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Low Thermal Conductivity Materials for Thermoelectrics: Physics, Materials, and Applications

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Abstract: *Thermoelectric materials have gained significant attention due to their ability to directly convert heat into electrical energy and vice versa. The efficiency of thermoelectric devices depends strongly on achieving high electrical conductivity while maintaining low thermal conductivity. This combination is challenging because these properties are often interdependent.*
Low thermal conductivity materials play a crucial role in enhancing thermoelectric performance by reducing heat flow and maintaining a temperature gradient across the material. This paper presents a detailed study of the physics behind thermal transport suppression, focusing on phonon scattering mechanisms, nanostructuring, and lattice engineering. Various classes of materials, including alloys, complex crystals, and nanocomposites, are discussed. The paper also highlights experimental techniques, applications, and future directions in thermoelectric research..

Keywords: Thermoelectrics, Low Thermal Conductivity, Seebeck Effect, Phonon Scattering, Nanostructured Materials, Figure of Merit, Energy Conversion