Battery Systems in Electric Vehicles: From Present State to Future Systems

Batteries are a major technological challenge in this new century as they are a key method to make more efficient use of energy. Although today's Lithium-ion technology has conquered the portable electronic markets and is still improving, it falls short of meeting the demands dictated by the powering of both hybrid electric vehicles and electric vehicles or by the storage of renewable energies (wind, solar).

A battery system consists of series and parallel connections of single cells to reach its rated electrical requirements (energy, voltage, etc.). There are usually three different cell formats which are used for electric vehicles:

- cylindrical cells,
- prismatic cells and
- pouch cells.

Furthermore, besides the electrolyte and anode material, one of the important characteristic of Lithium-ion cells is the cathode material. The most common cathode materials used in Lithium-ion cells are

- NCA($LiCo_{0.85}Al_{0.15})_2$,
- NMC($LiNi_{0.33}Mn_{0.33}Co_{0.33}O_2$) and
- LFP($LiFePO_4$).

Each cell format as well as each cathode material has its own advantages and disadvantages concerning energy density, lifetime, security, costs and capability of fast charging.

A major challenge on designing a battery system is to find the balanced ratio between the lifetime, energy density, security, costs and the capability of fast charging of a battery system in order to fulfill the defined battery system requirements. Increasing the energy density requires for example a more efficient thermal management, which will increase the costs. On the other hand, the higher the energy of a single cell is, the higher will be the safety efforts in case of a thermal runaway and crash scenarios etc. Moreover, the fast charging will accelerate the aging of today's battery systems due to lithium plating which will decrease the battery's lifetime.

In order to guarantee safe and proper use of Lithium-ion batteries during operation, an accurate estimate of the internal battery cell processes are of importance. These internal processes are for example the internal cell temperature, the pressure inside the cell housing, the internal resistance, etc… . Electrochemical impedance spectroscopy can be used to estimate the internal battery cell temperature. The knowledge of the internal cell temperature will be important especially for safety aspects in order to avoid/retard the thermal runaway and thus a propagation inside the battery system.

Moreover, the electrical impedance spectroscopy provides the possibility to estimate the state of charge as redundancy for the coulomb counting method and the state of health of battery systems by using the electrochemical impedance spectroscopy.

Short biography

Onur Misir is a research engineer within the Powertrain & Energy Systems Department of the Group Research at Volkswagen AG, Wolfsburg, Germany. His research area includes battery systems for electric and hybrid vehicles. He received the Dipl.-Ing. degree in electrical engineering from the Leibniz University Hannover, Hanover, Germany, in 2012, and the Dr.-

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