

Defect Engineering and Thermal Conductivity: Mechanisms, Materials, and Applications

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Abstract: *Defect engineering has emerged as a powerful approach for tailoring the thermal properties of materials, particularly in the field of solid state physics and materials science. The presence of defects such as vacancies, interstitials, dislocations, and grain boundaries significantly influences phonon transport, thereby affecting thermal conductivity. By controlling the type, concentration, and distribution of defects, it is possible to either suppress or enhance heat transport depending on the application. This paper presents a comprehensive analysis of the role of defects in modifying thermal conductivity, with a focus on phonon-defect interactions, nanoscale effects, and material design strategies. It also discusses experimental techniques, practical applications, and future directions in defect-engineered materials.*

Keywords: Defect Engineering, Thermal Conductivity, Phonon Scattering, Crystal Defects, Nanomaterials, Heat Transport, Lattice Imperfections