Batteries for Electric Vehicles

This fundamental guide will teach you the basics of battery design for electric vehicles. Working through this book, you will understand how to optimise battery performance and functionality, whilst minimising cost and maximising durability.

Beginning with the basic concepts of electrochemistry, the author moves on to describe implementation, control, and management of batteries in real vehicles, with respect to the battery materials. The author describes how to select cells and batteries with explanations of the advantages and disadvantages of different battery chemistries, enabling you to put your knowledge into practice and make informed and successful design decisions, with a thorough understanding of the trade-offs involved.

The first of its kind, and written by an industry expert with experience in academia, this is an ideal resource both for students and researchers in the fields of battery research and development, as well as for professionals in the automotive industry extending their interest towards electric vehicles.

Including a foreword by Leif Johansson, Chairman of Telefonaktiebolaget LM Ericsson and AstraZeneca PLC, and former CEO of the Volvo Group.

Helena Berg is the CEO of AB Libergreen, founded by herself in 2012 to advise other companies in the areas of electromobility and batteries. Previously she was the Global Corporate Battery Specialist of the Volvo Group and she also has a Ph.D. in battery materials.

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Materials and Electrochemistry

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CAMBRIDGE
UNIVERSITY PRESS

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University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India

103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107085930

First published 2015

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging in Publication data
Berg, Helena.
Batteries for electric vehicles : materials and electrochemistry / Helena Berg.
pages cm
Includes bibliographical references.
ISBN 978-1-107-08593-0 (Hardback)
1. Electric vehicles–Batteries. I. Title.
TL220.B427 2015
629.25´02–dc23 2015006511

ISBN 978-1-107-08593-0 Hardback

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Foreword

Already in the late 1970s when I was the Managing Director of *Husqvarna Motorcycles*, I was involved in a project where we tried to build useful and light electric scooters. We were forced to give up. The batteries of those days were simply insufficient regarding energy storage. In addition, there were few control components that worked at high enough powers.

Today, 30 years later, we see the first generation of electric vehicles – cars and scooters, as well as city buses – emerge. This is made possible through new types of batteries available in configurations that actually work at high-power outputs and relatively large amounts of stored energy. Today there are also computers capable of monitoring the batteries and there are high-power electronic components based on semiconductors. Altogether this provides the opportunity to construct systems suitable for vehicles. As CEO of the *Volvo Group*, I was happy and proud of the projects emerging with the electrification and hybrid electrification of vehicles during the first decade of the twenty-first century, and with which Helena Berg, among others, was working.

The task is bigger, though, than only supplying vehicles with well-functioning battery packs. As human beings, we are identifying increasing demands on mobility in our everyday life. This implies a desire to make extensive use of mobile devices such as cameras, smart telephones, tablets, media players, and in the future a vast number of products we cannot even imagine today.

'The internet of things' will result in many billions of products needing to communicate with one another in order to establish a society as efficient and accessible as we all wish. All these products will need an energy source most likely a battery. And when building the future electric power supply and distribution system – 'The smart grid' – we will need load levelling and energy storage.

For all this, batteries and battery technologies are needed. We need to deepen our understanding of today's batteries and to better assess what we can expect of batteries in the future.

The knowledge of batteries, battery configurations, and their control has become strategic knowledge that many people need to assimilate. This obviously applies

to all categories of product developers and the direct design and construction work, but also to the leaders of such development. I would also argue that it would be beneficial if interested political leaders, developers of society, and decision makers could better understand the possibilities of the technology in such an important field.

Helena Berg has written a book about all of this. She has a profound technical background in addition to a thorough experience of applications in real situations.

Gothenburg,
January 2015

Leif Johansson
Chairman of Telefonaktiebolaget LM Ericsson and AstraZeneca PLC

Preface

When I started to work with batteries 20 years ago, Li-ion cells had been introduced to the market a few years before and everyone was talking about the battery revolution – the electric car will finally become true. Since then we have seen the Li-ion batteries come to totally dominate the consumer electronics market and now starting their journey to become the source of electricity for electric vehicles. Today most vehicle manufacturers are promoting electric vehicles and large electromobility programmes exist among government bodies, universities, and companies around the world as crucial steps towards a sustainable world in terms of meeting the serious threats to our societies such as depletion of oil reserves and climate change.

The key for this to ultimately succeed is knowledge of the battery itself and how to design a battery with optimal performance and functionality at a low cost and with long durability. Trying to design a battery without proper knowledge about the materials used and electrochemistry basics sooner or later ends up in a non-optimal design in terms of cost, performance, or durability. Inside the battery it is the cell chemistry that sets the fundamental limitations and hence, in the long run, also the performance of the vehicle.

This is the book I would have liked to be able to hand out to my co-workers and managers during my years in the automotive industry. This book explains the fundamentals behind why a battery has to be handled according to specific constraints and how it should be matched with the type of vehicle; most of all this book should help design teams to talk the same 'battery language' and thus enable greater battery research.

During my winding road towards a finalised book, I have had the opportunity to work and discuss batteries and electric vehicles with Anette Häger, Erlendur Jónsson, Hanna Bryngelsson, Henrik Engdahl, Jenny Ring, Leif Johansson, Niklas Thulin, Patrik Johansson, Patrik Persson, and Mario Wachtler – all are gratefully acknowledged. A special thanks goes to the professional editorial team at Cambridge University Press who believed in the scope of the book from the very first day.

Helena Berg

Amiens
January 2015