Nanofluidic Energy Conversion

Dr. Xi Chen

Department of Earth and Environmental Engineering, Columbia University
xichen@columbia.edu, http://www.columbia.edu/~xc2107

Summary
When a liquid phase, whose motion is controlled by pressure, voltage, and/or heat, is confined in a nanoporous material, the ultra-large pore surface area exposed to the liquid becomes an ideal platform for energy conversion, including energy harvesting (convert mechanical or thermal energy into electricity), energy absorption (convert mechanical energy into heat and interface energy) and actuation (convert thermal or electrical energy into mechanical output). The energy conversion density is orders-of-magnitude higher than that of conventional materials, with potential performance gains typical of disruptive technologies and with large scope of impact. The design and optimization of the multifunctional nanocomposite material (with nanoporous matrix and functional liquid filler) are underpinned by the science of nanofluidics, a wide open area where solid mechanics and fluid mechanics meet at the small scale. At the nanoscale, owing to the counterintuitive behaviors of the confined liquid molecules and ions, as well as their unique interaction characteristics with the solid atoms, many conventional fluid mechanics laws break down and new nanofluidic theories are established based on atomistic simulations. The multiscale studies also provide critical insights for improving the energy conversion processes, and the novel nanoporous materials developed herein become very attractive as the building blocks of the next-generation multifunctional systems, with high-performance self-protective, self-powered, and self-actuated functionalities.