STEVENS
INSTITUTE OF TECHNOLOGY
1870

Ph.D. DISSERTATION DEFENSE

Candidate:	Yiwen Xi
Degree:	Doctor of Philosophy
School:	Charles V. Schaefer, Jr. School of Engineering and Science
Department:	Interdisciplinary Engineering (Mechanical Engineering & Biomedical Engineering)
Date:	Tuesday, January 23rd, 2023
Time/Location:	09:30-11:30 AM / Carnegie315
Title:	Tribological Effects of Micro/Nano Texturing in Biomimetic Aqueous Environments
Chairpersons:	Dr. Chang-Hwan Choi, Department of Mechanical Engineering, School of Engineering and Science Dr. Xiaojun Yu, Department of Biomedical Engineering, School of Engineering and Science
Committee Members:	Dr. Robert Chang, Department of Mechanical Engineering, School of Engineering and Science Dr. Jennifer J. Kang-Mieler, Department of Biomedical Engineering, School of Engineering and Science Dr. Prashant K. Sharma, Department of Biomedical Engineering, University of Groningen and University Medical Center Groningen

ABSTRACT

Micro/nano texturing, designed to minimize friction between implants and human tissues, may inadvertently elevate friction in physiological conditions, resulting in potential tissue damage, especially during low-speed reciprocating sliding motions. Despite the advantageous and promising biological response towards textured surfaces in vitro, it is imperative to investigate the tribological properties of micro/nano-textured surfaces before their in vivo application. This thesis delves into the intricacies of tribological phenomena associated with micro/nano surface texturing and its implications in biomimetic aqueous environments, specifically focusing on its relevance to biomedical applications. The primary objective of this research extends beyond merely reducing friction; it aspires to cultivate an environment for optimal interactions between textured surfaces and cells, acknowledging potential issues of heightened friction. It delves into the tribological principles of micro/nanopore and micrograte textures on various materials, from hard substrates like silicon to soft ones like hydrophobic polydimethylsiloxane (PDMS) and hydrophilic hydrogels. Using universal mechanical tester, friction was analyzed in the context of reciprocation sliding, a common motion pattern within the human body (e.g., chewing, blinking and joint articulation). The research illustrates the significant role of texture stiffness disparity in modulating friction. It highlights the influence of texture size on friction, emphasizing the distinction between nano and micro textures. It also showcases the advantage of hydrophilic hydrogels in friction reduction against hydrophobic polymers, pinpointing the importance of their water content. Generally, surface texturing may increase friction in biomimetic environments, but under certain conditions, friction can decrease, especially at higher sliding velocities, amidst viscous solutions, and when using harder probes on water-containing soft materials like hydrogels. In conclusion, this study offers valuable

insights into tribological effects of micro/nano texturing in biomimetic aqueous environments, guiding the enhancement of surface textures in medical applications while ensuring biocompatibility and minimizing friction-related challenges.