May this new edition of the "Handbook of Battery Materials" be a useful guide into the complex and rapidly growing field of battery materials. Beyond that, it is my personal wish and hope that the readers of this book may also take the chance to review Prof. Besenhard's work. Jürgen Otto Besenhard has been truly one of the fathers of lithium batteries and lithium ion batteries.

Münster, Germany, July, 2011 *Martin Winter*

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Preface to the Second Edition of the Handbook of Battery Materials

For Kijan and Stina

The language of experiment is more authoritative than any reasoning, facts can destroy our ratiocination – not vice versa.
Count Alessandro Volta, 1745–1827
Inventor of the Battery

You are looking at the second edition of the Handbook of Battery Materials. It has been 12 years since the first edition edited by Prof. Jürgen Besenhard was published.

This second edition is dedicated in memory of world renowned Prof. Jürgen Besenhard who was a pioneer in the field of electrochemical energy storage and lithium batteries. As a young scientist in the field of electrochemical energy storage, I am humbled to inherit this handbook from him.

Over the last decade, driven by consumer electronics, power tools, and recently automotive and renewable energy storage, electrochemical energy storage chemistries and devices have been developed at a never before seen pace. New chemistries have been discovered, and continued performance increases to established chemistries are under way. With these developments, we decided to update the handbook from 1999. The new edition is completely revised and expanded to almost double its original content.

Due to the fast pace of the market and very quick developments on large scale energy storage, we removed the chapter on *Global Competition*. It might be outdated by the time this book actually hits the shelves. Chapters from Parts I and II from the first edition on *Fundamentals and General Aspects of Electrochemical Energy Storage, Practical Batteries*, and *Materials for Aqueous Electrolyte Batteries* have been revised for the new edition to reflect the work in the past decade. Part III on *Materials for Alkali Metal Batteries* has been expanded in view of the many research efforts on lithium ion and other alkali metal ion batteries. In addition, we added new Parts IV on *New Emerging Technologies* and V on *Performance and Technology Development* with chapters on *Metal Air, Catalysts, and Membranes, Sulfur, System Level Modeling, Mechanics of Battery Materials*, and *Electrode Manufacturing*.

May this new edition of the "Handbook of Battery Materials" be a useful guide into the complex and rapidly growing field of battery materials. Beyond that, it is my personal wish and hope that the readers of this book may also take the chance to review Prof. Besenhard's work. Jürgen Otto Besenhard has been truly one of the fathers of lithium batteries and lithium ion batteries.

Münster, Germany, July, 2011 *Martin Winter*

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Preface to the Second Edition of the Handbook of Battery Materials

For Kijan and Stina

The language of experiment is more authoritative than any reasoning, facts can destroy our ratiocination – not vice versa.

Count Alessandro Volta, 1745–1827
Inventor of the Battery

You are looking at the second edition of the Handbook of Battery Materials. It has been 12 years since the first edition edited by Prof. Jürgen Besenhard was published.

This second edition is dedicated in memory of world renowned Prof. Jürgen Besenhard who was a pioneer in the field of electrochemical energy storage and lithium batteries. As a young scientist in the field of electrochemical energy storage, I am humbled to inherit this handbook from him.

Over the last decade, driven by consumer electronics, power tools, and recently automotive and renewable energy storage, electrochemical energy storage chemistries and devices have been developed at a never before seen pace. New chemistries have been discovered, and continued performance increases to established chemistries are under way. With these developments, we decided to update the handbook from 1999. The new edition is completely revised and expanded to almost double its original content.

Due to the fast pace of the market and very quick developments on large scale energy storage, we removed the chapter on *Global Competition*. It might be outdated by the time this book actually hits the shelves. Chapters from Parts I and II from the first edition on *Fundamentals and General Aspects of Electrochemical Energy Storage, Practical Batteries*, and *Materials for Aqueous Electrolyte Batteries* have been revised for the new edition to reflect the work in the past decade. Part III on *Materials for Alkali Metal Batteries* has been expanded in view of the many research efforts on lithium ion and other alkali metal ion batteries. In addition, we added new Parts IV on *New Emerging Technologies* and V on *Performance and Technology Development* with chapters on *Metal Air, Catalysts, and Membranes, Sulfur, System Level Modeling, Mechanics of Battery Materials*, and *Electrode Manufacturing*.