Department of Electrical and Computer Engineering
Materials Engineering Program
Center for Integrated Bio and Nano Systems
10:30 a.m., March 5, 2021

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Structured surfaces with switchable adhesion

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Abstract: Advances in robotics and automation are enabling increased use of pick-and-place processes for manufacturing systems at multiple scales, ranging from heterogeneous microsystems to complex macro-scale systems. A key challenge in all pick-and-place processes is the need to "grip" and then release the component being transferred. Surfaces with tunable or switchable adhesion are a promising solution for controllably gripping small-scale objects. We have developed two new strategies for creating surfaces with tunable adhesion. Both approaches exploit structured composite surfaces, but the adhesion and hence tunability are achieved in different ways in the two approaches. In the first approach, composite pillars comprised of a stiff core and a compliant elastomer shell are used to achieve enhanced adhesion under normal loading and the adhesion can be tuned through the application of shear. Finite element-based modeling was used to elucidate the underlying mechanics of these structures and design structures with specific adhesive characteristics. Experiments demonstrate dry (i.e., van der Waals mediated) adhesion strengths >1.5 MPa, significant tunability through shear loading, and the application of these composite structures as stamps for microtransfer printing of silicon nanomembranes. In the second approach, electrically tunable adhesion is realized through structured surfaces consisting of arrays of vertically aligned carbon nanotubes that are conformally coated with a thin dielectric layer. The structures were fabricated and characterized via controlled adhesion measurements and pick-and-place experiments. The surfaces offer significant adhesion tunability and the measured behavior is consistent with analytical models that have been developed.

Short Bio:

Kevin T. Turner is a Professor and the Department Chair of Mechanical Engineering and Applied Mechanics at the University of Pennsylvania. Professor Turner also holds a secondary appointment in Material Science and Engineering. He received his BS from the Johns Hopkins University and SM and PhD from MIT. Prior to joining the University of Pennsylvania in 2011, he was on the faculty of the University Wisconsin-Madison. His primary research interests are related to mechanics, manufacturing, and materials for micro- and nano-scale systems. His research spans multiple topics including, structured surfaces with tunable adhesion, experimental methods to characterize interface mechanics across length scales, transfer/printing processes for manufacturing flexible and hybrid electronic devices, and nanocomposites. He is a recipient of numerous honors and awards, including ASME Sia Nemat-Nasser Early Career Award, Adhesion Society's Young Adhesion Scientist Award, SME's Outstanding Young Manufacturing Engineer Award, NSF CAREER award, ASEE Ferdinand P. Beer and E. Russell Johnston Jr. Outstanding New Mechanics Educator. More information at: http://turner.seas.upenn.edu/.

Please contact Dr. Cunjiang Yu <cyu13@Central.UH.EDU> or Jiming Bao (jbao@uh.edu) if you want to meet with the speaker.