Global Science Research Journals

Global Educational Journal of Library and Information Science

Extended Abstract OpenAccess

Modulation doping and energy filtering in two-dimensional, dichalcogenides: Moving toward flexible thermoelectrics with a ZT ~ 1

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Introduction

Two-dimensional systems, with merely connected topologies, are synthesized in dichalcogenides. Such materials gift novel opportunities in heterogeneous physical phenomenon. This speak can demonstrate a part coherent, metal dopant supplemental to reactive edges of those low-dimensional dichalcogenide system that dramatically alters the physical phenomenon behavior of such materials in sudden ways in which. Temperature dependent conduction suggests that native band bending across the interface acts as associate degree energy filter for carrier injection. Further, important decoupling between the electrical conduction and Seebeck constant is ascertained in films of those platelettes, resulting in astonishingly high power factors. A fivefold/eightfold increase in electricity figure of benefit (ZT) and power issue (PF) is seen over pure Bi2Te3 platelettes with the addition of Ag/Cu severally, with the correlate being the barrier height at the platelette edge. This yields a ZT of zero.39 for Ag-doped Bi2Te3 and zero.6 for Cudoped Bi2Te3, each at temperature. The ZT is more augmented to zero.93 at 470 K within the atomic number 29 case. initial principles band structure calculations show that the physics of the semiconductor-metal interfaces square measure quite totally different for edge and facial configurations, suggesting that the location of metal dopant plays a vital role within the increased electricity performance.

Finally, flexible TE legs can be made from inorganic thermoelectric materials. An alternative here is to deposit thin legs of inorganic material on a flexible polymer substrate, where good thermoelectric performance of the inorganic material can be integrated with the flexibility of the substrate. However, this is subject to the inherent limitation of thermal stability of the polymeric substrate. Therefore, to enable high-temperature use of flexible thermoelectrics, the development of fully inorganic, and high-temperature-stable, materials for flexible thermoelectrics is an outstanding issue. There are reviews covering specific subtopics on flexible thermoelectrics, notably several excellent reviews on organic/wearable thermoelectrics and carbon-nanotube-based materials and devices. The purpose of the present paper is to provide a more complete overview the research progress on flexible (inorganic, organic, and hybrid) thermoelectric materials and devices. We highlight the current state-of-art strategies to optimize the TE properties of conducting polymers and their corresponding composites, and discuss approaches to achieve flexible inorganic materials. We review the preparation, characterization, and application of flexible TEGs, and assess outstanding research and technological challenges on flexible thermoelectric materials and devices. The paper is organized as follows. First, the theoretical basis is summarized (Section 2). TEGs can be put to use in various energy conversion applications, from wrist watches to vehicles, since their output power can be in the range from several μW to kW. In particular, thermoelectrics benefit from low- to medium-power and -size applications, while other conversion systems (including power plants) become less efficient as they are scaled down in size and power. They are therefore of interest for use in low- to medium-power applications, notably those used in large numbers. Taking the human body as an example, it is also a thermal source losing heat by convection, conduction, and radiation. The energy expenditures of the body vary depending on activities. When a person is sitting, ∼116 W power is dissipated. Assuming that the temperature of the human body is 310 K (37 °C), and the ambient temperature is 263 K, the theoretical maximum of the recoverable power is 17.6 W, assuming the Carnot efficiency (see Section 2.3) which is the theoretical maximum for the efficiency of a thermodynamic process (heat engine). If the ambient temperature increases to 308 K, the maximum recoverable power correspondingly decreases to 0.75 W. Evaporative heat, such as water-saturated air expelled from the lung and water diffusing through skin, etc., normally accounts for ∼ 25% of the total heat dissipation. As a result, the highest power that could theoretically be harvested from the human body is in the range from ∼0.5 W to ∼13 W depending on the temperature difference, which is still more than sufficient to power low-power personal electronics, since they normally require power supplies in the μW-to-mW-range. Conducting polymer TE materials are reviewed in Section 3, and Section 4 covers inorganic nanostructure/polymer TE nanocomposites. The emerging topic of fully inorganic flexible TE materials (thin films) is covered in Section 5. Section 6 reviews flexible thermoelectric devices, and Section 7 offers some final perspectives, outlook and challenges.

Biography

Carroll received his PhD from Wesleyan University in Connecticut and did his postdoctoral work at the University of Pennsylvania. He also served as a staff scientist at the Max-Planck-Institut für Metallforschung in Stuttgart before moving first to Clemson University then to Wake Forest University where he became Director of the Nanotechnology Center. Dr. Carroll has published more than 300 papers in reputed journals (h = 60), holds more than 30 patents, and serves on the editorial board of several academic journals.