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Topical Review

Phonon softening in nanostructured phonon–mediated superconductors (review)

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Abstract

Various aspects of phonon spectrum changes in nanostructured phonon-mediated superconductors are considered. It is shown how, with the development of experimental techniques and, accordingly, obtaining new results, the understanding of the influence of the surface and nanoscale on the magnitude of the electron–phonon interaction and the critical temperature T_c changed and deepened. The review is organized as follows. After the *Introduction*, in the *second* part we give the quick theoretical background for the description of superconductivity within the framework of various formalisms. In the *third* part we describe the properties of nanostructured (granular) thin films paying attention to the impact of grain sizes and methods of deposition on the T_c value. The role of material parameters is underlined and different aspects of the behavior of granular thin films are discussed. In the *fourth* section the impact of external sources of modification of the phonon spectra like noble gases and organic molecules are considered. Problems and progress in this area are discussed. The *fifth* part is dedicated to the phonon modification and related quantum size effects in nanostructured superconductors. In the *sixth* part we review the results of direct evidence of phonon softening in nanostructured superconductors and in the *seventh* section we discuss a possible alternative description of the superconducting properties of nanostructured superconductors related to the concept of metamaterials. In the *eighth* and *ninth* parts we review the impact of substrates with lattice mismatched parameters and graphene sheets, respectively, on the modification of the phonon spectrum and enhancement of superconductivity in various superconducting thin films. Finally, in the last *tenth* section we consider the nonequilibrium superconductivity driven by femtosecond pulses of light, which leads to generation of coherent phonons and to a significant increase in the critical temperature in a number of superconducting materials.

Keywords: superconductivity, nanostructure materials, Eliashberg function, phonons, electron–phonon interaction

(Some figures may appear in colour only in the online journal)

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