$ to EDTA mass ratio 1:4, milling time 4 h, rotary speed 600 r/min and ball-to-powder ratio 80:1, respectively. Mechanisms study implied that lone pair electrons provided by two nitrogen atoms and four hydroxyl oxygen atoms of EDTA could enter the empty orbit of Co and Li by solid-solid reaction, thus forming stable and water-soluble metal complexes Li-EDTA and Co-EDTA. Moreover, the separation of Co and Li could be achieved through a chemical precipitation approach. This study provides a high efficiency and environmentally friendly process for Co and Li recovery from spent LIBs.

Biography

Fu-Shen Zhang, PhD, is a Professor and Director of Solid Waste Treatment and Recycling Lab at Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. His recent research addresses effective recycling of solid wastes, including valuable matters recovery and functional materials development from electronic waste, construction waste, municipal solid waste and bio-waste. He has guided ten PhD, MSc students and several Postdoctoral Research Fellows in the field of Environmental Engineering. He has published around one hundred peer review articles and applied more than thirty patents.

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Lattice elastic and plastic deformation restoring stability in silicon carbide film anode of secondary lithium battery

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[2]Wuhan Chuneng electron Co. Ltd., China

In charge and discharge process of lithium ion battery special elastic and plastic deformation could be experienced with lithium intercalation and extraction in anode, which is a mechanical behavior. Silicon carbide has many polytypes, such as cubic symmetry, four hetero-structure, six hetero-structure, fifteen hetero-structure, etc., which is a solid with a compact structure. Normally, the lithium ion migration in its crystal could be impeded because of its strong covalent bond. Bulk silicon carbide is unable to store up lithium ion. Nanosized crystalline of silicon carbide could alternatively be a different situation. There could be a lot of surface defects and inner defects, the silicon carbide nanomaterials would produce the lithium ion migrating path. In nanocrystalline films of silicon carbide the nanocolumnar silicon carbide would be a dangling bond nanocrystal on surface with a great deal of defects, in which they are discrete distribution in the film of anode surrounded by the amorphous crystalline silicon carbide. The nanocrystalline columnar silicon carbide in film could supply the conducting pass due to its crystal structure defects. But its conductivity will not be large enough to make the lithium ion effectively move. It needs doping, especially nitrogen doping, which was in favor of forming high concentration nitrogen vacancy, to enhance its conductivity. The lithium ion migration in silicon carbide nanocrystalline would put up its lattice structure and configure six lithium atoms per silicon, which could realize the non-stoichiometric proportions of lithium ion. The crystal lattice would recovery its previous state while lithium ion extraction. The transversion of charge and discharge in lithium ion battery will repeat. The crystal lattice would attempt to recovery its original state, and the process would cycle repeatedly, and so on. It could need a proper indicator to describe the phenomena; we will use a word, which is the stability of elastic and plastic deformation restoring force. It would be related to the lithium ion diffusion, electron conduct, spatial distribution of lithium alloy, nanocrystalline size, and its dimension, diffusion coefficient. We could reduce a formula of the stability of elastic and plastic deformation restoring force

$$H = \frac{M}{R\Delta V}\left[\frac{I}{E}\right]^{n} \qquad (1)$$

R- the ratio of minimum and maximum value of nanocrystalline size, I-the strength of chemical bond, which could be computed by the bond breaking, E- lattice energy, ΔV-volume change ration , n-dimension, which would take the value 1 while zero dimension, the value 2 while one dimension, 1.5 while 2 dimension, and 0.5 while 3 dimension. The anode materials would divide into three types, i.e., stable, meta-stable, and unstable type. H could take the value $H \geq 15$, $1 \leq H < 15$, $H < 1$. The H of silicon carbide would be 20, it is stable.

Biography

Zhang Hongtao is a Professor in the Department of Communication Engineering, Hubei University of Technology, China. He is mainly engaged in quantum computing and quantum information, embedded systems development research and also have interest in battery and electric vehicles.

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Defect and interface induced Li/Na-ion storage in nano-engineered electrodes

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Development of rechargeable batteries with high performance and safety is one of the key challenges faced by modern electrochemistry. Rechargeable Li-ion batteries attracted significant attention during the last two decades due to their widespread application in portable electronics, medical implants, grid-level energy storage and electric vehicles. Recently, secondary Na-ion batteries emerged as an alternative candidate for large scale energy storage. Low-cost and abundance of resources are main advantages of this technology. Li-O_2 batteries are another high-performance battery system, which has several fold energy densities compared to the conventional Li-ion batteries. Despite of the several advantages of Li and Na-ion based batteries, their energy and power densities are not sufficient for more energy demanding commercial applications such as long-range driving. Consequently, development of high-performance electrode materials is necessary to improve the energy and power density of these secondary battery systems. Nanostructured transition metal oxide based electrodes are fabricated to mitigate the drawbacks of electrodes used in conventional Li and Na-ion batteries. Main focus of this work is the interface and defect engineering to boost pseudocapacitive type Li/Na ion storage. Solution based bottom-up synthetic approach and carbothermal reduction method are used for the synthesis of defect and interface engineered electrode materials. Lithium and sodium ion batteries containing defect engineered 1D, 2D and 3D electrodes demonstrated specific capacities up to 1300 mAh/g and high rate performance up to 30 A/g current density. Spectroscopic, microscopic and electrochemical studies proved conventional conversion reaction and pseudocapacitive Li/Na ion storage. High specific capacity (5000 mAh/g) and stable cycling are observed in the case of Li-O_2 batteries. Enhanced electrochemical performances are attributed to the synergy between pseudocapacitive and conversion-type charge storage mechanism.

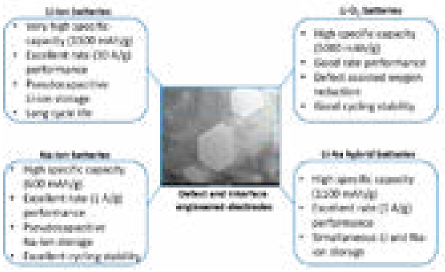

Figure 1: Schematic of the application of defect and interface engineered electrodes in Li-ion, Na-ion, Li-O_2 and Li-Na hybrid batteries.

Recent Publications

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2. Hong S M, Etacheri V, Hong C N, Choi S W, Lee K B and Pol V G (2017) Enhanced lithium and sodium ion storage in an interconnected carbon network comprising electronegative fluorine ACS Applied Mater Interfaces 9:18790-18798.
3. Henzie J, Etacheri V, Jahan M, Hong C N, Rong H and Pol V G (2017) Biomineralization inspired crystallization of monodisperse Mn2O3 octahedra and assembly of high-capacity lithium-ion battery anodes. Journal of Materials Chemistry A 5:6079-6089.
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5. Etacheri V, Yourey J E and Bartlett B M (2014) Chemically bonded TiO2 bronze nanosheet/ reduced graphene oxide hybrid for high-power lithium-ion batteries. ACS Nano 8:1491-1499.

Biography

Vinodkumar Etacheri is a Scientist and Electrochemistry Group Leader at IMDEA Materials Institute, Madrid, Spain. He obtained his PhD in Materials Chemistry from Dublin Institute of Technology (DIT), Ireland in 2011. He then completed Postdoctoral research at Bar Ilan University-Israel, University of Michigan, USA and Purdue University, USA in the area of Li-ion, Li-O_2, Li-S, and Na-ion batteries. His research areas extend from solar energy conversion to electrochemical energy storage materials and devices. He has co-authored more than 30 papers (>4500 citations) in international peer reviewed journals, three book chapters, and eight patents.

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Notes:

Wojciech Olszewski et al., J Fundam Renewable Energy Appl 2018, Volume 8
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The role of atomic bond strengths and structural disorder in cathode materials for rechargeable ion-batteries

Wojciech Olszewski[1, 2], **Carlo Marini**[1], **Nitya Ramanan**[1], **Masashi Okubo**[3], **Naurang Lal Saini**[4] and **Laura Simonelli**[1]
[1]ALBA Synchrotron Light Facility, Spain
[2]University of Bialystok, Poland
[3]University of Tokyo, Japan
[4]Universitá di Roma "La Sapienza", Italy

Ion batteries are a key technology and play a dominant role in today's world. Extensive research efforts have been dedicated to exploring and developing new cathode materials with higher capacities and lifetimes. Recently, a new family of transition metal carbides and carbonitrides called MXene has been synthesized with a layered hexagonal structure and $M_{n+1}AX_n$ chemistry, where M is an early transition metal, A is an A-group element (mostly groups 13 and 14), X is carbon or nitrogen, and n=1, 2, or 3. MXenes have been found to be promising electrode materials, with capacities close to that of commercially available batteries and an excellent capability to handle high cycling rates. However, studies of correlation of their structural stability and functional properties could help to expand further theirs performances. To address this issue we have performed temperature dependent extended X-ray absorption fine structure (EXAFS) measurements at the Ti K-edge on representative members of the MXene family. Temperature dependent measurements permit to have direct access to the local force constant between the atomic pairs and correlate this information with the battery capacity and ions diffusion rate. The presented results address fundamental structural aspects that define the functional properties of cathode materials for ion batteries.

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Biography

Wojciech Olszewski is a Postdoctoral Research Associate at the ALBA Synchrotron Light Facility. He studies energy materials, and his current research direction is the investigation of the structural stability, local atomic displacements and the force constants during the diffusion process for finding a realistic correlation between the local structure and functional properties of cathode materials.

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Developing, testing and analyzing new Li-Ion battery solutions using an integrated R&D infrastructure

Alexandru Ciocan, Mihaela Buga, Mihai Balan and **Alexandru Rizoiu**
ICSI, Romania

The work focuses on the development of lithium-ion battery in the new battery R&D production line from Rom-EST Centre of the National R&D Institute for Cryogenics and Isotopic Technologies - ICSI Rm., Valcea, the first and the only facility in Romania, capable of fabricating the industry standard 18650 lithium-ion cells, customized pouch cells and CR2032 coin cells. Among the objectives of this work are the presentations both theoretical and experimental results regarding setting new electrodes recipes, mainly, for LTO and NMC chemistry, the use of different binders, charging and discharging processes testing performances at different current density: 0.1, 0.2, 0.5, 0.8 and 1.0 C, thermal behavior analysis of lithium-ion batteries for EV, a life cycle assessment for the NMC technology and a comparison with other types of technologies available on the market with the main objective in identifying and demonstrating battery chemistry with higher energy densities and improved safety. Technical characteristics of Li-Ion batteries are closely related to the economic ones, and for the final user is less important the cost of a single cell and especially the cost per functional unit (e.g. the cost of storing a kWh of electricity). So in the end beside the development and testing batteries analysis study of the various solutions available in a comparative way, highlighting the evolution of the price of Li-ion battery storage in recent years, as well as the different scenarios of price developments in the coming years will be also presented.

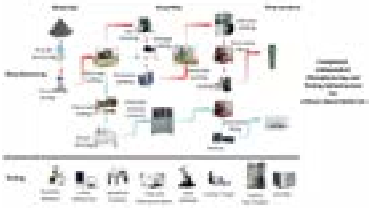

Figure 1: Completely independent manufacturing and testing infrastructure for Lithium based batteries.

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5. Mihai Balan, Adrian Badea, Mihaela Buga and Alexandru Ciocan (2016) Power-to-Gas: development of analysis framework based on a Romanian case study. UPB Scientific Bulletin, Series C ISSN 2286-3540.

Biography

Alexandru Ciocan is a Young Researcher with a Master's degree in Power Engineering that has been part of the National R&D Institute for Cryogenics and Isotopic Technologies - ICSI Rm. Valcea starting with 2012. At the end of 2017 he defended his PhD thesis at IMT-Atlantique, France. His PhD topic and also his research activity are focused on the integration of renewable energy sources with various energy storage technologies, including Li-Ion batteries or hydrogen based technologies.

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Scientific Tracks & Abstracts

Day 2

SESSIONS

Fuel Cell Technologies | Applications of Fuel Cells | Electric Vehicles | Hydrogen Energy | Lithium Batteries

Chair: Muhammad Afzal, KTH Royal Institute of Technology, Sweden

SESSION INTRODUCTION

Title: Catalyst Coated Membrane (CCM) with a Microporous Layer (MPL) attached for Polymer Electrolyte Fuel Cells (PEFCs)
Toshihiro Tanuma, Asahi Glass Research Center, Japan

Title: Doped lanthanum create catalytic materials for fuel cell applications
Naveed K Janjua, Quaid-i-Azam University Islamabad, Pakistan

Title: Insight into the degradation of polymer based fuel cells
Katharina Hengge, Max-Planck-Institut für Eisenforschung GmbH, Germany

Title: New methodology developments based on electrochemical noise analysis of PEMFC
Anthony Thomas, Pprime Institute, France

Title: Impacts of cell reversal on Li-Ion batteries in western world and it’s significants
Bernice Amponsa, Rana Motors, Ghana

Title: Selection of safe salt-in-carbonate electrolytes for lithium-ion batteries
Zhengqi Wang, Karlsruhe Institute of Technology, Germany

Title: *In situ* synthesis of 3DC-NiS_2-CNTs as a multi-functional host for Li-S batteries
Ning Wang, Tianjin University, China

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Toshihiro Tanuma, J Fundam Renewable Energy Appl 2018, Volume 8
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Catalyst Coated Membrane (CCM) with a Microporous Layer (MPL) attached for Polymer Electrolyte Fuel Cells (PEFCs)

Toshihiro Tanuma
Asahi Glass Research Center, Japan

We have already shown that membrane electrode assemblies (MEAs) with a hydrophilic microporous layer (MPL) work much better in a wide range of operating conditions. The hydrophilic MPL is made of carbon fiber and ionomer, and its functions are to remove excess water from the cathode catalyst layer under wet conditions and to prevent dehydration of the membrane under dry conditions. In addition to the typical MEA fabrication methods (gas diffusion electrode (GDE) and decal methods), a brand-new MEA fabrication method (M-CCM method) was conceived as shown in Fig. 1. Generally, an MPL is formed on the gas diffusion layer (GDL) substrate for water management. However, in M-CCM method, a hydrophilic MPL is attached to the cathode catalyst layer. If the CCM with an MPL attached (M-CCM) is used instead of a standard CCM using the decal method, the MEA performance will still improve even when using conventional GDLs with a hydrophobic MPL. Figure 2 compares the MEA performance of an M-CCM and a standard CCM, using commercially available hydrophobic GDLs. The M-CCM shows higher cell voltage in high current density region under a wet condition of 80°C, 100% RH. Under a dry condition of 80°C, 20% RH, M-CCM shows higher cell voltage through the whole current density region. The hydrophilic MPL is beneficial in distributing gas more effectively and keeping the membrane suitably wet. As any GDL substrate is applicable to this M-CCM, this is a unique and promising method for MEA fabrication.

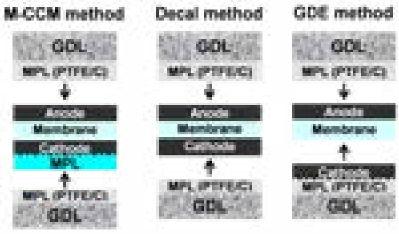

Figure 1: Comparison of MEA fabrication methods.

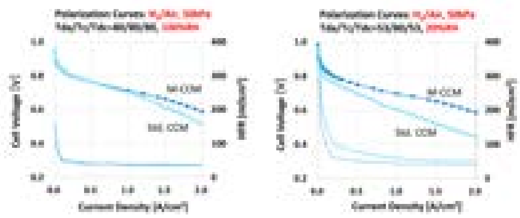

Figure 2: Performance of M-CCM using standard GDLs

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5. Tanuma T, M Kawamoto and S Kinoshita (2017) Effect of properties of hydrophilic microporous layer (MPL) on PEFC performance. Journal of the Electrochemical Society 164(6):F499-F503.

Biography

Toshihiro Tanuma received his BS degree and MS degree in Chemistry from the University of Tokyo, Japan, in 1986 and 1988, respectively. In 1988, he joined Asahi Glass Co., Ltd., and after over 20 years of industrial experience, he received his PhD degree in Chemistry from the University of Tokyo in 2010. For the last 18 years, he has been doing research on polymer electrolyte fuel cells (PEFCs), especially on electrode design. His research interests are generally in Physical Organic Chemistry, Environmental Chemistry, and Electrochemistry.

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Doped lanthanum create catalytic materials for fuel cell applications

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Lanthanum cerate perovskites have been found to be the electrocatalysts for water splitting and other electrolysis under laboratory conditions. The lanthanum cerate perovskite is well known for its position in fuel cell technology as a highly active and compatible electrode material in solid oxide fuel cells (SOFCs) and proton exchange membrane fuel cells (PEMFCs). A doped LaCe1-x MxO3 perovskite offers versatile solid state chemistry with defects balance and resulting electrochemistry poses the versatility for the important industrial process of water splitting. In this perspective, three series of LaCe1-x MxO3 (M=Cr3+, Fe3+, Al3+, x=0.02-0.10) nanopowders were envisioned and tested electrochemically by using cyclic voltammetry and impedance analysis for water splitting in KOH and methanol solution at ambient conditions. Hydrogen evolution reaction (HER) was multifold with all of the perovskite powders. There was an obvious correspondence between the electrocatalytic activity and the morphological, structural properties of the doped systems. The most proactive ceramic in each series was tested for the SOFC technology and average fuel cell performance was observed for a few samples under ambient FC conditions.

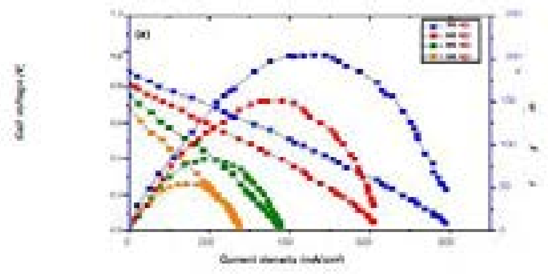

Fig. 1: Cathode performance evaluation curves for a) LCC-10

Figure 1: Cathode performance evaluation curves for a) LCC-10 powders with dry H2 as fuel and air as oxidant at various temperatures 700°C, 650°C and 600°C and 500°C.

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Biography

Naveed Kausar Janjua is an Associate professor in Department of Chemistry, Quaid-i-Azam University Islamabad, Pakistan. She has completed her Post-Doc in Fuel Cell Research. She has her interests in Materials chemistry, Electrochemistry, Fuel cells.

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Insight into the degradation of polymer based fuel cells

Katharina Hengge[1] and **Christina Scheu**[1, 2]
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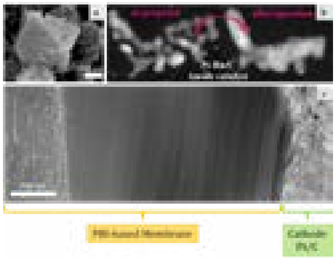
[2]RWTH Aachen University, Germany

The impact of greenhouse gases on the environment and the scarcity of natural resources demand for sustainable solutions to maintain our steadily increasing demand for energy supply; one possibility are fuel cells. In particular for the transportation and stationary sector, polymer-electrolyte-membrane fuel cells are used. Their centerpiece is the membrane-electrode assembly which is composed of several functional layers: the polybenzimidazole-based membrane and two electrodes. Generally the lifetime of fuel cells is limited due to harsh operation conditions leading to several degradation mechanisms that affect all functional layers. In our studies, we focused on alternative materials for the fuel cells´ electrodes. We combined new catalyst or support materials with standardly used material systems and investigated the catalyst´s growth behavior during preparation and its aging properties in various operation conditions. In one study, octahedral shaped, high-surface-area platinum networks were grown on a tungsten suboxide support layer via a template-free synthesis route. Using various transmission electron microscopy (TEM) based techniques, we were able to explain their growth mechanism and evaluate their higher stability and lower degradation rate during fuel cell operation. In another study we investigated the structural characteristics and the stability of Pt/Ru catalyst nanoparticles on a high-surface-area carbon support material. Dynamic fuel cell operation was simulated using cyclic voltammetry experiments and site specific degradation mechanisms of single nanoparticles were evaluated by performing intermitted TEM studies on identical locations. Our results reveal dissolution and agglomeration to be the main degradation mechanisms. Continuous fuel cell operation gives rise to a further degradation mechanism: dissolution of the Pt and Ru catalyst particles promote the diffusion of the concomitantly formed ions into the membrane where they precipitate with different crystal structure and composition. Finally a band of nanoparticles was observed in the membrane adjacent to the cathode catalyst layer.



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4. K. Hengge, C. Heinzl, M. Perchthaler, D. Varley, T. Lochner, C. Scheu, Journal of Power Sources 2017, 364, 437.

Biography

Katharina Hengge studied Chemistry at the Ludwig-Maximilians-University in Munich. After finishing her Master degree in 2013, she started her PhD work at the Max-Planck-Institut für Eisenforschung GmbH in Düsseldorf. The scope of her PhD work is the degradation analysis of polymer-based fuel cells. Knowledge of the parameters that influence different operation related degradation mechanisms helps improve the fuel cells´ overall performance and elongate their lifetime. She completed her PhD in September 2017.

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3rd International Conference on

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New methodology developments based on electrochemical noise analysis of PEMFC

Anthony Thomas[1], **Serguei Martemianov**[1], **Radouane Maizia**[2] and **Abdelhafid Dib**[2]
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[2]University of Bejaia, Algeria

Recently, there is an active research and developments applied to new energy sources. One of the most perspective systems on electricity production is the proton exchange membrane fuel cell (PEMFC). PEMFC is potentially beneficial for a wide range of applications, thanks to its attractive advantages, such as high efficiency, high power density, zero greenhouse gases emissions, and low temperature range 50-80°C operation. However, there are still two barriers: the reliability and durability, which imped the wide application of PEMFC. Fault diagnostics can be an efficient solution to overcome these barriers. In this field, method based on informational properties of electrochemical noise is promising. Indeed, it allows developing a diagnostic of the system without perturbation in operation mode. In frame of the present work, electrochemical noise analysis (ENA) was applied to study the effect of the relative humidity and current density in a single PEMFC cell. It has been found that diagnostic features can be extracted by the power spectral density (PSD) and short time analysis of the FC electrochemical noise. The PSD of electrochemical noise versus frequency for fuel cell (FC) operated under constant current mode (8 A) is presented in Figure (1a). It was revealed that in low frequency range (f<100 Hz) the PSD highlighted a linear slope of α=2 for all relative humidities except RH=20/20. When the membrane is under dry conditions (RH=20/20), PSD shows a different signature with slopes behavior divided in three parts (α=1.63, 3.98 and 1.82). Under flooding or drying conditions, short time analysis shows an explosion of the noise due to inoperative conditions. In conclusion, ENA is very sensitive to changes of operating conditions of the FC and can be a powerful tool for the detection of an incorrect water balance (drying and flooding).

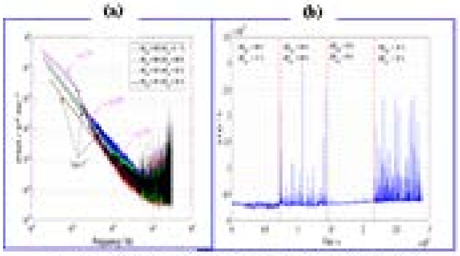

Fig. 1. (a) Power Spectral Density vs frequency and **(b)** Short time analysis for different humidities at I = 8 A.

Recent Publications:

1. R Maizia, A Dib, A Thomas and S Martemianov (2017) Proton exchange membrane fuel cell diagnosis by spectral characterization of the electrochemical noise. Journal of Power Sources 342:553-561.
2. R Maizia, A Dib, A Thomas and S Martemianov (2017) Statistical short-time analysis of electrochemical noise generated within a proton exchange membrane fuel cell Journal of Solid State Electrochemistry 22:1649.
3. B Legros, P X Thivel, Y Bultel and R P Nogueira (2011) First results on PEMFC diagnosis by electrochemical noise. Electrochemistry Communications 13:1514–1516.

Biography

Anthony Thomas has his expertise in heat, mass transfer and charge transfer applied to electrochemical systems (fuel cell, battery). His metrology developments based on temperature sensors and electrochemical noise analysis generated descriptors that help the diagnostics of these systems.

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Impacts of cell reversal on Li-Ion batteries in western world and it's significants

Bernice Amponsa
Rana Motors, Ghana

Cell inversion in lithium particle batteries is the state of the anode electrochemical potential transcending that of the cathode, bringing about a negative voltage estimated at the phone level. There are two essential responses that happen at the anode at high possibilities which increment cell impedance: oxidation of copper current gatherer, and oxidization of the carbonate electrolytes to Carbon dioxide. At the cathode, the decreasing potential can prompt the electrodeposition of copper to frame dendrites, which represent a shorting hazard in the event that they connect the anode and cathode. Cell inversion can be caused by inadequately coordinated cells, a disappointment of the battery administration gadgets, or a blemished cell in a pack. Under these conditions, one or a few of the cells can go into inversion causing execution diminishes or even an unsafe warm runaway occasion. This paper analyzes a pack of business 18650 Li-particle cells in reproduced geosynchronous circle test under conditions where at least one cells were constrained into inversion. Duracell cells were coordinated and collected into a pack to make a virtual cell. Estimations were gathered utilizing coordinated current shunts, and cells were cycled at a 60%, yet with just 90% of evacuated charge supplanted each cycle to reenact a battery administration framework disappointment. After disappointment, cells were non-ruinously inspected utilizing CT X-beam, and afterward analyzed for disappointment examination. The parallel cell pack worked far into inversion, with up to four finish cycles finished before all cells shorted. CT X-beam outputs of the cells subsequent to shorting distinguishable measures of copper dendrites in the cell, and exhibited the main nondestructive test for cell inversion in Li-particle. Hazardous physical investigation of the cells demonstrated broad copper erosion at the anode current gatherer and additionally copper dendrites that were found to have completely entered the separator in chose regions. These outcomes demonstrate that these cells can work a few cycles into profound inversion without going into warm runaway, regardless of the watched development of copper dendrites which penetrate the cell separator. This has solid ramifications on cell wellbeing and battery administration.

Biography

Bernice Amponsa is a procurement manager at the Rana Motors, Ghana.

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Selection of safe salt-in-carbonate electrolytes for lithium-ion batteries

Zhengqi Wang[1, 2], **Andreas Hofmann**[1] and **Thomas Hanemann**[1, 2]
[1]Karlsruhe Institute of Technology, Germany
[2]University of Freiburg, Germany

While proceeding to drive down costs and boosts capacity, lithium-ion batteries (LIBs) face challenges in safety issues, such as the storage reliability, the cell safety in terms of burning and thermal runaway and the work stability of the electrolyte. Our focus is therefore the prevention of these main risks associated with electrolytes. For preparation of suitable "salt-in-solvent" electrolyte mixtures, selected thermal stable conducting salts, e.g. lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium tetrafluoroborate ($LiBF_4$) and lithium difluoro(oxalate)borate (LiDFOB) were dissolved in several high-boiled carbonates. The carbonates of different structures are available, e.g. cyclic ethylene carbonate (EC), propylene carbonate (PC), 1, 2-butylene carbonate (1, 2-BC) and fluoroethylene carbonate (FEC), and e.g. linear dibenzyl carbonate (DBC) and dipropyl carbonate (DPrC). Various possibilities inspired the interest to understand the relationship between molecular structures, composition of components and the properties of the electrolyte mixtures. Regarding the practical use, the solubility and chemical stability of salt-carbonate mixtures were investigated. We measured physicochemical properties (phase transition behaviour, density and viscosity) to draw a picture of interaction between ions and carbonate molecules. The temperature dependent viscosity η and ions conductivity κ of the mixtures could be well described by the empirical Vogel-Fulcher-Tammann (VFT) equation and correlated by the fractional Walden rule. The flow activation energy Ea was calculated and compared with each other regarding to Angell fragility concept. The electrochemical stability obtained by the cyclic voltammetry revealed the oxidative potentials of selected mixtures. The aluminum (Al) corrosion of mixtures with and without additives (e.g. lithium bis(oxalato) borate) was investigated by cell-cycling versus Li/Li+. Charge-discharge cycling performance of the electrolyte mixtures were investigated by full-cell tests using $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ and graphite as electrode materials. Due to the electrochemical damage or the Al corrosion, electrolytes might show unstable cycling results (e.g. irreversible loss of discharge capacity (mAh/g), capacity conservation problems). These phenomena could be significantly improved or avoided by utilizing additive, which forms a passivation film on the electrode surfaces. Besides, the flash point (>140°C) and the burning tests for the selected mixtures revealed safety improvement regarding to the practical aspects such as the vapour-leakage of the boiled electrolytes. In summary, the electrochemical measurements showed various properties influenced by the structure/composition and indicated that novel electrolyte mixtures could be regarded as stable and better performance candidates for basic electrolytes in lithium-ion batteries for safety improvement compared to state-of-the-art low boiling electrolyte mixtures.

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2. A Hofmann et al., (2014) Anodic aluminum dissolution of LiTFSA containing electrolytes for Li-Ion-batteries. Electrochimica Acta 116:388-395.

Biography

Zhengqi Wang received his Bachelor degree in Material Science and Technology from Tongji University, China and a Master degree in Material Science and Material Technology from Karlsruhe Institute of Technology (KIT). From 2016 as a PhD student, he worked at Institute for Applied Materials (IAM-WK) of KIT. His research focus is the safety improvement of lithium ion battery by combination of innovative strategies with the different parts in batteries such as electrolytes, electrode materials. The various physiochemical characterizations, electrochemical measurements and cell tests will be used for analysis of the properties and the performances of lithium ion batteries.

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In situ synthesis of 3DC-NiS_2-CNTs as a multi-functional host for Li-S batteries

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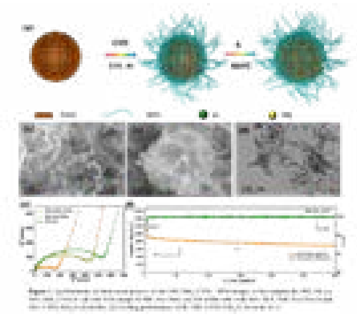
Lithium sulfur (Li-S) batteries are promising to be the next generation energy storage devices. Unfortunately, there are still many challenges for the practical application of Li-S batteries, such as the insulation of sulfur and the "shuttle effect" of lithium polysulfides (LiPSs). The introduction of carbon materials as a light, high electronic conductive host for sulfur and the inorganic compound as the polar host for the LiPSs has made some progress in solving these problems. Herein, for the first time, we present a new synthetic route to obtain the three-dimensional carbon-NiS_2-carbon nanotubes (3DC-NiS_2-CNTs) composites as the multi-functional host for Li-S batteries. The 3DC and CNTs are connected by the NiS_2 nano particles, which serves as both effective entrapment and catalysis for LiPSs. The effective combination of graphene, CNTs and NiS_2 can not only inherit their individual advantages, but also herald a new multi-functional nanostructured material with unexpected properties. As a consequence, electrochemical performance of the Li-S batteries employing a 3DC-CNTs-NiS_2 host was enhanced significantly. The cell exhibits a high initial capacity 946 mAh g^{-1} and stable cycling performance at 1 C with a fade rate of 0.093% per cycle over 300 cycles.



Recent Publications:

1. Zhong Y, Yin L, He P, Liu W, Wu Z and Wang H (2018) Surface chemistry in cobalt phosphide-stabilized lithium-sulfur batteries. Journal of the American Chemical Society 140(4):1455–1459.
2. Paolella A and Zaghib K (2018) The Role of Metal Disulfide Interlayer in Li-S Batteries. Journal of Physical Chemistry C 122(2):1014-1023.
3. Babu G, Arave L M R (2017) Transition Metal Dichalcogenide Atomic Layers for Lithium Polysulfides Electrocatalysis. Journal of the American Chemical Society 139(1):171-178.

Biography

Ning Wang entered into Nanjing Tech University to study Metal Material Science and Engineering in 2008, and received his Bachelor degree in 2012. Then he continued to study Post graduation degree in Nanjing Tech University, engaged in research on lithium sulfur batteries. And he received his Master degree in 2015. After that, he entered Tianjin University to study PhD and his research direction is still lithium sulfur batteries.

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