Preface

We originally wanted to call this book *Dr. Thom's Big Book about Little Things*, but, apart from being perhaps too playful a title, we didn't like the word "big" in it. That's because the book was intended to be an introduction to the world of science and engineering at the microscale, not a comprehensive treatment of the field at large. Other authors have already written books like that, and they have done a wonderful job. But we wanted something different. We wanted an introductory MEMS text accessible to *any* undergraduate technical major, students whose common background consists of freshman level physics, chemistry, calculus and differential equations. And while a "little" book about little things might not suffice to that end, we at least desired a somewhat compact book about things micro.

When we taught an introductory MEMS course for the first time in the spring of 2002 to just such an audience, it was, at least to our knowledge, a unique endeavor. We attempted to cover way too much material though, and we threw one of those big comprehensive books at the students. It nearly knocked them out. In subsequent installments, we cut back on the material and started using instructor notes in lieu of a text. Those notes, outlines, bulleted lists, and fill-in-the-blank handouts became the skeleton around which this text was formed.

As creating microstructures requires such a different set of tools than those encountered in the macro-world, much of learning about MEMS rests squarely in learning the details of how to make them. Part I of this text therefore deals mainly with introducing the reader to the world of MEMS and their fabrication. Actuation and sensing are also treated from a generic standpoint, with MEMS devices used as examples throughout. In Chapter 7 of Part II, an overview of some of the most common MEMS transducers is given from a mainly qualitative, non-mathematical standpoint. Hence, the first seven chapters should suffice for the majority of introductory courses.

Following Chapter 7 are specific treatments and modeling strategies for a handful of selected MEMS. The mathematical modeling is more detailed than in previous chapters, covering a number energy domains. Though the models given can be a bit involved, the necessary tools are developed for the reader. Part II is therefore better suited for a follow-up course, or perhaps a standalone course for students with the appropriate background. Alternatively, an introductory course covering Chapters 1-7 could culminate with one modeling chapter from Part II. The last chapter on microfluidics is in some sense a standalone treatment of the field.

Just as no one is able to design a functioning power plant after having taken an introductory course in thermodynamics, no one will be able to design, build and test a successful MEMS device after only reading this text. However, the reader will have acquired the new skill of considering microtechnology-based solutions to problems, as well as the ability to speak intelligently about MEMS and how they are modeled. The text can therefore serve as both a springboard for further study or as an end in itself.

One of the challenges in writing such a text is that it is a bit like writing a book entitled "Introduction to Science and Engineering," as this is what MEMS really is – science and engineering – at the microscale, that is. It can therefore be quite difficult to keep it truly general. By making the intended audience an undergraduate technical major in any field, and therefore not assuming any other specialized background, we have avoided slanting the text in some preferred direction. That is to say, we have done our best to keep the text a true introduction to MEMS as a whole rather than an introduction to, say, dynamic systems modeling of MEMS devices, or materials engineering aspects of MEMS.

The opposite danger, of course, is not including enough material to really understand MEMS. To address this, where needed we have included introductions to fields that are generally not part of the common experience of all technical majors. The introductions are kept brief, as they are intended to give the reader just enough background to understand the field in context of the MEMS device(s) at hand. Naturally these sections can be omitted when tailoring a course for specific majors.

In reading the text, most readers will find themselves outside of their comfort zone at some point. At other times the reader may find themselves reading things that seem obvious. Which things are which will be different for different readers, depending on their backgrounds. What's more, readers may occasionally find themselves a trifle disoriented even within a field in which they have heretofore considered themselves well-versed. A prime example is Chapter 12 on microfluidics, in which electro-osmotic flow is treated. In electro-osmotic flow the traditional fields of fluid mechanics and electrostatics, topics usually thought of as having little to do with each other, are coupled and of equal importance. Throw in a smattering of mass transfer and chemistry and you have a topic in which very few of us can hit the ground running.

Such is the world of MEMS. Scientists and engineers of all fields are necessarily drawn to one another in order to make things work. The cliché that the world is getting smaller has found new metaphorical meaning with the miniaturization of technology. It is for this very reason that we feel so strongly that this text and the types of courses it is designed to accompany are vitally necessary in the education of scientists and engineers. Gone are the days when technical professionals could pigeonhole themselves into not venturing outside of narrow areas of expertise. Multidisciplinary endeavors are all the buzz anymore, and rightfully so. For MEMS they are its very lifeblood.

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