
Preface

The recent remarkable development of microsystems dates back to 1983 when Richard P. Feynman of California University delivered a speech to a large audience of scientists and engineers at the Jet Propulsion Laboratory. He presented the concept of sacrificed etching to fabricate a silicon micromotor, and pointed out the need for a friction-less, contact sticking-free structure, due to the relative increase of the surface effect in such microsystems and devices. A micromotor fabricated by Fan *et al.* in 1988 caused a tremendous sensation and opened the way for Micro-Electro-Mechanical-System (MEMS) technology. The diameter of the rotor was 120 μm , its rotational speed was 500 rpm, and the gap between the rotor and the stator was 2 μm . Today, many successful examples of MEMS products can be found: MEMS such as accelerometers, pressure sensors, microphones and gyros are used commercially, and various branches of industry are already including MEMS components in their new products.

Furthermore, optical MEMS, or micromechanical photonics, are evolving in interdisciplinary research and engineering fields to merge independently developed technologies based on optics, mechanics, electronics and physical/chemical sciences. Manufacturing technologies such as semiconductor lasers, surface-micromachining and bulk-micromachining are promoting this fusion of technologies. In addition, new devices such as optical MEMS including optical sensors, optical switches, optical scanners, optical heads, near-field probes, optical rotors and mixers, actuators, and microsystems for diagnosis and treatments, and new conceptual frameworks such as micromechanical photonics including an optical encoder, a tunable laser diode with a micro-cantilever and Nano-Electro-Mechanical-Systems (NEMS) are appearing.

Rapidly emerging interdisciplinary science and technology are expected to provide new capabilities in sensing, actuation, and control. Advances such as MEMS, optical MEMS, micromechanical photonics and microfluidics have led not only to a reduction in size but also be the merging of computation, communication and power with sensing, actuation and control to provide new functions. By integrating smart optoelectronics and antennas for remote control with a microstructure, the ability of microsystems to interpret and control

its environment will be drastically improved. Much further work, however, is required to develop this new field to the stage of commercial production.

The purpose of this book is to give the engineering student and the practical engineer a systematic introduction to optical MEMS and micromechanical photonics not only through theoretical and experimental results, but also by describing various products and their fields of application. Chapter 1 begins with an overview spanning topics from optical MEMS to micromechanical photonics and the diversity of products using them at present and in the near future. Chapter 2 demonstrates extremely short-external-cavity laser diodes, tunable laser diodes, a resonant sensor and an integrated optical head. The chapter deals with laser diodes closely aligned with a microstructure including a diaphragm, a microcantilever and a slider. Chapter 3 addresses optical tweezers. This new technology is employed to manipulate various types of objects in a variety of research and industrial fields. The section first analyzes the trapping efficiency by geometrical optics and then compares the theory with the results obtained experimentally, finally presenting a variety of applications. Chapter 4 deals with the design and fabrication of an optical rotor and evaluates its improved mixing of micro-liquids for future fluidic applications such as micrototal analysis systems (μ -TAS). In Chap. 5, the fundamentals and applications of the near field are described for the future development of micromechanical photonics. This technology enables us to observe, read/write and fabricate beyond the wavelength resolution by accessing and controlling the near field. The chapter deals with near-field features, theoretical analyses, experimental analyses and applications mainly related to optical recording.

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Hiroo Ukita

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Ukita, H.

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