

# Progress in Lubrication and Nano- and Biotribology

EDITED BY

Catalin I. Pruncu  
Amit Aherwar  
Stanislav Gorb



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# Preface

Tribology is a multidisciplinary science that encompasses mechanical engineering, materials science, surface engineering (surface coating, surface modification, and surface topography analysis), lubricants, and additives chemistry. Since its early time, tribology – rubbing science – has been seen as an emergent and very challenging topic because it brings together different aspects as principles of friction, lubrication, and wear. The knowledge of tribology science was applied first about 3500 BC at a basic level for moving stone in which water was used as a lubricant in order to reduce friction and protect the surface of materials finally leading to reduced wear. Nowadays, the science of tribology is used very broadly and covers the fields of metals, polymers, ceramics, and a combination of composites with tremendous applications. To further help the research community and industry environment to be informed with the latest advancement, the proposed book will provide an update of all the different pairs of materials used in tribological contact in a widespread way. Leading researchers from industries, academia, government, and private research institutions across the globe will benefit from the knowledge provided by this highly application-oriented book. Moreover, it provides cutting-edge research from around the globe on the tribology field. Current status, trends, future directions, opportunities, and so on are discussed in detail, making it friendly for young researchers too. Furthermore, this part of the book is focused mainly on providing a systematic and comprehensive account of the recent progress in lubrication and nano-biotribology.

The contents of this book are spread over nine chapters.

Chapter 1 gives a brief overview of the recent advancement in biotribology followed by a careful discussion of its future projection. The major areas of biotribology research, such as joint, skin, and dental, are considered.

Chapter 2 focuses on the preparation methods and tribological performances of the best-known lubricant nanoadditives. The synthesis and modification processes of typical nanomaterials are described, and the rheology performance of lubricants with nanoadditives is introduced.

Chapter 3 discusses the recent progress in ceramic matrix high-temperature self-lubricating materials, including oxide ceramic matrix, nitride ceramic matrix, carbide ceramic matrix, boride ceramic matrix, and MAX phase ceramic matrix high-temperature self-lubricating materials.

Chapter 4 presents the current trends in the development of lubricating grease and its lubrication behavior.

Chapter 5 aims to inquire and foresee the operative analytical behavior of finite hydrodynamic bearing in the turbulence regime, which deals with non-Newtonian lubricants. The classical momentum and continuity equations have been utilized under turbulent and non-Newtonian flow, and details of the steady-state characteristics are presented too.

Chapter 6 focuses on the current development in the research area of bio-functionalized macro-porous Ti, which is a promising implant material. Some highlights are indicated for further efforts to study essential long-time clinic trials and applications.



Chapter 7 provides an overview of structural, experimental, and numerical studies on interactions between the ventral surface of snake skin and various substrates. Finally, some biomimetic implications of these results and future perspectives of studies on snake skin tribology are discussed.

Chapter 8 explores the tribo-behavior of Ti6Al4V (influential factors and interactive responses) and the ability of the EDM process to develop protective surface layers over the substrate used in the biomedical field.

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# Editors

**Dr. Catalin I. Pruncu** is a Research Fellow in the Design, Manufacturing, and Engineering Management at the University of Strathclyde, Glasgow UK with 10 years of research experience in academia and industry. He has published more than 100 papers in ISI journals, 3 books, a patent, and other papers at various national and international conferences. Catalin is a Charter and Member of the Institute of Mechanical Engineers (UK) since November 2015. He has experience in prestigious universities (Imperial College London, University of Birmingham, University of Sussex) and industries such as IMI Truflo Marine Ltd. and Spanish Navy. Recently, he was invited as Editor for Special Issue, Wear Behavior of Polymer Composites and Mathematical Modeling and Simulation in Mechanics and Dynamic Systems, MDPI, and he is also a reviewer for almost 50 ISI journals including *Measurement*, *Elsevier*, *Journal of Materials Research and Technology*, *Surface and Coatings Technology*, *Journal of Cleaner Production*, and so on. He was involved in organizing different international conferences including the 12th International Conference on New Trends in Fatigue and Fracture, Brasov, Romania 2012.

**Dr. Amit Aherwar** is an Assistant Professor at the Department of Mechanical Engineering, Madhav Institute of Technology & Science, Gwalior, Madhya Pradesh, India. He received his Ph.D. from Malaviya National Institute of Technology, Jaipur, Rajasthan, India. He has more than eight years of teaching and research experience. His research interest includes tribology, biomaterials, surface characterization, multi-material and advanced composites, recycle/reuse of industrial wastes for engineering applications, and multi-criteria optimization. He has published more than 35 technical papers in reputed national and international journals/conferences, and also served as a reviewer for various journals.

**Prof. Dr. Stanislav Gorb** is a Professor and Director at the Zoological Institute of the Kiel University, Germany. He received his Ph.D. degree in zoology and entomology at the Schmalhausen Institute of Zoology of the Ukrainian Academy of Sciences in Kiev (Ukraine). Gorb was a postdoctoral researcher at the University of Vienna (Austria), a research assistant at the University of Jena, and a group leader at the Max Planck Institutes for Developmental Biology in Tübingen and for Metals Research in Stuttgart (Germany). Gorb's research focuses on morphology, structure, biomechanics, physiology, and evolution of surface-related functional systems in animals and plants, as well as the development of biologically inspired technological surfaces and systems. He received the Schlossmann Award in Biology and Materials Science in 1995, the International Forum Design Gold Award in 2011, and the Materialica "Best of" Award in 2011. In 1998, he was the winner of BioFuture Competition for his works on biological attachment devices as possible sources for biomimetics. Gorb is a corresponding member of the Academy of the Science and Literature Mainz, Germany (since 2010) and member of the National Academy of Sciences Leopoldina, Germany (since 2011). Gorb has authored several books, more than 500 papers in peer-reviewed journals, and 4 patents.



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