Edited by
Alexander Mitsos and Paul I. Barton

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Microfabricated Power Generation Devices

Design and Technology

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Further Reading

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Wirth, T. (ed.)

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2008
Hardcover
ISBN: 978-3-527-31869-8

Preface

In the past decades there has been a dramatic increase in the power demand for portable electronics, and batteries are in many respects limiting. As a consequence, a variety of new power generation devices are under research and development, such as microfabricated fuel cell systems or microturbines. There are numerous publications on micropower devices, but they only cover aspects of this complicated system. This book is the first to give a broad coverage on portable power generation devices, encompassing technological aspects and system design using computational methods. The chapters are written by internationally recognized experts. Each chapter is self-contained, but at the same time there is a continuity between chapters, ensuring a coherent book as opposed to a collection of articles. We believe that the book is at the same time a great introduction for beginners and a very valuable tool for expert researchers in academic and for-profit institutions. While not a text-book, our own experience shows that it is also suitable as a complement to micropower design courses.

We are grateful to the contributors of the individual chapters; we appreciate the time they devoted in writing articles that describe the state-of-the-art in a tutorial fashion. In many ways the basis of this book was a Multidisciplinary University Research Initiative (MURI) at MIT. Many of our colleagues in the MURI program contributed as authors of individual chapters. We would also like to thank our colleagues who did not have the chance of contributing, in particular: Klavs F. Jensen for his leadership of the MURI; Leonel R. Arana and Steve Weiss for numerous discussions; Michael M. Hencke and Ignasi Palou-Rivera for their contribution to the system-level analysis; Ruth Misener for her numerical experiments on DAEs inside DAEs; and Mehmet Yunt for his work on variable power demand. Finally we thank the publisher for the invitation to put together this book.

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June, 2008 *Alexander Mitsos and Paul I. Barton*

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1
Introduction

Alexander Mitsos and Paul I. Barton

The widespread use of portable electric and electronic devices increases the need for efficient autonomous man-portable power supplies, of the order of 0.1 W to about 50 W. The predominant technology for portable power generation is the battery. However, the energy density of batteries is of the order of only a few hundred $Wh\,l^{-1}$ and $Wh\,kg^{-1}$. Battery performance has significantly improved over the last decades, but it is believed that the upper limit on performance is being approached, because the list of potential materials is being depleted. Additionally, batteries have high cost and life cycle environmental impact.

This book focuses on alternatives to batteries based on microchemical systems, that is, miniaturized devices that use chemical fuels as the primary source of energy. Energy conversion technologies considered include electrochemical reactions in fuel cells, combustion in connection with heat-engines and combustion combined with thermo-photovoltaic elements. The promise of these systems is that significant increments in energy density can be made compared to state-of-the-art batteries. Suppose, for the sake of argument, that it would be practical to operate a fuel cell reversibly at ambient conditions. Then, common chemicals would outperform state-of-the-art batteries by orders of magnitude, as shown in Figure 1.1 [1]. As a consequence, relatively inefficient microchemical systems can significantly outperform batteries. Miniaturization has the advantage of smaller systems as well as potential process intensification. Such considerations have sparked great military [2] and civilian interest in developing these alternatives to batteries.

1.1
Alternatives to Microchemical Systems

The focus of this book is on microfabricated devices that transform chemical energy to power, either directly (fuel cells) or indirectly (micro-engine, photovoltaics). This section briefly describes some other potential alternatives.

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