A wave theory of heat transport with applications to Kapitsa resistance and thermal rectification

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Abstract

We develop a theory of thermal transport in nanoscale layered structures based on wave processes. The theory incorporates two fundamental principles, first, that the spectra of thermally excited waves are determined by the temperature differential and the heat flux, and second, that the wave fields in the heat exchanging domains are coupled. The developed method includes classical theories as special cases that are valid in larger scales, and it naturally explains such phenomena as interface thermal resistance (Kapitsa resistance) and thermal rectification (asymmetry of thermal transport). Numerical examples demonstrate the feasibility of the approach, and they show good agreement with measurements of Kapitsa resistance reported in the literature.