Introduction

This book was developed from lectures held at RWTH Aachen University, Germany and Tsinghua University at Beijing, P.R. China. It may be used as a basis for similar lectures on designing of microsystems. For this purpose, it is recommended to follow the sequence of this book, because it is arranged such that following chapters are building up on previous ones. Students are also strongly recommended to solve the problems included in this book, because this is important for getting familiar with the units and orders of magnitude to be expected in microtechnique. Besides this, often the relevance of the lessons becomes clear much more, when an example calculation shows the importance of the subjects taught.

This book is written such that the reader does not need to know how microsystems are fabricated and what are the big possibilities and limits of microtechnique. When real microsystems are to be designed, a lot of knowledge of the fabrication possibilities is required of cause. This knowledge is not provided in this book, because other literature is available which covers this topic [3–6]. Students may be taught the contents of this book without any prior knowledge of the fabrication processes. However, it is recommended to teach microfabrication first and then the design of microsystems whenever this is possible.

Besides teaching, the purpose of this book is to provide the equations which are needed to calculate the behavior of basic elements and physical effects which are important in microtechnique. For a quick reference, several tables are included, which allow to find the equation needed for a certain problem. At the beginning of this book, there is an index of all tables.

The equations introduced in this book are not restricted to microtechnique. They are all valid in the macroscopic world also. It may be, however, that an effect such as capillary force is less important in macroscopic applications. On the other hand, it is expected that the coherent description of topics such as strain gauges and the piezo-electric effect will also help readers not working on microsystems.

Nowadays, finite element methods (FEM) are available which allow calculating the behavior of macroscopic as well as microscopic structures and elements with high precision. However, FEM do not provide an overview and an understanding of the interrelationships and how to optimize a component for a certain application. Therefore, analytical calculations are desirable which provide an overall understanding of a given problem first, and, after an advantageous way of solving the

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problem is envisaged, FEM can be used to find the precise optimum. An approximate description of the problem by an analytical equation will help optimizing by FEM, because the equation gives a good hint where to search for the optimum and which parameters show the largest effect.

The existence of FEM also allows making more rough approximations in analytical calculations, because the calculations are no longer needed to find the exact results. In this book, very rough approximations are accepted achieving an analytical description of the overall behavior of structures such as the buckling up of membranes and beams when the compressive stress exceeds the critical stress. This shows how analytical calculations and FEM nowadays complement each other.

Microsystem technology combines a lot of technical fields such as mechanics, electronics, fluidics, optics, etc. Therefore, the notations of all these fields need to be mixed up, and avoiding confusion of variables is not an easy task. Every variable is assigned a unique notation throughout this book which is found in "Notations and Symbols" section. As a consequence, variables need to be distinguished by subscripts where this is not necessary normally. For example, the Greek letter α may be used for an angle, a damping constant, the thermal expansion coefficient, and the temperature coefficient of an electrical resistance. These quantities are assigned the distinctive notations α, α_{D}, α_{th}, and α_{T}, respectively.

In microtechnique, typically very small structures and shape changes are next to much larger ones. If both small and large structures would be shown up to scale, the smaller ones could not be recognized in general. Therefore, it is usual both in microtechnique and throughout this book to draw smaller structures larger than they are in comparison to surrounding larger ones. The real dimensions are given in the figure caption or the text related to it.