Functional Materials 9, No.3 (2002) © 2002 — Institute for Single Crystals

Superconducting nanoparticle response to electromagnetic perturbation

V.Z.Lozovski, D.V.Reznik

Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, 45 Nauki Ave., 03028 Kyiv, Ukraine

Received December 14, 2001

Formally exact solutions of self-consistent field equations for an electromagnetic wave scattered by a superconducting nanoparticle have been obtained. Expressions have been derived for effective susceptibility and dissipative function of the system. The electr omagnetic energy absorption by the superconducting nanoparticle has been shown to be due to the particle interaction with substrate. It has been shown that it is necessary to take into account the non-local effects when considering nanosized superconducting systems.

В работе рассмотрены формально точные решения уравнений самосогласованного поля для электромагнитной волны, рассеянной на сверхпроводниковой наночастице. На основании этих результатов проанализированы эффективная восприимчивость и диссипативная функция системы. Показано, что поглощение электромагнитной энергии сверхпроводящей наночастицей обусловлено взаимодействием частицы с подложкой. Продемонстрирована необходимость учета нелокальных эффектов при рассмотрении сверхпроводниковых систем наноразмеров.

Recently, the interest in superconducting materials increases considerably. This is due to novel high-temperature superconductors (HTSC) developed and thus an increased availability of superconducting devices for widespread applications [1]. On the other hand, unique properties of superconductors such as low noise level and essentially zeroed losses are widely required. That is why superconducting devices become more and more popular as inductive current limiters, memory devices with prolonged updating periods, high-frequency keys with high impedance change factor, various filters and, first, highest precision magnetic field sensors [2–4]. The rapid development of micro- and nanoscale engineering resulted in principally novel devices, such as light-receiving superlattices, photonic crystal fibers, etc. [5, 6]. Superconductors are ideal means for those devices meeting the main requirements thereto, namely, low losses and noise levels. Moreover, the superconducting properties are known to become improved when passing to microscale systems, thus enlarging considerably the application branch for superconductors. In particular, the superconducting structures were proposed recently for use in system operating in optical range, namely, in optical processors, light converters, and other photonic devices.

In this connection, the problem of electromagnetic radiation absorption by a superconducting nanoparticle is of considerable interest. Of importance is the understanding of local field effect on the particle electrodynamic properties. In this work, when considering a nanosize disc, no assumptions were made limiting the considerations for other particle shapes. The disc case was considered only to define unambiguously the problem geometry. Not going into details of rather cumbersome analytical and numerical results obtained for the problem confined in this manner, we were interested only in general conclusions concerning