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FRACTIONAL DIFFUSION FOR THERMAL TRANSPORT IN SUBMICRON SEMICONDUCTORS

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EXTENDED ABSTRACT

Most micro/nanoscale heat transport experiments are interpreted using phenomenologically adjusted Fourier theory. We show that the energy dynamics are much better described as truncated superdiffusive Lévy flights instead of conventional Brownian motion [Vermeersch 2015a, Vermeersch 2015b]. Generalization of the Fourier equation by fractional diffusion is described. All essential physics of nondiffusive transport are captured by the fractal dimension and the ballistic-diffusive transition length of the stochastic process [Vermeersch 2015b]. We determine these two new material parameters experimentally for several semiconductors using transient laser thermoreflectometry [Vermeersch 2015b, Mohammed 2015]. Nonlocal relation between the heat flux and the temperature gradient is quantified. This new formalism enables more accurate characterization of thermal interface resistances [Vermeersch 2014]. When there is a temperature gradient on the length scale of ballistic-diffusive transition length (couple of microns for several semiconductor alloys at room temperature) or during transient thermal response in 0.1-10's nanosecond time scale, significant deviations between superdiffusive and standard diffusive theory is observed [Vermeersch 2015b]. This has important implications in the design of high power and high speed electronic and optoelectronic devices.

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