Introduction to Microsystem Design

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Preface

This second edition of "Introduction to Microsystem Design" corrects errors found in the previous version of the book and is extended by a chapter on electrical measurements, 8 tables, 14 figures, 57 equations, and 12 new exercises. Significant improvements are found in the chapters on conductor paths, membranes, strain gauges on membranes, capacitive forces, and pressure sensors. All exercises have been proven by feedback from students. Lecturers interested in using the book for teaching may write to the author (Schomburg@KEmikro.RWTH-Aachen.de) and ask for the solutions of the exercises. Exercises and their solutions are also available in German.

To ease looking up specific topics, they are systematically arranged in chapters of this book and at the end of the book there are lists of all characteristic curves of sensors and actuators, and of tables with equations. As a consequence, teaching based on this book can become more interesting, and thus effective, if the sequence in which the subjects are taught partly differs from the book. For instance, feedback in the chapter on electrical measurements could be presented where it is first needed for an application in the chapter on pressure sensors.

I am expressing my sincere thanks to the many assistants and students who contributed to this book with their constructive criticisms, questions, and suggestions helping me in recognizing weaknesses and correcting errors. Readers of this book are encouraged to write to the author and contribute to further improvements with their criticisms, hints, and suggestions.

Preface of the First Edition

Micro Systems Technology (MST) or Micro Electro Mechanical Systems (MEMS) as it is called in America is a comparatively young emerging technology which allows building up miniaturized devices such as micro valves for implantable medicament dosing systems or micro total analysis systems (μTAS), which shall provide a miniaturized laboratory on a polymer chip just a few centimeters in size. The first steps to MST were done more than 30 years ago when anisotropic etching of silicon was discovered [1] and sacrificial layer technique was invented [2].

Nowadays, MST is a well-established technology which is the basis of many products. Modern life in many fields is based on a variety of micro systems unnoticed by most of us. In most cars micro sensors for the measurement of acceleration, yaw rate, pressure, and flow are implemented. Watches, hearing aids, mobile phones, beamers, ink jet printers, PCs, and catheters for minimal invasive surgery are other examples of applications which became possible in the present form by micro technologies. Accordingly, many jobs are available in micro technique and much more jobs are depending on it.

In the previous decades the fabrication techniques of MST had been the main issue of research and development resulting in today's more or less standard production processes such as bulk silicon etching, reactive ion etching, surface micro machining, micro molding, silicon fusion bonding, etc. These processes are well described in several textbooks [3–6], and, therefore, are available for both industry and teaching at universities.

However, MST is not only characterized by its novel fabrication processes. The transition to smaller dimensions is combined with the need for a change in design also. A miniaturized sensor or actuator requires a different design due to both the new fabrication techniques and the smaller scale which results in a change in the significance of effects and forces. For example, capillary force is of no importance in the macroscopic world while it may be used as the driving force in microscopic designs. The piezoelectric effect and thermal strain are known and need to be considered in macroscopic engineering but play a much more important role in MST.

Until now, there is no textbook which describes the design of micro systems systematically. Therefore, this book was written to fill this gap. It is based on a course given at RWTH Aachen University and Tsinghua University in Beijing for undergraduate students in their 5th or higher semester. This book may be used as the basis for similar courses, for self-study, or as a reference for the experienced engineer. All the equations presented here are not limited to micro systems but are valid in general. Therefore, this book may help also engineers working in different fields.

This book does not describe the fabrication processes of MST but can be understood without knowing these processes. It provides the basic equations needed to calculate or at least estimate the order of magnitude of the effects and forces which are important in MST. For quick reference these equations are presented in tables which are found in an index on page xxiii.

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