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Peltier cooling in carbon nanotube circuits

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Conversion of the heat energy directly into electricity and vice versa attracts a significant attention nowadays. Systematic study of thermoelectric phenomena allows for better understanding of the intrinsic mechanisms of the energy transformation and dissipation on the nanoscale. A bias electric voltage DV, applied to a conducting sample, pulls the charge carriers, thereby inducing a finite electric current Ie= GeDV, where Ge is the electric conductance. Since the bias voltage, DV also induces an inhomogeneity of charge carrier density along the sample, it leads to a finite temperature difference hot and cold DT=Thot -Tcold, where Thot(cold) is the temperature of the hot (cold) part of the sample. The thermoelectric effect is described as DV=SDT where S is a linear-response, two-terminal property known as Seebeck coefficient. Thermoelectric effect is measured using two sequentially-connected carbon nanotube (CNT) field-effect transistors (FETs), each with charge carriers of opposite sign, either electrons or holes, whose concentration is controlled by the side gate electrodes. A change DT of the intrinsic temperature is determined from the change of the position and width of spectral singularities manifested in the experimental curves of the source-drain electric conductance. We deduce an impressive Peltier effect ±DT=57 K inside the CNT associated with cooling and heating, depending on the direction of the electric current. The effect can be utilized for building thermoelectric devices having a figure of merit up to cold ZT=7.5>>1 and the cooling power density Pcooling~80 kW/cm2.

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CNT and GrO as excellent platform for synthesis of nano-structured metal–organic frameworks (MOFs) with vast potential applications

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Graphene oxide (GrO) and carbon nanotubes (CNTs) have shown vast applications in various areas such as electronics, sensors, and structural composite materials. Owning vast surface area and tunable surface chemistry, GrO and CNTs have the great advantages of acting as perfect platform for loading different nanoparticles. Metal–organic frameworks (MOFs) are an interesting class of porous materials composed of metal and organic components, with large number of applications in gas storage, catalysis, drug delivery, and separation. Over past two decades, an explosion in field of research and development of new porous materials was witnessed, at which the spearhead being highly porous MOFs. New trend in MOFs field deals with construction of MOF-based hybrid composites with enhanced porosity and surface area of MOFs in order to elevate their potential application. GrO and CNTs are among the most suitable and smart materials to synthesize MOF-based composites. In this concept, GrO and CNTs with nonporous layered structure and large surface area are introduced as excellent platform to MOFs at which MOF nanoparticles form and get loaded over them.

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