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Possible coherent backscattering of lightwaves from a strongly absorbing nanoporous medium

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Abstract

We report on anomalous light retroreflection from strongly absorbing nanoporous semiconductor materials, GaAs and InP, with strongly polarized retroreflected light with linear polarization coinciding with that of incident beams. The high polarization of retroreflected waves suggests coherent backscattering as the underlying physical mechanism. This phenomenon resulting from multiple scattering is supposed to be possible in an absorbing medium owing to longitudinal electromagnetic waves generated at interfaces. Strong absorption for transverse waves has negligible effect on longitudinal ones and therefore does not prevent their multiple scattering but ensures a high refraction index promoting strong scattering. This hypothesis is supported by a theoretical model and calculations.

Keywords: nanoporous materials, GaAs, InP, coherent backscattering, longitudinal electromagnetic waves

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

Introduction

The wave optics of scattering media, a traditional and classical field of physics, has undergone a renaissance during the last few decades with a number of novel phenomena and concepts including photonic crystals, coherent backscattering, Letokhov's lasers (random lasers), and Anderson localization [1–14], with the latter still hard to observe in the optical range because of the lack of highly refractive transparent materials [15–17]. All the above phenomena are essentially based on the multiple scattering and interference of scattered waves and may occur only under the condition of negligible dissipation of electromagnetic energy in the material forming the medium under consideration. In recent work, we have reported on the unusual effect of pronounced retroreflection from a nanoporous semiconductor material (InP) in the spectral range of the interband transitions with a simultaneously high refractive index ($n = 3.8$) and absorption coefficient ($\alpha = 10^5\,\mathrm{cm}^{-1}$) [18]. The effect was experimentally proved to vanish for weakly absorbed light (when photon energy is less than the band gap energy, E_g) [19]. Retroreflection was observed with coherent and incoherent, monochromatic and wide-band radiation and was apparent to the naked eye with sunlight. Since multiple scattering was *a priori* excluded from consideration at that time, coherent backscattering was ruled out and the polarization properties of the retroreflected light (which would be indicative of coherent backscattering) were not thoroughly investigated. Later, the formation of longitudinal electromagnetic waves was suggested as the possible reason for the observed phenomenon [20]. If this is the case, then multiple scattering becomes possible because the high absorption inherent in ordinary, transverse waves becomes

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