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# Charge Transport of Individual Thermoelectric $Bi_2Te_3$ Core-Poly(3,4-Ethylenedioxythiophene):Polystyrenesulfonate Shell Nanowires Determined Using Conductive Atomic Force Microscopy and Spectroscopy

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**Abstract :** Due to demands of sustainable energy, thermoelectricity converting waste heat into electrical energy has become one of the intensive fields of worldwide research. However, such harvesting technology has shown low device performance in the temperature range below 150℃. In this work, a hybrid nanowire of inorganic bismuth telluride ($Bi_2Te_3$) and organic poly(3,4-ethylenedioxythiophene):polystyrenesulfonate (PEDOT:PSS) synthesized using a simple in-situ one-pot synthesis, enhancing efficiency of the nanowire-incorporated PEDOT:PSS-based thermoelectric converter is highlighted. Since the improvement is ascribed to the increased electrical conductivity of the thermoelectric host material, the individual hybrid nanowires are investigated using voltage-dependent conductive atomic force microscopy (CAFM) and spectroscopy (CAFS) considering that the electrical transport measurement can be performed either on insulating or conducting areas of the sample. Correlated with detailed chemical information on the crystalline structure and compositional profile of the nanowire core-shell structure, an electrical transporting pathway through the nanowire and the corresponding electronic-band structure have been determined, in which the native oxide layer on the $Bi_2Te_3$ surface is not considered, and charge conduction on the topological surface states of $Bi_2Te_3$ is suggested. Analyzing the core-shell nanowire synthesized using the conventional mixing of as-prepared $Bi_2Te_3$ nanowire with PEDOT:PSS for comparison, the oxide-removal effect of the in-situ encapsulating polymeric layer is further supported. The finding not only provides a structural information for mechanistic determination of the thermoelectricity, but it also encourages new approach toward more appropriate encapsulation and consequently higher efficiency of the nanowire-based thermoelectric generation.

**Keywords :** electrical transport measurement, hybrid $Bi_2Te_3$-PEDOT:PSS nanowire, nanoencapsulation, thermoelectricity, topological insulator
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