TRANSIENT TERAHERTZ CONDUCTIVITY IN NANOSCALED SYSTEMS

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Abstract

Ultrafast photoconductivity and charge carrier transport in nanostructured semiconductors is poorly understood on the microscopic level in many systems. The terahertz spectroscopy constitutes a suitable method to probe the nanoscopic motion of charges with a sub-picosecond time resolution and without need to deposit electrical contacts. However, straightforward fitting of the raw terahertz conductivity spectra by the Drude-Smith model, which was abundantly used in the literature, did not lead to a significant advance in an in-depth understanding of these phenomena. This is mainly because of the depolarization fields which build up in any inhomogeneous system. On the one hand, these fields reflect the sample morphology and their understanding in each particular system may provide new information e.g. about the nanostructure connectivity; on the other hand, the effect of unknown depolarization fields can hide or distort fingerprints of the nanoscopic transport. In this contribution we propose a general analytical description of the photoconductivity and transient transmission spectra where the effects of depolarization fields are systematically disentangled from the local carrier response function for both percolated and non-percolated samples. Analysis of experimental data within this framework allows one to uncover the nature of charge carrier transport at nanoscale and assess the connectivity of nanoparticles in quite arbitrary nanostructured systems. This will be shown on the example of various nanocrystalline silicon samples.

Keywords: Nanostructures, photoconductivity, terahertz, percolation, mobility, charge carrier transport, depolarization fields

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