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Nanostructured polymer-based piezoelectric and triboelectric materials and devices for energy harvesting

Harvesting energy from ambient mechanical sources in our environment has attracted considerable interest due to its potential to power applications such as ubiquitous wireless sensors and Internet of Things devices. In this context, piezoelectric and/or triboelectric materials offer a relatively simple means of directly converting mechanical energy from ubiquitous ambient vibrating sources into electrical power for microscale/ nanoscale device applications. In particular, nanoscale energy harvesters, or nanogenerators, are capable of converting low-level ambient vibrations into electrical energy, thus are vital to the realization of the next generation of self-powered devices. Polymer-based nanogenerators are attractive as they are inherently flexible and robust, making them less prone to mechanical failure which is a key requirement for vibrational energy harvesters. They are also lightweight, easy and cheap to fabricate, lead-free and biocompatible, but in many cases their energy harvesting performance is found lacking in comparison to more commonly studied inorganic materials. Recent advances have been made in developing scalable nanofabrication techniques for flexible and low-cost polymer-based nanogenerators with improved energy conversion efficiency, including the incorporation of high-quality polymer nanowires with enhanced crystallinity, piezoelectric and/or surface charge properties. In this talk, I will discuss aspects of nanomaterials growth and energy harvester device design, including those involving nanowires of polymers of polyvinylidene fluoride and its co-polymers, nylon-11, and poly-lactic acid for scalable piezoelectric and triboelectric nanogenerator applications, as well as the design and performance of polymer-ceramic nanocomposite nanogenerators. In particular, I will highlight the effects of growth parameters, nanoconfinement effects, self-poling, surface polarization, crystalline phases, and device assembly on the energy harvesting performance of a range of nanostructured polymer-based materials and devices.