Cambridge EnerTech
A Division of Cambridge Innovation Institute

Final Agenda

aabc ASIA

Inaugural

advanced automotive battery conference

May 19-23, 2014 • International Conference Center • Kyoto, Japan

AdvancedAutoBat.com/Asia

COVER

CONFERENCE CHAIRS

SYMPOSIUM 1
Large Lithium Ion Battery Technology & Application

SYMPOSIUM 2
Advanced Automotive Battery Technology, Application & Market

TUTORIALS

POSTER SESSION
- Lithium-Ion Cell Materials
- Cell Design
- Battery Management, Testing, and Simulation
- and Other Topics

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AABC ASIA 2014

Conference Chairs

International Conference Center | Kyoto, Japan


Menahem Anderman, *President, Advanced Automotive Batteries*


Michael Lord, *Senior Principal Engineer, Vehicle Regulation and Certification Engineering, Toyota Motor Engineering & Manufacturing NA*


Tadatoshi Asada, *Head, Engine Electrical Systems Engineering Division, DENSO Corporation*


Heinz-Willi Vassen, *Manager Energy and Storage Systems, Audi AG*


Minoru Noguchi, *Chief Engineer, Honda R&D Co., Ltd.*


Ted J. Miller, *Senior Manager of Energy Storage Strategy and Research, Ford*


Takeshi Miyamoto, *Engineering Director, EV Energy Development Department, Nissan Motor Co.*


William Wallace, *Director, Global Battery Systems, General Motors Co.*


Yoshio Ukyo, *Professor, Office of Society-Academia Collaboration for Innovation (SACI), Center for Advanced Science and Innovation, Kyoto University*


Martin Winter, *Chair, Applied Material Science for Energy Conversion and Storage, MEET Battery Research Center, Institute of Physical Chemistry, University of Muenster*


Chika Amemiya, *Senior Manager, Development Division, Automotive Energy Supply Corporation*


Robert Spotnitz, *President, Battery Design LLC*


Mo-Hua Yang, *General Manager, TD HiTech Energy Inc.; President, EnergyBus e.V.*


Tatsuo Horiba, *Professor, Advanced Lithium Batteries, Mie University*

SYMPOSIUM 1

Large Lithium Ion Battery Technology and Application

Tuesday, May 20 to Wednesday, May 21, 2014 | International Conference Center | Kyoto, Japan

NEXT-GENERATION CELL MATERIALS

Next Generation Li-Ion Cell Materials

Yoshio Ukyo, Professor, Office of Society-Academia Collaboration for Innovation (SACI), Center for Advanced Science and Innovation, Kyoto University

Advanced Materials Development for Li-Ion Batteries

Kisuk Kang, Professor, Department of Materials Science and Engineering, College of Engineering, Seoul National University

High-performance and cost-effective rechargeable batteries are key to the success of electric vehicles and large-scale energy storage systems. Extensive research has focused on the development of new high-energy electrodes that can store more lithium. However, the current status of lithium batteries based on redox reactions of heavy transition metals still remains far below the demands required for the proposed applications. In this presentation, we introduce two novel approaches toward transition metal-free cathode materials. In the first part, it is demonstrated by using tunable functional groups on graphene nano-platelets as redox centers. The electrode can deliver high capacity of 250 mAh g^{-1}, power of 20 kW kg^{-1} in an acceptable cathode voltage range, and provide excellent cyclability up to thousands of repeated charge/discharge cycles. The simple, mass-scalable synthetic route for the functionalized graphene nano-platelets is also proposed. In the second part, we utilize a redox center from biological system. Energy transduction and storage in biological systems involve multiply coupled, stepwise reduction/oxidation of energy-carrying molecules such as adenosine triphosphate (ATP), nicotinamide, and flavin cofactors. Here, we demonstrate a biomimetic approach to design high-performance energy devices based on the analogy between energy-storage phenomena of mitochondria and lithium rechargeable batteries. It is found that flavins such as vitamin B2 and lumiflavine are capable of reversibly storing lithium by using redox-active nitrogen atoms in the diazabutadiene motif during battery operation. The energy density of the flavin cathode (i.e. 510 Wh kg^{-1} for lumiflavine) can compete with those of the commercial inorganic electrode materials such as $LiFePO_4$.

Materials and Application Challenges of Layered Li-Excess Mn-Ni Oxide Cathode

Nick Wu, Distinguished Professor, Department of Chemical Engineering, National Taiwan University

The class of layered Li-rich Mn-transition metal oxides with a general formula of $Li_{1+x}(Mn,M)_{1-x}O_2$ has lately drawn attention due to their high capacities greater than 200 mAh/g. In these materials, the excess Li ion gives rise to the presence of inter-grown Li_2MnO_3 within $Li(Mn,M)O_2$ matrix to form a layered "composite" structure. Li_2MnO_3 is transformed to electrochemically active MnO_2 by removal of Li^+ upon charging above 4.5 V (versus Li/Li^+) and stabilizes the layered structure under deep lithiation/de-lithiation cycles. This presentation discuss on the synthesis and application issues of $Li_{1+x}(Mn_{0.6}Ni_{0.4})_{1-x}O_2$.

- Synthesis and fundamental properties:
- continuously stirred reactor process for making spherical powder
- synthesis-structure-performance relationships
- inhibition of potential fading
- oxide/graphite full cell charateristics
- Electronic conductivity issue:
- surface conductive coating.
- conductive-coated Al current collector
- Characterization of Si/oxide full-cell
- Li-ion compensation
- Voltage-capacity relation

Element Selective Evaluation of Cation Mixing by Anomalous Scattering X-ray Diffraction

Kenji Sato, Assistant Chief Engineer, Technology Development Division, Honda R&D

Specific Bragg reflection intensities of Li-rich layered oxide were monitored on scanning the X-ray energy around the K-edge of Ni, Co and Mn. The experiments were conducted at BL28XU of SPring8. Site exchange of Li and transition metal cations can be detected by intensity change of anomalous scattering. We can identify the transition metal element engaged in cation mixing by knowing at which absorption edge of elements the intensity change occurred. This new method can be a powerful tool to study degradation mechanism of battery active materials.

Interface between Lithium and Solid Electrolytes

Osamu Yamamoto, Professor Emeritus, Mie University

Lithium metal is the best anode candidate for high energy density batteries, because it has very high theoretical specific capacity of 3861 mAh g^{-1}. However, the formation of lithium dendrite during lithium deposition limits the use of lithium metal as the anode in lithium batteries with liquid electrolyte. Much effort has recently been focused on lithium metal electrode with solid electrolytes. This presentation will discuss the key issues facing a lithium dendrite formation between lithium metal and solid electrolyte. These issues include:

- Stability of the interface between lithium metal and solid polymer electrolytes
- Lithium dendrite formation on the interface of lithium metal and polymer electrolytes
- Stability of the interface between lithium meal and garnet-type solid lithium ion conductor of $Li_7La_3Zr_2O_{12}$
- Lithium dendrite formation on the interface of lithium metal and $Li_7La_3Zr_2O_{12}$

ROADMAP FOR LITHIUM-ION CELL MATERIALS DEVELOPMENT

Progress of Laminate Cells and Requirements of Battery Materials for xEVs

Chika Amemiya, Senior Manager, Development Division, Automotive Energy Supply Corporation

Since 2007, Automotive Energy Supply Corporation (AESC) has been developing the lithium Ion batteries for xEVs. In 2010, AESC launched mass productions of lithium Ion batteries with laminate structure. ESC's batteries have been installed for LEAF, KANGOO, FUGA, SKYLINE, etc. In January 2014, the selling volume of battery pack for LEAF surpassed 100,000 units that is

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equivalent to 2,400MWh as energy. Key factors of the lithium Ion batteries for xEVs are as follows:

1. High energy
2. Low cost
3. High reliability
4. Long life

What is the difference between the large batteries for xEVs and the small batteries for consumer use? Three major points are as follows:

1. LIB system for vehicle application requires about 100 to 200 cells.
2. Requirement for reliability is severer than consumer use.
3. Requirement for life is 5 to 10 years.

This presentation obtained about the laminate cell progress of AESC at this moment and requirements of battery materials which conduct the market expansion of xEV.

Roadmap for the Development of Lithiated Metal-Oxide Cathodes with Enhanced Performance

Dong Joon Ihm, Director Global Applied Technology, Research & Development, Umicore

Since the introduction of lithium ion batteries in early 1990s there have been continuous improvements in energy densities of the batteries mainly focused on lithium cobalt oxides / graphite systems. On the otherhand lithium ion batteries for automotive application needs not only performance improvement but also cost reduction. To lower $/kWh ratio for automotive cells different type of cathode and anode materials needs to be considered. Among the cell components, the cathode material is the biggest driver for improving performance and choosing the right cathode material platform is the key for future success.

This presentation discusses:

- Presenting Umicore, global leader in active battery materials
- Review on the evolution of energy density of lithium ion batteries
- Update on cathode material developments at Umicore

Anode Development for xEV Batteries

Jian-Guo Ren, Deputy Director, Institute of New Energy Technology, BTR New Energy Materials, Inc.

The anode material plays a critical role in determining the performance of xEV batteries. For meeting the increasing demands of various types of xEV batteries, many different categories of anode materials have been fully developed in Shenzhen BTR New Energy materials Inc. including natural graphite, artificial graphite, MCMB, soft carbon, SiOC, Si-C, LTO, and their composites. The progress of these advanced materials in BTR will be discussed in the conference.

Topics covered:

1. The artificial graphite and MCMB with high energy density applied in xEV.
2. The soft carbon with high power density, low temperature discharge and safety capabilities applied in xEV.
3. Si-based materials with high energy density and good cyclability applied in xEV.

Recent Development of Silicon-Based Anodes at Shin-Etsu

Tetsuo Nakanishi, Chief Researcher, Shin-Etsu

Properties of Si based anode materials;
Si, SiO and SiOC

- Structural property
- Chemical property
- Electrical property
- Application for high energy density batteries
- Vehicle application

Electrolyte Development for xEV Batteries

Qiao Shi, Chief Technology Officer, Lithium Division, Shenzhen Capchem Technology Co., Ltd.

Compared with batteries for consumer electronic market, xEV batteries have much higher performance requirement, especially in cycle life, high temperature storage, low temperature discharge and safety. Electrolyte plays a very important role in determining those battery performances. There are different chemistry applied in xEV batteries aimed at different applications, and the main difference lies in the cathode. Almost all xEV batteries using graphite in anode, but there are several different choices in cathode, and typical solutions are as following:

1. LFP for EV/PHEV batteries
2. LMO+α for EV batteries
3. NMC for HEV/PHEV/EV batteries

These cathode materials have very different performances, especially in cycle and storage. And these differences come from different electrochemical stability of cathode in electrolyte, which including two important aspects:

1. Metal dissolution from cathode
2. Electrolyte decomposition on cathode

For each typical cathode material, the stability of cathode in electrolyte was analyzed and the effect of additives was analyzed and discussed as a key point of electrolyte.

Influence of Cell Materials on Li-Ion Battery Cost

Klaus Brandt, Head of Technology & Business Development, Business Line Energy Storage, Clariant Produkte GmbH

Li-Ion batteries are in constant development with a focus on increasing energy density and reducing cost. Cell materials are more than half of the cell cost and therefore there is pressure on industry to reduce the cost of today's materials. However, it is not only the cost of an anode or cathode material per kg or per Ah that influences cell cost; it will be shown that other properties are just as important. Developers of advanced materials for tomorrow's Li-Ion batteries usually put the emphasis on increasing specific energy and energy density. How the properties of the new active materials affect the battery cost is less often considered. In this presentation the influence of anode and cathode material properties and the influence of some cell design parameters on energy density and cost at the cell level are analyzed using a simple mathematical cell model. The relationship between material properties and electrode design will also be discussed. Some indication of the influence of material properties on cost at battery system level is also given. The following parameters will be examined for both anode and cathode materials:

- Specific capacity of active materials
- Electrochemical potential of active materials
- Active material density
- Electrode density
- Electrode area capacity
- Choice of binder and conductive agent

The results give a direction for the development of active material properties with improved energy density and cost.

The Possibility of "Pouch" in xEV Battery

Masataka Okushita, Division Director, Dai Nippon Printing

We launched our laminated film for automotive LIB market in 2010. This product is the culmination of our experiences and our studies in mobile LIB market more than 15 years. Test items for automotive LIB market themselves, e.g. retention period, are not different from that for mobile phone LIB market, but required performance level is totally different in the point of the hurdles. For years, several users have made variety of trials and requested a lot. Based on their requests, we have been providing further insights into our products. The result of these process our products have been commercialized. Now

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we will present the key factors of our insights and requirements that are needed for the future.

1. How to check the sealing performance and barrier properties
2. Concept of transport vibration intensity and safety valve for heat and pressure
3. Electrical insulation properties which cause corrosion
   - Requirement for electrical insulation
   - How to check its values
4. Outer Chemical resistance against automotive principal liquid

LiB Materials Market Trends

Sachiya Inagaki, Seoul Branch Office General Manager, Yano Research Institute

Li-ion batteries have been used as a power source for a variety kind of applications including electronic devices, automobiles, and energy storage systems. In the Li-ion battery market, cell makers are required to improve their product properties and cost performance in order to meet different specifications and requirements of each application market and so do the material makers. Under these circumstances, Chinese material makers are emerging rapidly and encroaching on the material markets, benefiting from the strong domestic Li-ion battery market and cheap manufacturing costs. In this presentation, we will take a detailed look at the current trends and future prospects of the Li-ion battery and material markets. Topics covered:

- Overview of the Li-ion battery market
- Overview of the four major Li-ion battery material markets (cathodes, anodes, electrolytes, and separators)
- Future prospects of the Li-ion battery and material markets

LIGHT- AND SPECIALTY-EV TECHNOLOGY AND MARKET

Battery Market for Light Electric Vehicles

Hiroshi Mukainakano, Vice President, B3 Corporation

LEVs (Light Electric Vehicles, typically weighs less than 100kg) are one of the largest electric vehicle markets. The pace of growth in the LEV industry has continued with greatest strength in China today. But most of all Electric bike equipped Lead-acid battery because of cost performance in China. On the technology side, Lithium ion powered electric scooters have developed in Taiwan. PEDELCs (Pedal Electric Bicycle) are getting popular in Japan and EU these utilize Lithium ion. In this session, how batteries are used for LEVs and explain battery demand in near future with market record.

Lithium-Ion Battery for a Dual-Battery System in a Car Utilizing Conventional Technology

Gaku Kamitani, Manager, Design Section 2, LIB Business Development Group, Murata Manufacturing Co., Ltd.

Dual battery system largely attracts interest especially from automotive industries. Combination of a cheap and large capacity lead-acid battery and a high power and effective lithium-ion battery seems complementary each other to make a satisfactory battery with reasonable cost. There is a challenge residing in the difference of their operational voltages, however it is publicly known that a lithium-ion battery possessing a certain characteristic should overcome the difficulty. In the presentation, Murata's challenge to realize such a lithium-ion battery is discussed. Murata's approach is to make the best use of conventional technology, avoiding development of a novel technology as possible. Specifically we will:

- Review automotive dual battery system of our interest
- Summarize the requirements for the lithium-ion battery in the system
- Introduce an example of the design of the lithium-ion battery
- Discuss the challenges to overcome

High Performance Lithium-Ion Battery for Motorcycles

Kazunori Ozawa, Li-Ion Cell Design and Manufacturing Consultant, Enax, Inc.

Moped has been popular for commuting for a long time, but the sales have been gradually declined because of diversification of commuting systems. However bigger motorcycles are becoming popular and the sales are expected to increase one million in 2020 in Japan. The reason is that motorcycles more than 250 cc are used not only for daily life but also for sports, leisure and other hobbies. Especially the riders of 1000 – 1200 cc motorcycles desire active driving and good feeling. Then lithium ion batteries were used for the starters of motorcycles and the tastes of the driving were examined. Considering the voltage from a generator the battery pack was constructed with 6-series and 2-pallarels using 1.45 Ah cells. The cathode and the anode materials were LNO and LTO, respectively. The performances of these cells were also investigated for taking account of the future vehicles.

Recent 18650 Li-Ion Battery Development for EV/LEV Applications

Mo Hua Yang, General Manager, TD HiTech Energy Inc.; President, EnergyBus e.V.

Thanks to the mass market of NB applications in the past 20 years,18650 cylindrical type cell becomes a mature standard Li-ion battery. Today, more than 1 billion 18650 cells produce to the market every year for different applications. Highly automatic manufacturing process leads to 18650 cell has high uniformity and quality. Low cost, high performance and high safety design experience are the 18650 cell advantage as well. It makes the 18650 cell consider using for EV applications. This presentation will discuss:

- LEV market developing trend
- 18650 cell developing status
- 18650 cell design consideration for EV/LEV
- Characteristics of current NCA-based high capacity 18650 cell
- Conclusions and Outlook

Public Transportation Powered by Wanxiang A123 Systems Asia

Xinbao Gao, Chief Technology Officer, Wanxiang A123 Systems Asia Ltd.

Public Buses play an important role in China, yet the diesel engines worsen the air pollution of metropolitan areas. WxAA provides a battery solution to electrify buses. The battery system is composed of several sub-pack systems to get the >100Km driving range. Each Sub-pack is integrated with the thermal control and battery management system. The modular structure design is applied to flexibly make the prismatic pouch cells into different S/P configurations. The battery system has been successfully deployed in many cities even the low temperature north China area.

1. WxAA Company Introduction and Business Focus
2. Battery Cell Products and Roadmap
3. Battery Systems for Public City Buses
4. Low temperature solution
5. Practical Applications in China

Battery Systems for Commercial and Industrial Electric and Hybrid Vehicles: Technical Challenges

Beatrice Lacout, Business Development and Sales Manager, Saft Industrial Battery Group

Challenges and stakes in the commercial and industrial electric and hybrid vehicles market

Within all vehicle applications, a special focus will be put on commercial and industrial vehicles.

- Off road vehicle segment: forklifts, AGV, Underground and surface mining truck, Farm and forest trucks,

Construction equipment, Airport Ground Support equipment, Seaport yard tractors…
- On road vehicle segment: Buses and public transportation, Delivery trucks
- Off road outdoor vehicles represent an untapped potential as they are switching from internal combustion engine to electric or hybrid drive.
- Range of operating voltage and typical energy need will be presented by main application segment
- Such industrial and commercial applications require either a lot of power or a lot of energy and often both. Moreover, industrial and commercial vehicles represent a very wide range and large diversity of applications. Both above specificities of this vehicles segment bring complexity in the battery design.

Main technical challenges in system battery development

(Discuss process to develop the battery: cells, modules, BMU with angle of safety -Talk about Matlab…).
- Battery sizing strategy: what customer wants vs what battery manufacturers can offer?
- Simulation tools and process for optimum sizing
- Design of the system and validation process

Saft standard offer for industrial and commercial electric vehicles

(Some example of integration from cells to modules to complete battery system will be given)

SYMPOSIUM 2

Advanced Automotive Battery Technology, Application and Market

Wednesday, May 21 to Friday May 23, 2014 | International Conference Center | Kyoto, Japan

xEV AND xEV-BATTERY MARKET

U.S. Electrified Vehicle Market and CARB ZEV Regulation Impact

Michael Lord, Senior Principal Engineer, Toyota Motor Engineering & Manufacturing

Toyota is committed to advancing vehicle electrification in the US market with 12 models of Hybrid Electric Vehicles (HEVs), the Prius Plug-in Hybrid, the RAV4 EV, the iQ EV and, in 2015, our Fuel Cell (electric) Vehicle (FCV). In the 2013MY, there were 15 models of Plug-in Electric Vehicles (PEVs) offered for sale by nearly a dozen manufacturers and it is expected that these offerings will increase significantly in 2014. This presentation will take a closer look at the state of the PEV market and will touch upon the following:

- PEV Usage Data
- Owner Demographics
- Market Data and Drivers
- Regional Market Differences

Much of the sales growth is driven by California's Zero Emission Vehicle (ZEV) regulation which requires manufacturers to sell an increasing number of ZEVs with an overall target for compliance of approximately 15% of sales in 2025. This presentation will also provide a brief review of the ZEV regulation while assessing the current state of market development with a focus on customer acceptance.

Competition and Cooperation in Asia xEV-Battery Industry and Market

Mark Lu, Certified Senior Industrial Analyst, Industrial Economics & Knowledge Center (IEK), Industrial Technology Research Institute (ITRI)

For the global xEV and related battery players, Asia market may become the next growing opportunity. China, Japan, Korea and South-East Asia countries involve in the xEV promotion and provide policy subsidy. However, there are still some barriers like trade protectionism, local competitors exist. Facing the attractive and threatening status, cooperation method may another better way for global and local players both. This presentation will introduce the competition and cooperation in Asia xEV market as below:

1. Present Asia xEV and Battery Market Potential: China, Japan, Korea, HK and South-east Asia.
2. Competition Status:
   - Trade Protectionism
   - Battery Technology Sharing Request
   - Local Venders Threatening
3. Cooperation Viewpoint:
   - Local Strategy for Assembly, Production and Material Supply Chain
   - 50/50 Joint Venture ICE Experience in xEV?
   - For the Joint Venture, not only company can choose…

Market Trends for xEV Batteries

Hideo Takeshita, President and CEO, B3 Corporation

Five years have passed since the start of mass production of Li-ion battery for xEV in 2009. Market expansion at this moment is a bit slower than the original expectation but the quality and technical reliability of Li-ion is proven by the first generation chemistry and cell structure. With the second generation product using advanced NCM cathode, xEV and battery market will enter the second stage from CY15. At the presentation, the following topics are discussed to understand the short to long term market trends.

- Original xEV market forecast until 2012
- LIB supplier status for xEV; shipment volume & MWh, production capacity
- OEM-battery supplier relationship update
- Cost composition of xEV cell/module/pack
- Technology & Cost roadmap for prismatic & pouch type cell
- Outlook for 48V Micro HEV

xEV Market Direction: The Role of Regulations, Customer Interest, and Battery Technology

Menahem Anderman, President, Advanced Automotive Batteries

The current wave of vehicle electrification started in 1997 with the introduction of the Toyota Prius. Regardless of the level of electrification, geographical region, and class of vehicle, three factors played a key role in vehicle development and market offerings: i) regulations and incentives from governments, ii) customer interest, and iii) vehicle and (predominantly) battery technology. This presentation will show how the interactions of these three factors continue to shape the new electrified-vehicle offerings from micro-hybrids to full EVs, with the European CO2 legislation, the California Air Resources Board's Zero-Emission-Vehicle legislation, and the Chinese New-Energy Vehicle laws driving different vehicle offerings in the world's three largest automotive markets.

We will discuss:

1. Vehicle architectures from micro-hybrid to full EV
2. Battery-technology solution for each architecture
3. xEV market
4. xEV-battery market

Market Update on China LIB Industry: from Materials to xEV

Xiaoyu Zhang, Analyst, China Industrial Association of Power Sources

Currently, environmental issues like air pollution can no longer be overlooked in China, where developing new-energy vehicles xEV becomes a solution and the foremost priority over the next six years to 2020. The government aims to achieve a new-energy vehicle sales of 500,000 units annually by 2015, and the investment in this industry would be at least 10 billion RMB per year. However, the ultimate goal is not only for government demonstration, but to push xEV in everyday life as well. In addition, lithium-ion batteries (LIB) are considered as the key components for xEV. Taking this background, the market update

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on China LIB industry in 2013 will be fully presented in this report.

- Upstream: LIB materials review by segment
  1. Cathode
  2. Anode
  3. Separator
  4. Electrolyte
- Midstream: LIB
  1. LIB review: from mobile devices to xEV application
  2. Key LIB players assessment
- Downstream: xEV in China
  1. xEV market: government attitude vs. customer interest
  2. Strategy trend of main OEMs

The presentation will end with a forecast on key factors to succeed in the battery business in China based on the previous discussion.

Chinese xEV Market Development

Jack Zhang, Chief Executive Officer, Gaogong Industry Research Institute

The Chinese xEV market has experienced difficult time since government policies makers have been wavering in developing of HEV or EV in the past years. To make saver EVs, all the Chinese EV makers choose low energy capacity cells which take LiFePO4 as cathode material. Low driving mileage and lack of battery charge station or poles are two main factors that xEVs are mostly used in public transportation. With Tesla presenting its super performance features, Chinese government is making new subsidies policies to promote the xEVs around the country and enterprises are investing huge capital in developing high capacity cells and xEVs, especially EVs. However, following issues have to be addressed:

- Government has to unite with private enterprises to build up its infrastructure facilities;
- Local markets have to be opened to non-local xEVs makers;
- High energy capacity cells have to be developed and chosen by xEVs makers;
- Chinese xEVs makers have to promote their xEVs' performance to cope with foreign competitors;
- Summary: Chinese xEV market is explosive in every sense of the word and will be the main targets for most xEV makers from the world.

ENERGY-STORAGE REQUIREMENTS AND SOLUTIONS FOR LOW-VOLTAGE HYBRIDS

Micro-Hybrids Fit for the Future: Requirements for an Additional Battery in the 14V Power Supply

Armin Warm, Research Engineer, Ford Aachen GmbH

Micro hybrids are getting higher market shares as they are becoming part of car-maker's CO2 roadmaps. Micro hybrids are becoming also a standard fit for mainstream powertrains. Based on the potential and limitations of regenerative braking in micro hybrid systems for a conventional battery technology, potential optimizations for micro hybrid systems will be discussed. The focus here is on a dual battery system. The presentation outlines the battery requirements of the second battery and its related use cases.

Mazda "i-ELOOP" Regeneration Energy-Storage System and Strategy

Akitomo Kume, Assistant Manager, Mazda Motor Corporation

Mazda commits to offer significant CO2 emission reduction, Driving pleasure and Environment and Safety to as many cars as possible. To make it possible, Mazda adopted a Building Block Strategy of gradually introducing electric devices such as regenerative braking while thoroughly improving the base technology such as powertrain efficiency improvement and vehicle weight reduction with use of the technology called "SKYACTIV TECHNOLOGY". As the second step, Mazda introduced i-ELOOP (Intelligent Energy Loop) that recovers deceleration energy with electricity and reuses it to the electrical components of car in 2012. This system is made up of the variable voltage alternator up to 25V for recovering more deceleration energy, the EDLC up to 25V for charging the generated energy and the Step-down DCDC converter for supplying the energy to 12V devices for efficient recovery of kinetic energy. Mazda improves i-ELOOP functionality further for higher fuel economy at a reasonable cost. The paper will cover:

- Aim of i-ELOOP
- System design of i-ELOOP
- Effects of i-ELOOP
- Potential of i-ELOOP for more fuel saving.

12V Energy Recovery System

Ryuji Kawase, General Manager, Sanyo Electric Co., Ltd.

Hybrid electric vehicles (HEVs) with a battery system have been expanding the eco-friendly car market thanks to their good economy and performance. More simplified Idling Start and Stop (ISS) system compared to HEV system can also improve the fuel efficiency with more affordable cost, and is contributing to the expansion of such eco-friendly car market. For further improvement of the performance, we have developed 12 V energy recovery system using nickel metal hydride (Ni-MH) batteries, and this time the vehicles equipped with the energy recovery system are eventually launched on the market. The 12 V energy recovery system uses nickel metal hydride (Ni-MH) batteries that are combined in parallel with a main lead-acid battery as sub-batteries. The parallel connection of the Ni-MH batteries contributes with their better regain characteristics to increase in recovery energy which can be supplied to the electrical components and realization of an extended life of the lead-acid battery by taking in part the role of the main battery. Toward the next stage, we are examining the feasibilities of hot cranking with sub Ni-MH batteries and of replacing main battery from dedicated lead-acid battery for ISS to lead-acid battery for starting. We aim to contribute to a better global environment by expanding the eco-friendly car market, as well as spreading this energy recovery system.

Toshiba Lithium-Ion Rechargeable Battery "SCiB™"

Shun Egusa, General Manager, Automotive Systems Division, Social Infrastructure Systems Company, Toshiba Corporation

The low-voltage hybrid vehicle, especially 12V advanced Start & Stop (S&S) system is focused because the fuel consumption is effectively improved by the recuperative energy to be stored in the secondary battery, and the further improvements are expected by adding new functions of coasting, re-cranking and motor-assist. Lithium ion battery with Lithium Titanate (LTO) as the anode is recognized to be the best matched with the these low-voltage hybrid system, and Toshiba is only manufacturer which can mass-produces the LTO-basis battery cells, SCiB™, with high-quality, and has been providing the power type of 3Ah cell to the advanced S&S system from 2012. In this presentation, the new product lineup and

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performance of SCiB™ will be introduced for the future vehicle system as follows:
- Tuning of cathode materials to match with the voltage requirement of 12V and 14V.
- Increase of cell capacity and size to provide the more power
- Safety requirement

48V System Development for Premium Cars
Thomas Weber, Manager Energy and Storage Systems, Volkswagen Group Japan

The continuous increase of functionalities such as comfort, safety, driver assistance, infotainment systems, as well as enhanced innovation, raises the demand on a vehicle's electrical power network. In combination with the electrification of powertrain functions and ancillary units for CO2 reduction, these requirements reach the limit of today's vehicle power supply. The 48 Volt Power Supply is an extension of the existing 12 Volt Power Net to enable new functionalities in future. Specifically, this presentation will focus on:
- Upcoming electrical innovation
- Limitation of 12V power supply
- The 48V power supply system approach - Two possible architectures
- Specific requirements on energy storage systems for 48V Systems
- The Audi iHEV approach

Lithium-Ion Battery Technology for Low-Voltage Hybrids: Present and Future
Wonhee Jeong, Senior Manager, Development Center, LG Chem

Lead acid batteries have been the predominant battery technology for conventional 12V vehicle power networks. However, upcoming regulation of CO2 emission and fuel economy draws much attention to low-voltage hybrids based on lithium-ion battery technology, as lithium-ion batteries are lightweight power sources with high recuperation capability. Automotive manufacturers have investigated various 12V and 48V systems with different dimension and performance requirements. Depending on their needs for a pack location and system design, OEMs' interest in cell chemistry varies from conventional carbonaceous anode-based one to LTO anode-based one to LFP cathode-based one. In this talk, current lithium-ion battery solutions to various low-voltage needs will be discussed with a focus on technical challenges in cell design. Also, we will explore future directions for the development of more cost-effective lithium-ion battery technology.

Lithium-Ion Battery Pack for Stop & Start System
Yuki Nagai, Engine Electrical Systems Eng., Division 1, Denso Corporation

Stop & Start(S&S) System using two power supplies, combined with energy regeneration, isan effective technology to reduce CO2 emissions. Lithium-ion battery is an optimal power supply for this system because of its high charge acceptance per weight. We developed the system with low cost and simple structure, which eliminates the DC-DC converter by utilizing a Lithium-ion battery that has voltage characteristics similar to the lead-acid battery. The Lithium-ion battery's range of capacity must be managed appropriately. Therefore, State Of Charge (SOC) detection is very important, and we developed the SOC detection method within the target accuracy. The method adopts the correction system with estimation of OCV during the long time stable electric discharging. It is the characteristic behavior of S&S system.
- Background of the development
- Advanced Stop & Start system
- Lithium-ion Battery Pack
- Detection of Lithium-ion battery condition
- Conclusion

BATTERIES FOR HIGH-VOLTAGE HEVS AND PHEVS

Honda's Technology and Strategy Regarding HEV
Koichi Shinmura, Senior Chief Engineer, Honda R&D Co., Ltd.

Honda developed three kinds of HEV systems so that it may meet social needs and the needs of a market. He introduces the LIB cell adopted as these HEV systems and the feature of three HEV systems. Moreover, he speaks about the characteristic required of the battery for vehicles based on the environment used, what is expected in the future.

High-Energy Automotive Battery Safety Performance and Modeling
Ted Miller, Senior Manager of Energy Storage Strategy and Research, Ford

Advanced lithium ion rechargeable energy storage systems (RESS) are critical to vehicle electrification. However, there are technology challenges which must be mastered in order to ensure RESS safety. Among key challenges are robust controls, active safety systems, and passive safety design. As well, RESS behavior in the event of a crash, or other such safety issues, must be fully comprehended and addressed in the vehicle system design. Finally, a means must exist to effectively assess the safety performance of RESS at the vehicle level. This talk will consider an approach to assessing RESS safety performance within the context of vehicle safety qualification, progress to date, and plans for safety performance modeling tools. The range of efforts undertaken by the Ford Energy Storage and Materials Research Team will be presented. Key topics to be presented include:
- RESS safety performance project status
- RESS safety testing update
- RESS safety performance project plans
- Ford RESS safety research
- RESS safety performance modeling

Energy-Storage Requirements and Solutions for Subaru's Hybrid Vehicles
Kenji Inakoshi, Senior Engineer, Subaru Heavy Industries Co. Ltd.

The high voltage battery system, which is installed in SUBARU XV CROSSTREK HYBRID, is presented. In this battery system, Ni-MH battery, which is superior in safety and durability, is adopted. Furthermore, the design and control management of this battery system are optimized to maximize vehicle performance. The technologies about safety, reliability and control management are mainly presented. Why we chose Ni-MH battery system?
- Battery performance
- Safety
- Reliability
- Packaging (weight, space, and other requirements)
- Cost

SAE Standards for Li-Ion Batteries
Monique Richard, Senior Principal Engineer, Materials Engineering Department, Toyota Technical Center

Safety. Performance. Cost. These are the key metrics to success of Li-ion batteries in xEV applications. Quantifying and understanding the performance of Li-batteries on the first 2 metrics is not trivial, in part because different methodologies are used to measure said performance. Cost can be calculated based on design, but with so many designs in the market it is difficult to imagine how standardization, necessary for sufficient production to get economies of scale, will occur. This presentation will focus on efforts in the US, by the Society of Automotive Engineers (SAE), to

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POSTER SESSION
- Lithium-Ion Cell Materials
- Cell Design
- Battery Management, Testing, and Simulation
- and Other Topics

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address Safety, Performance and Standardization, as well as other initiatives. Key topics include:
- Introduction of the SAE Battery Steering Committee and its activities
- Status of the various battery committees

Battery System Design Approach to Reduce Cost and Weight
Uwe Wiedemann, Senior Product Manager, Global Competence Team, AVL List GmbH
As a result of the permanent search for further reduction measures in battery pack cost, AVL has developed a technological approach to significantly push down production costs and to reduce the weight and to improve the thermal cell management at the same time. The basic idea is to embed cell stacks and consequently a complete battery pack into foam. The foaming technology allows a part count that is minimized to the limit. The cells are covered, protected and isolated by foam. In addition the foam also carries mechanical load and provides a seal encapsulation to the ambient. A typical example of a much cost sensitive application is a 48V Li ion battery pack for a modern mild hybrid powertrain system. AVL has developed such a battery. It includes the following features, which are most cost relevant:
- Use of cost effective pouch cells
- Cell tab clinching
- Foamed in battery cells and E/E components
- Foam replaces housing and structural components
- Simplified electrical safety concept (<60V)

A simple cell stack incorporates the cooling system and the BMS. Finally the battery pack is a compact foam block with only the main electrical terminals, the cooling air inlet and outlet and a LV connector as interfaces. The pouch cells are well insulated against thermal cycling and are well protected from vibration load and external acceleration. The foam prevents the cells and live components from contact with cooling air and condensate. Cell tab clinching, the AVL cell connection method is used to further reduce production costs. Both clinching and the foaming technology itself are very insensitive to production and assembly tolerances. That also allows low cost production tools. Recycling aspects as well as possible cell venting events were considered in the design of the pack. Next to the cost benefit, also the gravimetric and volumetric energy density is excellent due to the fact that the number of components was reduced to the bare minimum.

Optimizing Cell, Module, Pack and Controls Design with Comprehensive Simulation
Sandeep Sovani, Director, Global Automotive Industry, ANSYS Inc.
Large format automotive propulsion batteries are made up of components at many different length scales - starting from electrode pairs at the small scale, and up through cells, modules, cooling system, and to the pack. The performance of these components is governed by widely different physical phenomena including electrochemistry, electric current fields, heat transfer, fluid flow, structural mechanics, and electromagnetics. In a battery pack, these physical aspects are tightly coupled with each other. Further, the performance of each component depends closely on those of others. Therefore, in creating and testing a virtual prototype of an advanced battery, it is necessary to use comprehensive simulation methods based on multiphysics and system integration of sub-component models. This presentation discusses a comprehensive simulation methodology for an advanced automotive propulsion battery. In a single simulation platform, the methodology performs detailed simulations of all design aspects of the battery, starting from models of electrochemistry, cell current and thermal models, cooling system models, equivalent circuit models, bus bar models, controller models, crash crush vibration and fatigue models, and full pack models.

EV TECHNOLOGY, LOGISTICS, AND INFRASTRUCTURE

Current Status and Future Prospects of EV-Battery Development
Takeshi Miyamoto, Engineering Director, EV Energy Development Department, Nissan Motor Co.
In Dec. 2010, the first of the world's mass-produced Lithium-Ion battery EV "Nissan LEAF" was introduced to Japan and US market. As of January 2014, more than a hundred thousand Leaf vehicles were sold globally. The Leaf is the best-selling mass-production EV. Nissan got various feedbacks including a great response about battery reliability. This presentation will discuss optimizing trade-off of battery characteristics based on the premise of reliability, effort for expansion, and so on.

Battery Targets for Future EVs and PHEVs
Bill Wallace, Director, Global Battery Systems, General Motors Co.
The global auto industry has completed the launch of the first generation lithium Ion plug-in electric vehicles and is soon to start launch on the next generation. Using first generation field lessons this presentation will look forward to the Gen2 and Gen3 PHEV / EREV / EV vehicles and their market place of the future. Vehicle level targets will be proposed and translated to battery pack and cell targets. Key technologies and enablers for meeting these targets will also be discussed.

AESC Cells and Pack Development and Roadmap
Shigeaki Kato, President, Automotive Energy Supply Corporation
Nissan Leaf sales achieved 100 thousand units globally in Jan. 2014, and AESC provides Lithium-ion battery as a core component of EV. The key competitiveness for these customers' acceptance of the Nissan Leaf and its battery is as follows.
1. Reliability – not only battery fire reliability, AESC collaborate with vehicle engineer to realize multiple phase reliability.
2. Quality – Through entire battery production process, AESC have been checking around 800 items for each product. And we can trace back from vehicle level to cell one by one if necessary.

Through this presentation, AESC show the wide-range capability of xEV pack and future cell roadmap to keep global No.1 EV battery.

Why is Everyone Excited about Tesla, except the xEV Industry?
Menahem Anderman, President, Advanced Automotive Batteries
Tesla, the wonder kid EV producer, became a household name for the general public and in particular for the investment community within a few months of the introduction of its highly acclaimed Model S Luxury EV. Tesla has already broken many of the industry's common convictions, including:
1. That it is almost impossible for a newcomer to break into the automotive business
2. That practical EVs must be limited to a range of 100-150 miles
3. That EVs are more suitable as small urban vehicles
4. That EVs imply a financial loss to carmakers

The general excitement over the success of the company to date has driven its stock value through the roof and the company's plans are generating additional excitement. Automakers can no longer

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ignore the Silicon Valley wonder kid who entered their territory but their responses vary from a "no impact on our business" type of attitude at one end of the scale to attempts to develop long-range EVs at the other extreme. In this presentation we will:
1. Analyze the ingredients of Tesla's success to date
2. Discuss the pros and cons of Tesla's battery technology
3. Analyze the risk/reward elements of Tesla's approach
4. Discuss the likely responses form carmakers
5. Explore Tesla's potential impact on the xEV battery supply chain

Automobile Battery Development in China
Anthony Wong, Vice President Business Development, ATL Battery
Automobile Electrification in China -- Overcoming Challenges and Seizing Opportunities. China's tremendous economic growth in the last decades has lifted millions of people out of poverty and has created a thriving 300 million plus middle class. This astonishing development and urbanization has also ushered in unintended consequence -- environmental and climate impact, among others. Seldom in modern history has a country faced such an urgent and daunting task of reducing pollution in such a magnitude of scale. AUTOMOBILE ELECTRIFICATION, in which automobile battery development plays a critical role, is now a national policy. This presentation will focus on the trajectory of China's automobile battery development. Topics will include: (1) an update on China's projected xEV market, (2) China's evolving national policy towards automobile electrification, and (3) an overview of China's xEV battery landscape including key players, essential developmental projects and investment opportunities.

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Lithium-Ion Cell Engineering Fundamentals
Robert Spotnitz, President, Battery Design LLC

Lithium-Ion Cell Materials Fundamentals
Martin Winter, Chair, Applied Material Science for Energy Conversion and Storage, MEET Battery Research Center, Institute of Physical Chemistry, University of Muenster

Lithium-Ion Cell Design and Manufacturing
Kazunori Ozawa, Consultant

High-Energy Density Batteries: Advanced Lithium Ion and Beyond
Martin Winter, Chair, Applied Material Science for Energy Conversion and Storage, MEET Battery Research Center, Institute of Physical Chemistry, University of Muenster

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Battery Design and Performance Simulation
Robert Spotnitz, President, Battery Design LLC

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Lithium-Ion Cell Materials

1. Solid-State Battery Formulations: Influence of Compositions and Combinations
Dr. Dee Strand, Wildcat Discovery Technologies
2. Heraeus Porocarb® – a New Class of Additives for Electrodes in Lithium Ion Cells
Dr. Christian Neumann, Heraeus Quarzglas GmbH & Co. KG
3. Analysis of Advantages and Disadvantages of Different Anode Materials and Prospect Outlook
Dr. Wenping ZANG, Tianjin Kimwan Carbon Technology & Development Co., LTD
4. Water-Based PVDF Binder for Improved Performance and Processing of Batteries
Dr. Roberta Colombo, Solvay Specialty Polymers
5. New PVDF Binder for Balanced Flexibility and Adhesion of Electrodes
Milena Stanga, Solvay Specialty Polymers
6. The Electrochemical Properties of the Modified 0.6Li[Li1/3Mn2/3]O2 – 0.4 Li[Ni2/5Co1/5Mn2/5]O2 Cathode Materials for Lithium Batteries
Dr. Hsiu-Fen Lin, Indutrial Technology Research Institute
7. A Comprehensive Approach to the Conductive Carbon Percolation Network in Lithium-Ion Battery Cathodes
Dr. Pirmin Ulmann, Imerys Graphite & Carbon
8. Novel Conductive Carbon Additives for Ultra-High-Density Electrodes
Satoshi Kubota, Nippon Chemi-con Corp.
9. New Carbon Coating Under LFP Active Material Layer Improves LIB Performance
Yusuke Otsuka, Zeon Corporation
10. Development of Novel Carbon Black Conductors for Lithium-Ion Batteries
Dr. Togo Yamaguchi, Asahi Carbon Co., Ltd.
11. Advanced Electrolytes for High-Voltage Lithium-ion Battery
Ran Shi Wang, Nano and Advanced Materials Institute Limited (NAMI)

Cell Design

12. Performance and Application of Lithium-Ion Capacitors
Dr. Chisato Marumo, JM Energy Corporation
13. Fabrication and Electrochemical Performance of a Large-Size All-Solid-State Lithium-Ion Battery
Satoshi Fujiki, Samsung R&D Institute Japan
14. High-Performance Lithium-Ion Aqueous Battery for Large-Scale Energy-Storage, Automobile and Renewable Energy Applications
Dr. Zhumabay Bakenov, Nazarbayev University
15. Synthesis of Hierarchical Porous Sulfur/Polypyrrole/Multiwalled Carbon Nanotube Composite Cathode for Lithium Batteries
Dr. Yongguang Zhang, Nazarbayev University

Battery Management, Testing, and Simulation

16. Failure Analysis Testing of a Cycle Aged Automotive Lithium-Ion Battery Electrolyte
Paul Voelker, Thermo Scientific
17. Analog Electronics for Cell Measurement and Balance in Large Lithium-Ion Battery Packs
Michael Kultgen, Linear Technology Corporation
18. Three-Dimensionally Resolved Simulations of a LiCo02 Electrode Structure Obtained via FIB/SEM
Gaetan Damblanc, CD Adapco Japan
19. Internal Impedance Estimation of Lithium-Ion Battery Using Arbitrary Waveform
Yuki Tominaga, Honda R&D Co., Ltd. Automobile R&D Center
20. Output Fading Mechanism of Mixed Composite Cathode in Lithium-Ion Battery
Kaori Hibino, Mitsubishi Motors
21. Performance Evaluation of Wireless Battery Management System
Dr. Inseop Lee, Navitas Solutions
22. Safety and Performance Testing for Automotive Batteries
Yuichi Aoki, ESPEC Corp.

Other Topics

23. Integration of Aluminium in Lithium-Ion Battery Packs
Dr. Mathieu Grandcolas, SINTEF Materials & Chemistry
24. Lithium-Ion Battery Systems for Fully Electrical and Hybrid Light Aircraft Prototypes
Hichem Smaoui, Airbus Group Innovations
25. Energy-Storage Technology Requirements for Heavy (Hybrid) Electric Commercial Vehicles – A Promising Growing Market and Durability Reference for High-Tech Batteries
Samu Kukkonen, VTT Technical Research Centre of Finland
26. Lithium-Ion Battery Cooling by Direct Liquid Immersion
Prof. Hirokazu Hirano, Kanagawa Institute of technology