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Influence of Dimensionality on Thermoelectric Device Performance[1] RASEONG KIM, Purdue University, SUPRIYO DATTA, MARK S. LUNDSTROM — Significant improvements in the thermoelectric figure of merit have recently been demonstrated in low dimensional structures. These improvements have been largely due to the reduced lattice thermal conductivity, so the question of how much additional improvement is possible by engineering the electronic structure has become important. Our goal is to present a clear answer to this question using the Landauer formalism, which applies from the ballistic to diffusive limits. We first relate thermoelectric coefficients to the transmission and the number of conducting channels, M(E). The optimum M(E) is known to be a delta-function. We then compare thermoelectric coefficients in one, two, and three dimensions and show that the channels are utilized more effectively in lower dimensions. The shape of M(E) improves as dimensionality decreases, but lower dimensionality itself does not guarantee better performance because it is controlled by both the shape and the magnitude of M(E). To realize the advantage of lower dimensionality, the packing density must be very high. The benefits of engineering the shape of M(E) appear to be modest, but approaches to increase the magnitude of M(E) could pay large dividends.

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