October 26, 2023

Overcoming the adhesion paradox and switchability conflict on rough surfaces with shape memory polymers

Huajian Gao

Distinguished University Professor

Nanyang Technological University

ABSTRACT:

Maintaining adhesion on rough surfaces is a long-standing challenge in engineering due to the adhesion paradox (rapid decrease in adhesion strength with increasing surface roughness) and the switchability conflict (trade-off between strong adhesion strength and easy detachment). Here, we show [1,2] that, utilizing the rubber-glass transition of shape memory polymers (SMPs), both challenges are overcome. Making contact between an SMP adhesive and a rough surface in the rubbery state followed by shape-locking in the glassy state results in orders of magnitude enhancement in adhesion strength. On the other hand, detaching the SMP adhesive upon transitioning back to rubbery-state results in weak adhesion and on-demand detachment. We further demonstrate that, employing our method, rougher surfaces enable stronger adhesion and easier detachment.

BIOGRAPHY:

Huajian Gao received his B.S. degree from Xian Jiaotong University in 1982, and his M.S. and Ph.D. degrees in Engineering Science from Harvard in 1984 and 1988, respectively. He served on the faculty of Stanford from 1988-2002, as Director at the Max Planck Institute for Metals Research from 2001-2006 and as Walter H. Annenberg Professor of Engineering at Brown from 2006-2019. At present, he is one of 6 Distinguished University Professors at Nanyang Technological University and Scientific Director of the Institute of High Performance Computing in Singapore.

Professor Gao's research has been focused on the understanding of basic principles that control mechanical properties and behaviors of materials in both engineering and biological systems. He is Editor-in-Chief of Journal of the Mechanics and Physics of Solids, the flagship journal in his field. His list of honors includes elections as Member of National Academy of Sciences, National Academy of Engineering, American Academy of Arts and Sciences, Fellow of the Royal Society, German National Academy of Sciences Leopoldina, and Foreign Member of Chinese Academy of Sciences and Academia Europaea, as well as numerous academic awards including the Timoshenko Medal and Rodney Hill Prize, the two highest lifetime achievement awards in his field.