
Preface for the Fourth Edition

Tribology is the science and technology of interacting surfaces in relative motion and of related subjects and practices. The nature and consequences of interactions that take place at a moving interface control its friction, wear, and lubrication behavior. Understanding the nature of these interactions and solving the technological problems associated with interfacial phenomena constitute the essence of tribology. The importance of friction and wear control cannot be overemphasized for economic reasons and long-term reliability.

There has been an emergence and proliferation of proximal probes, in particular tip-based microscopies and the surface force apparatus, and of computational techniques, for simulating tip-surface interactions and interfacial properties. These have allowed systematic investigations of interfacial problems with high resolution, as well as ways and means of modifying and manipulating nanostructures. These advances provide the impetus for research aimed at developing a fundamental understanding of the nature and consequences of the interactions between materials on the atomic scale, and they guide the rational design of material for technological applications. In short, they have led to the appearance of the new fields of nanotribology and nanomechanics.

The field of tribology is truly interdisciplinary. Until the 1980s, it had been dominated by mechanical and chemical engineers who conducted macroscale friction and wear tests to predict the useful life of machine components. They devised new lubricants to minimize the effects of friction and wear, and extend that useful life. The development in the field of nanotribology has attracted many more physicists, chemists, and material scientists who have contributed significantly to the fundamental understanding of friction and wear processes and lubrication on an atomic scale. Thus, tribology and mechanics are now studied by both engineers and scientists. The nanotribology and nanomechanics fields have grown rapidly, and it has become fashionable to call oneself a “tribologist.” Tip-based microscopies have also been used for materials’ characterization, as well as for the measurement of mechanical and electrical properties, all on the nanoscale. Since 1991, international conferences and courses have been organized regularly by various professional societies and other organizations on the new fields of nanotribology, nanomechanics, and nanomaterials characterization.

There are many applications that require detailed understanding of tribological and mechanical processes on the macro- and nanoscales. In the early 1980s, tribology of magnetic storage systems (rigid disk drives and tape drives) became one of the important parts of tribology. Microelectromechanical Systems (MEMS)/Nanoelectromechanical Systems (NEMS) and bioMEMS/NEMS, all part of nanotechnology, have appeared in the marketplace since the 1990s. These, of course, present new tribological challenges. Tribology of processing systems such as copiers, printers, scanners, and cameras is important also, although it has not received much attention. Along with many industrial applications, there has been development of new materials, coatings, and treatments such as synthetic diamond, diamond-like carbon films, self-assembled monolayers, and chemically grafted films, to name a few with nanoscale thicknesses.

It is clear that the general field of tribology has grown rapidly since the mid-1980s. Conventional tribology is well established, but nanotribology and nanomechanics also have taken the center stage. Nanomaterials also have been developed and are used in some applications. Furthermore, new industrial applications, particularly biomedical applications, continue to evolve with their unique challenges.

Very few tribology handbooks exist, and those that do are dated. They have focused on conventional tribology, traditional materials, and matured industrial applications. No mechanics handbooks exist. Nanotribology, nanomechanics, and nanomaterial characterization have become important in many nanotechnology applications. A primer to these subjects is needed. The purpose of this revised 4th Edition of Nanotribology and Nanomechanics is to present the principles of nanotribology and nanomechanics and their relevance to various applications. The appeal of the subject book is expected to be broad. The first edition was published in 2005, the second in 2008, and the third in 2011. This fourth edition is an update based on recent developments.

The chapters in the book have been written by internationally recognized experts in the field, from academia, national research laboratories and industry, and from all over the world. The book integrates the knowledge of the field from mechanics and materials science points of view. In each chapter, we start with macroconcepts leading to microconcepts. We assume that the reader is not expert in the field of nanotribology and nanomechanics, but has some knowledge of macrotribology/mechanics. It covers various measurement techniques and their applications, and theoretical modeling of interfaces. The organization of the book is straightforward. The first part of the book covers fundamental experimental and theoretical studies. The latter part covers applications.

The book is intended for three types of readers: graduate students of nanotribology/nanomechanics/nanotechnology, research workers who are active or intend to become active in this field, and practicing engineers who have encountered a tribology and mechanics problem and hope to solve it as expeditiously as possible. The book should serve as an excellent text for one or two semester graduate courses in scanning probe microscopy/applied

scanning probe methods, and nanotribology/nanomechanics/nanotechnology in mechanical engineering, materials science, applied physics, or applied chemistry.

I would like to thank the authors for their excellent contributions in a timely manner. I also wish to thank my wife, Sudha, my son, Ankur, and my daughter, Noopur, who have been very forbearing during the preparation of this book.

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