

# Preface

During the last 10 years, the modern world has seen at least the second attempt to electrify the powertrains of road traffic vehicles. Beyond the battery, which is a key component in this electrification process, all other parts have been further developed. All power devices have made a huge step forward. The combination of powerful control devices and semiconductor enhancements are providing adequate functionality from a customer point of view.

Much research has been conducted on the electrochemical level, and there has been progress made on energy density and cost as well. However, currently there is no electrochemical energy storage system available that fulfils the energy demand of today's drive trains and the related passenger comfort functions. Of course, it is simple to blame the battery and argue that this technology does not cover the needs. On the other hand, we can see that society is embracing the need to be more efficient when using energy, a need which is particularly strong in the area of mobility. Thus, the trend towards the electrification of drive trains is revealing the essential weakness of today's vehicle concepts. In the past, the availability of fossil fuels, with their high energy density, fostered drive vehicle evolution. Due to the limitation of on-board installed energy in storage systems, public awareness of the low efficiency of current vehicles has been growing, and the automotive industry has grasped the demand for more efficiency.

Two developments are anticipated:

- An increase in efficiency on the drive-train level, comfort (HVAC, etc.) and safety functions within a vehicle
- An increase in energy density in terms of energy storage:
  - Energy density will increase on the chemical level
  - Technology integration aspects (e.g. ageing, safety) will become better understood and development processes will be implemented in the automotive industry.

This book provides a comprehensive overview of the current research work in the latter area (i.e. integration). The two main topics of this book, safety and ageing, both directly influence the size and utilization of the applied storage system.

## Articles Related to Safety

In [Chap. 1](#), Martin et al. offer an overview of today state-of-the-art safety standard. Although this standard is well defined in ISO 26262, from an overall system-safety perspective, important processes and methods are still missing. Since safety aspects influence cost, it is essential to understand how different safety measures reduce risk for a new product (e.g. a battery system) that is integrated into the vehicle environment.

In [Chap. 2](#), Trattning and Leitgeb provide an overview of the challenge of mechanical battery modelling in crash/crush battery simulations. The current challenge in this area is to bridge the gap between the battery's micro structures and the need to keep simulation effort manageable. The question is, how simple can a model be made while still preserving its ability to provide all of the necessary information at the vehicle level to enable crash-relevant optimizations.

In [Chap. 3](#), Golubkov and Fuchs focus on the thermal runaway process. Their team is currently working to develop a basic, application-related understanding of this process. The knowledge of this process will enable the creation of a battery system simulation framework that can predict the propagation of thermal runaway within the whole battery and the vehicle as a whole.

## Articles Related to Ageing

In [Chap. 4](#), Pichler and Cifrain describe an approach for modelling the electro-chemical battery cell with all of the necessary details. The major challenge here is to devise a model that covers the physical properties of the cell in nanometre scale (e.g. anode/cathode porosity) while still providing simulation output in a reasonable amount of time and with an acceptable level of quality. The final step is the optimization of the cell design and technology in front of the application (e.g. driving cycle), while also covering major ageing aspects. A detailed model of physical processes always requires real parameters derived directly from physical measurements. In [Chap. 5](#), Weber et al. provide an overview of analytical methods for quantifying the ageing of lithium-ion batteries. Such laboratory work is a necessary input for the models mentioned above. Since a complex model uses parameters that are not directly measureable, in [Chap. 6](#), Scharrer et al. present a mathematical method for parameter optimization. To demonstrate this method, they present the results of a synthetic fitting problem solved by a parallel-adaptive Markov chain Monte Carlo method.

In [Chap. 7](#), Hametner and Jakubek present a data-based, chemistry-independent approach to nonlinear observer design for the state-of-charge (SoC) estimation. In order to operate the energy storage system throughout the required lifetime, knowledge of the SoC is essential, and one of the key factors related to ageing.

One significant challenge for all of these individual approaches towards improved safety and life time of battery systems is the complexity this component adds to the car. Standards in the automotive industry are particularly high, especially in terms of quality and durability, and all research conducted in these fields must be measured against these standards. In the field of applied research, the key to meeting these high standards is the combination of knowledge from different specialist domains.

Such collaboration can produce high quality, highly useful development environments (modelling, simulation tools, accompanying tests and standards). In this context, the coordination of the efforts of specialists from different industries and from research institutes is the way forward.

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