Preface

Traveling is highly essential to broaden our horizons, discover new landscapes, and understand the perspective of the locals. Sometimes the journeys are adventurous or challenging; in most cases, they are pure pleasure and fun—if not in the situation itself at least in retrospective. Academic careers in interdisciplinary fields are similar to traveling to different cultures, striving for the best of all by understanding the different languages, thinking about the concepts, and listening to the different points of view. My own experience being a microsystems engineer with a background in physics and electronics, exposed to electrochemistry while developing sensors for biomedical applications is a typical course in this sense.

The outcome of my journey between the disciplines resulted in a class on electrochemical methods for master students in Microsystems Engineering. After teaching the topic a few semesters, the outline improved while students from different subjects such as Functional Materials, Embedded Systems Engineering, and Sustainable Systems Engineering attended the lecture and provided their feedback. The selection of topics proved to fit together perfectly. I realized that such a combination of a consistent electrochemical theory, coherent description of methods, insight into the instrumentation, and implications for the different applications in microelectromechanical systems (MEMS) and nanotechnology is unique. The positive feedback encouraged me to write a full textbook based on this class.

A vast and further growing field of application for electrochemical methods is the energy sector. Two primary drivers stick out: For systems smaller in size, it is the need for portable energy storage for mobile computers, smartphones, smartwatches, headphones, and any kind of wearables. Secondly, the increasing awareness of climate change and new strategies for “greener power” asks for efficient energy storage and energy conversion for both the power grid and automotive application. At the same time, elements like lithium commonly used for energy storage are not an optimal solution when thinking of widespread usage in large batteries, e. g., for electromobility. Here, other materials are needed to replace lithium and cobalt because of their limited resources, environmental concerns, and to avoid further exploitation of poorer nations. Beyond different materials for batteries also other storage forms of energy, e. g., as hydrogen gas, appears a promising alternative.

Nanotechnology allows us to fabricate materials for energy conversion and storage, electrochemical sensors, and to some extent, electrochemical actuators. Additionally, electrochemical methods are employed to make the nanosystem itself or for the characterization of the obtained materials. Studies with engineered nanostructures lead to an awareness of effects on the nanoscale, even when dealing with microscopic or macroscopic structures.

Electrochemistry seems far from natural processes when looking from the perspective of material science or energy systems. However, considering how information transfer happens while you read this preface, it is mainly about electrochem-

istry. There are some optical effects to bring the information onto the retina of your eye (slightly different if you are reading the printed or electronic book), or maybe an acoustic pathway if you use a screenreader. But as soon as the information is within you, it is all about the interplay between (bio-)chemistry and electricity—the core domain of electrochemistry. With these thoughts in the back, it is clear why electrochemical methods are so powerful when considering applications in the biomedical field, in neurotechnology, and generally in the life sciences.

Many current MEMS devices incorporate an electrochemical principle with either sensor or actuator functionality. That is especially true for bioMEMS applied in life science. While most MEMS are designed using state-of-art microfabrication technologies, electrochemical features are often rudimentary developed, and hence lower overall system performance. Electrochemical analytical methods are widely used for sophisticated purposes in laboratories, often with ultramicroelectrodes exploiting microspecific features within macroscopic setups. However, there is little transfer of advanced electrochemical methods to lab-on-chip systems, although the performance of devices would increase by orders of magnitude with the same fabrication effort.

I hope you enjoy the journey described in this book as I did during writing—at least in retrospective—and be able to apply the knowledge to future micro- and nanosystems on which you are working. Besides, take your time to attend scientific conferences—they can be a good starting point for travel in its literal sense as well as to communicate the powerfulness of electrochemical methods in MEMS and nanotechnology.

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