Preface

Micro- and nanotechnologies are recent fields of interest that offer high innovation potential. These technologies lead to small dimension multifunctional systems that are of great interest in various domains: biomedical, aerospace, military, automotive, small factories, etc.

The technologies initially developed for the microscale have brought an information revolution through the capability of integrating an incredible number of microscopic transistors in a small surface. More recently, MEMS technologies were developed to introduce mechanical, optical, and/or thermal functions to integrate microactuators and microsensors. Inkjet printer heads, accelerometers, micro-mirrors, micro-relays, and pressure sensors are among the most known and widespread devices that open cost-effective and highly integrated solutions to the car industry, aeronautics, medicine, biology, energy, and telecommunication domains. One step further, nanotechnologies deal with the technology at the nanoscale.

All developed devices aim at sensing or acting at a very small scale, so small that new phenomena negligible at the macroscale become very influent. These scale effects are generally not fully mastered. They include for instance adhesion forces and high noise-to-signal ratio. Furthermore, microsystems dedicated to micro/nanopositioning or micro/nanomanipulation require micrometric and submicrometric accuracy for motions and micronewtons for forces. Such severe characteristics require the need of integrated systems able to perform motions in a controlled way, which requires proprioceptive measurement. Actually, while many solutions exist for actuation, sensing at the micro/nanoscale for measuring their motions is a great challenge. Several projects have emerged during these last years to develop new solutions able to efficiently measure at the micro/nanoscale in an integrated way. The editors of this book have organized a scientific workshop during the IEEE-International Conference on Robotics and Automation (ICRA) held in May 2010 in Anchorage Alaska USA to consider and discuss these issues. The workshop has brought researchers and engineers together to present, discuss, and exchange ideas on this new topic: “Measurement at the micro/nano-scale.” The exciting discussions and exchanges between the speakers of the workshop and

the audience, composed of engineers, researchers, and students, have resulted the necessity to make a perennial archive available for a large public of the interesting presentations and discussions. This is the motivation of this book.

The book is made of eight chapters.

Chapter 1 introduces the specificities of the micro/nanoscales. The scale effects as well as some typical corresponding magnitudes are presented. The difficulty to get internal measurement is particularly highlighted. The interesting contribution of the control theory (observers, estimators) to that issue ends the chapter.

Chapter 2 is a deep presentation of the so-called self-sensing technique. This technique, allowing the use of an actuator also for the measurement of position and/or force, is presented in this chapter as an efficient approach for piezoelectric-based microactuators. Recent developments are therefore detailed and discussed along the chapter.

Chapter 3 is concerned with the efficient use of the well-known Kalman filtering to reduce noises in signals measured at the micro/nanoscale. The powerful of this filter makes it very complementary with existing microsensors that measures micronewtons forces and micrometers displacements during micromanipulation or microassembly tasks.

In Chap. 4, the design and development of a new generation of microforces sensors based on a capacitive principle are detailed. The singular properties of these sensors make them recognized in various applications at the micro/nanoscale such as micromanipulation, microassembly, and small objects characterizations.

Chapter 5 deals with the particular application of manipulation and characterization of biological cells. The mechanical characterization of oocytes is detailed using computer vision including microscopy and a new polymeric device.

In Chap. 6, the authors describe innovative techniques to characterize thin-film nanostructures, notably helical nanobelts. These nanostructures can be further used as NEMS, tools for nanohandling. Their mechanical properties, such as stiffness, are therefore investigated in the chapter.

Chapter 7 is dedicated to mechanism approaches to enhance the performances of MEMS. The chapter is particularly focused on the dynamics enhancement of sensors based on optical MEMS. Both theory and design cases are included.

Finally, Chap. 8 discusses the state-observer approach to estimate signals in scanning probe microscopes. This chapter introduces the notion of parameter amplification that allows the enhancement of the measurement accuracy and that is demonstrated through an illustrative example.

We express our deep thanks to the authors who describe new results in a very didactic way. Most of them originally participated to the workshop mentioned above.

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