A Solution Processable Polymer-Hybrid Thermoelectric Material

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Thermoelectrics have the potential to become an alternative power source for distributed electrical generation as they are ideal for applications where heat is underutilized. More recent material and manufacturing advances have further suggested that thermoelectrics could independently generate primary power. However, due to cost, manufacturability, abundance, and material performance, the full potential of thermoelectrics has yet to be realized. In the last decade, thermoelectric material improvements have largely been attributed to a reduction in thermal conductivity caused by nanostructuring. An alternative approach is to decouple and optimize the electrical conductivity and thermopower using the unique properties of organic-inorganic interfaces. One method to do this could rely on the electrical properties of a conducting polymer in combination with the thermoelectric proprieties of an inorganic semiconductor. It is expected that the thermal conductivity of this hybrid material would be low due to the inherent phonon mismatch between polymers and inorganics. Previously, we have developed a method for producing a solution processable thermoelectric material suitable for thin film applications using a hybrid polymer-inorganic systems consisting of crystalline tellurium nanowires coated in a thin layer of a conducting polymer (i.e., PEDOT:PSS). The interface properties of these materials scale and bulk films demonstrate enhanced transport properties beyond those of either component. More recently, we have been able to significantly improve the thermoelectric properties of these materials by morphological and chemical modifications. Here, we present our methodology and experimental transport properties of this new material where the thermal conductivity, electrical conductivity, and thermopower predictably vary as a function of composition, size, and chemical doping. The mechanism for these improvements is currently under investigation, but experimental results suggest that transport is dominated by interfacial phenomenon. Furthermore, both the electrical conductivity and thermopower can be independently increased without appreciably increasing the thermal conductivity. These improvements in concert with the solution processable nature of this material make it ideal for new thermoelectric applications.