

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.

Batteries for Electric Vehicles

Materials and Electrochemistry

HELENA BERG



CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS

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

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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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Contents

	<i>Foreword</i>	<i>page</i> ix
	<i>Preface</i>	xi
	Introduction	1
	I Electrochemistry and battery technologies	5
1	The electrochemical cell	7
	1.1 Definitions	8
	1.2 Cell components	8
	1.2.1 Electrodes	9
	1.2.2 Electrolytes	9
	1.2.3 Separators	10
	1.2.4 Current collectors	10
	1.2.5 Casing	11
	1.3 Cell and battery	11
	1.3.1 Half cells	11
	1.3.2 Full cells: monopolar and bipolar	12
	1.3.3 Full cells: three-dimensional	13
	1.3.4 Battery	14
	1.4 Thermodynamics	14
	1.4.1 Chemical and electrochemical potentials	15
	1.4.2 Cell voltage	17
	1.4.3 Temperature	20
	1.5 Electrode and electrolyte processes	21
	1.5.1 Electrode kinetics	22
	1.5.2 Electrode–electrolyte interfaces	23
	1.5.3 Mass transport	24
	1.5.4 Ion transport	25
	1.5.5 Mass transport in solid states	28
	1.5.6 Electrolyte stability	31
	1.6 Practical cell measures	32
	1.6.1 Cell voltage under load	33

vi	Contents	
	1.6.2 Charge and discharge rates	35
	1.6.3 Capacity	36
	1.6.4 Energy and power	38
	1.6.5 Efficiency	40
	1.7 Electrochemical analysis methods	41
	1.7.1 Galvanostatic and potentiostatic cycling	41
	1.7.2 Cyclic voltammetry	42
	1.7.3 Electrochemical impedance spectroscopy	43
	1.7.4 Reference electrode	46
2	Battery technologies for electric vehicles	47
	2.1 Lead-acid batteries	48
	2.1.1 Basics	48
	2.1.2 Lead-acid concepts	51
	2.2 Nickel metal-hydride batteries	52
	2.2.1 Basics	53
	2.2.2 NiMH battery materials	55
	2.3 Lithium batteries	57
	2.3.1 Lithium metal	58
	2.3.2 Li-ion and Li-ion polymer	59
	2.3.3 Lithium-oxygen	59
	2.3.4 Lithium-sulphur	60
	2.4 Electrochemical double-layer capacitors	62
	2.4.1 Capacitor materials	65
	2.4.2 High-energy capacitors	65
	2.5 Other battery technologies	66
	2.5.1 High-temperature molten-salt batteries	66
	2.5.2 Nickel zinc batteries	68
	2.5.3 Zinc-air batteries	69
	2.5.4 Metal-ion batteries	70
	2.5.5 Redox flow batteries	72
	2.6 Fuel cells	74
	2.6.1 Polymer electrolyte membrane fuel cells	75
	2.6.2 PEMFC usage	78
	II Li-ion battery technology – materials and cell design	81
3	Lithium battery materials	83
	3.1 Negative electrode materials	86
	3.1.1 The solid electrolyte interphase	87
	3.1.2 Metallic lithium	89
	3.1.3 Carbons	91

3.1.4	Alloys	96
3.1.5	Oxides	98
3.2	Positive electrode materials	100
3.2.1	Layered materials	102
3.2.2	The cubic spinel LiMn_2O_4	105
3.2.3	Olivine LiFePO_4	109
3.2.4	Other materials	111
3.2.5	Mixed electrode concepts	113
3.3	Electrolytes and separators	114
3.3.1	Liquid electrolytes	115
3.3.2	Separators	120
3.3.3	Polymer-based electrolytes	123
3.3.4	Ionic liquids as electrolytes	124
4	Cell design	126
4.1	Composite electrodes	126
4.2	Energy and power-optimised electrodes	129
4.3	Energy and power-optimised cells	130
4.3.1	Cell balancing	130
4.3.2	Energy and power relationship	131
4.3.3	Example: energy and power-optimised cells	132
4.4	Cell format and design	134
4.4.1	Cylindrical cells	134
4.4.2	Prismatic cells	135
4.4.3	Pouch cells	135
4.4.4	Cell safety devices	137
4.5	Production processes	137
4.5.1	Safety and reliability	139
III	Battery usage in electric vehicles	141
5	Vehicle requirements and battery design	143
5.1	Vehicle types and requirements	143
5.1.1	Vehicle types	143
5.1.2	Usage conditions	146
5.1.3	Energy and power requirements	147
5.2	Battery design	152
5.2.1	General design criteria	154
5.2.2	Cell selection	156
5.2.3	Additional battery components	163
5.2.4	Design impact on reliability and safety	166

6	Battery control and management	168
6.1	Battery management system	168
6.1.1	Charge and discharge control and methods	171
6.1.2	Thermal control and management	174
6.1.3	Battery monitoring	178
6.2	State functions	179
6.2.1	State of charge	180
6.2.2	State of health	189
6.2.3	State of function	192
7	Battery usage and degradation	194
7.1	Degradation basics and mechanisms	195
7.1.1	Examples: origins of capacity fade	199
7.1.2	Accelerated degradation	201
7.2	Degradation of Li-ion cells	208
7.2.1	General degradation categories	209
7.2.2	Degradation of active materials	212
7.2.3	Degradation of electrolytes	219
7.3	Degradation analysis methods	221
7.3.1	Galvanostatic cycling	222
7.3.2	Electrochemical impedance spectroscopy	223
7.3.3	Incremental capacity	224
7.3.4	Differential voltage	226
7.3.5	Half cell	227
7.3.6	Post-mortem	228
	<i>Glossary</i>	230
	<i>Further reading</i>	234
	<i>Index</i>	235

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

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January 2015