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Preface

Demand for in situ surface analysis tools has increased considerably with the advent of nanotechnology and the rapid development of life sciences and chemical sensors. Investigating surface reactions in physics, chemistry, and biology is rewarding and demanding at the same time. In particular, non-invasive techniques are required to study subtle effects as they occur at cellular membranes. The detection and quantification of subtle shifts in mechanical properties comprising viscoelastic properties of soft matter, friction on small length scales, adsorption of biomolecules, and interfacial forces created by molecular contacts are desirable measurements for understanding processes occurring at the solid liquid and solid gas interface.

In the last few years, acoustic resonators have leaped forward, meeting many of the demands of interfacial sensors. Among them, thickness shear mode (TSM) resonators are the most widespread and versatile acoustic resonators capable of studying viscoelastic properties of soft matter, adsorption of molecules down to the picogram regime, motility of living cells just to name a few prominent achievements. The beauty of this approach is that the information content goes beyond most optical techniques comprising information about mass density, contact mechanics, dynamics of interfacial processes, surface roughness, and viscoelasticity of many layer systems. Acoustic sensor technology is a highly interdisciplinary field. Researchers from different areas ranging from electrical engineering to cell biology have contributed valuable technological concepts, theoretical insights and applications to the use and development of thickness shear mode resonators as extremely sensitive, robust and versatile sensors, which are discussed in this book.

The book is intended to give a state-of-the-art overview of the recent achievements in the area of piezoelectric sensors. The focus lies on TSM resonators, since this class of piezoelectric devices is most frequently used in physical and chemical sensor and biosensor applications, and they are largely commercially available. The book is divided into three parts. The first four chapters cover the physical background of piezoelectric devices. While Ralf Lucklum and Frank Eichelbaum discuss different interface circuits to drive a TSM resonator in the first chapter, Diethelm Johannsmann provides a comprehensive picture of how to treat different load situations of the quartz crystal microbalance (QCM) in the second, including rather new development in the area of con-
tact mechanics in the fourth chapter. The third chapter, written by Michael Urbakh and coworkers, the solid/liquid interface, as probed by the QCM, is discussed focusing on the impact of surface roughness and interfacial friction. The second part of the book then presents a variety of possible applications of the QCM and surface acoustic wave (SAW) sensors. The chapter by Franz Dickert and Peter Lieberzeit describes how functionalization of a QCM and SAW sensor surface with imprinted polymers allow monitoring very different analytes ranging from simple organic molecules to bacteria and cells. The next two chapters by Marco Mascini and coworkers and Robert Vaughan and George G. Guilbault, respectively, provide an overview of nucleic acid biosensors and immunosensors based on QCM techniques. In the eighth chapter we show that, besides pure analytical applications, the combination of QCM with atomic force microscopy measurements, and Monte-Carlo simulations allow for a better understanding of the formation process of solid supported membranes (SSMs) on quartz resonator surfaces and the interaction of proteins with SSMs. Joachim Wegener and coworkers demonstrate in the ninth chapter that, due to the sensitivity of a TSM resonator to changes in viscoelasticity, the QCM is an invaluable tool to monitor and understand the interface between cells and the resonator’s surface, which makes it possible to use this device in whole cell biosensor applications.

This aspect is also discussed in the chapter written by Kenneth Marx, who not only describes recent applications of the QCM to study thin polymer films, electron transfer systems, biological macromolecules, and cells, but also the application of the electrochemical QCM. This chapter is one of four of the third part of this book, which is devoted to advanced QCM techniques. Yoshio Okahata and coworkers demonstrate that a 27 MHz quartz plate enables one to monitor the action of enzymes online, while Matthew Cooper gives an overview on resonant acoustic profiling (RAP\textsuperscript{TM}) and rupture event scanning (REVS\textsuperscript{TM}) realized by a QCM at Akubio. Fredrik Höök and Bengt Kasemo point out the applicability of the QCM-D technique to biological questions pronouncing that there is more than pure microgravimetry involved in interfacial processes.

We hope that the reader will find these contributions from leading scientists working in the field of piezoelectric sensors stimulating.

Finally, we would like to express our gratitude to all the authors who have contributed to this book, to Britta Wecker for her able handling of the manuscripts, and to Otto S. Wolfbeis for his invitation to edit a book on this cutting-edge topic in sensor development for this series and to Springer for their professionalism in producing this book.

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