Promoted Electron Transport and Sustained Phonon Transport by DNA down to 10 K

Zaoli Xu [C, S]
Department of Mechanical Engineering, Iowa State University, Ames, IA, U.S.A.
zaolixu@iastate.edu

This work reports on a pioneering study of the electron transport in nanometer-thick Ir film supported by a DNA fiber, and the phonon transport sustained by the DNA itself. By evaluating the electrical resistivity (r_e)~temperature relation based on the Block-Grüneisen theory, we find the Ir film has weak phonon softening indicated by 7~15% Debye temperature reduction. The Ir film's intrinsic r_e is promoted by DNA electron thermal hopping and quantum tunneling, and is identical to that of bulk Ir. Although the nanocrystalline structure in ultrathin metallic films intends to give a higher Lorenz number since it reduces the electrical conductivity more than thermal conductivity, the DNA-promoted electron transport in the Ir film preserves a Lorenz number close to that of bulk crystalline Ir. By defining a new physical parameter entitled "thermal reffusivity", the residual phonon thermal resistivity of DNA is identified and evaluated for the first time. The thermal reffusivity concept can be widely used to predict the phonon thermal transport potential of defect-free materials. We predict that the thermal diffusivity of defect-free DNA fiber could be 36~61% higher than the samples studied herein. The structure domain size for phonon diffusion/scattering is determined as 0.8 nm in DNA.