ANISOTROPIC THERMOELECTRIC PROPERTIES OF ORDERED PEDOT:PSS FILMS

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Thermoelectric devices, which can be used for the direct conversion of heat energy to electricity, have drawn intense interest as promising candidates for harvesting waste heat and solar thermal energy.[1,2] Pioneering studies of thermoelectric materials mainly focused on inorganic semiconductors, such as bismuth-telluride (Bi-Te) alloys, magnesium-silicon (Mg-Si) alloys, and metal oxides. Most of these materials work at temperatures higher than 200°C; the best known low-temperature thermoelectric material is Bi₂Te₃, which has a room temperature ZT greater than 1. Unlike their inorganic counterparts, organic semiconductors have not been thoroughly investigated, because of their relatively low electrical conductivity and Seebeck coefficient. Very recently, Crispin et al. reported that the de-doping of highly conductivity poly(3,4-ethylenedioxythiophene):tosylate (PEDOT:tos) with tetrakis (dimethylamino)ethylene (TDAE) can produce a remarkable ZT value of 0.25.[3] This shows that the performance of organic thermoelectrics could approach that of their inorganic counterparts. Poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) is the most studied conducting polymer system because of its potential use as a transparent electrode. Adding a second solvent, such as ethylene glycol (EG) or dimethyl sulfoxide (DMSO), to an aqueous dispersion of PEDOT:PSS can dramatically enhance its electrical conductivity. Numerous studies have been published on optimizing the process conditions to improve electrical conductivity of PEDOT:PSS, and on understanding the underlying mechanisms. However, there are relatively few studies on the thermoelectric properties of these highly conductive PEDOT:PSS systems.

In this talk, we report the anisotropic thermoelectric properties of commercial Clevios PH1000 PEDOT:PSS doped with a second solvent, EG. Grazing-incidence wide angle X-ray diffraction (GIWAXD) and grazing-incidence small-angle X-ray scattering (GISAXS) showed that adding EG to the PEDOT:PSS solution improved the crystallinity of PEDOT and the ordering of the PEDOT nanocrystals in the solid films. The ordered PEDOT:PSS shows a lamellar structure and thiophene rings have a face-on packing. Free-standing PEDOT:PSS films doped with different concentrations of EG were prepared, and their thermal properties at the through-plane and in-plane direction were studied systematically.