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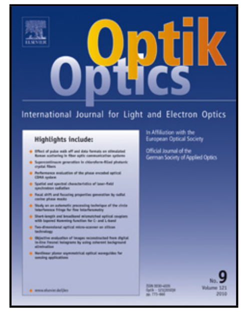

Title: Random lasers tuning by combining a dye-doped liquid crystal and CdS nanoparticles

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Random lasers tuning by combining a dye-doped liquid crystal and CdS nanoparticles

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Abstract

We report the development of LC (negative liquid crystal and mixing liquid crystals) random lasers doped with a gain medium and CdS nanoparticles. By performing frequency doubled 532 nm Nd:YAG (yttrium aluminum garnet) laser as a function of excitation wavelength, we demonstrate laser action in a new category of materials, namely dye doped liquid crystal with semiconductor nanoparticles. The CdS nanoparticles prove to be perfect candidates for building, as shown, a series of laser systems. Lasing is presented in cells, freely suspended liquid crystal films. The optical emission properties are investigated in terms of spectral analysis, below and above lasing energy threshold behavior, emission efficiency, far field spatial laser modes intensity profiling etc. As demonstrated, these DDLC random lasers with the CdS nanoparticles are very promising platforms for investigating the optical mechanism of cadmium sulfide.

Keywords: random lasing, negative liquid crystal, mixing liquid crystals, CdS nanoparticles.

1. Introduction

Semiconductor-based random lasers[1], have certain advantages of controllability in their lasing characteristics (e.g., energy threshold or lasing wavelength) by thermal, electric, or other means, even when compared with other random laser systems such as dye-based lasers[2, 3, 4, 5, 6, 7]. Specifically, semiconductor-based random lasers consist of only randomly shaped particles and can be pumped optically. Besides, the semiconductor nanoparticle and LCs as hosts for gain medium offer additional advantages compared to other materials[8, 9], such as low material costs, small-scale processability, and advanced functionality. The semiconductor nanoparticles enhanced scattering properties of such systems combined with their random morphology provide unique opportunities to engineer multiple light scattering and random lasing using LCs. The light amplification in a random laser originates from strong multiple light scattering among scatterers in an optical gain media. Random lasers with high quality factors (Q factors), combined with large oscillator strength gain media are a promising approach for development of optical (electrical) pumping lasers. In order to achieve high Q factors in random lasers, material textures induced light scattering is essential, as a significantly reduced surface absorption results in low scattering losses of the devices. To date, the nanoparticles have been widely studied in organic gain media and proven to be an efficient scatterers suitable for direct integration in LCs host matrices[10, 11, 12, 13, 14, 15]. More recently extensive work has been carried out towards using nematic liquid crystals as scatters for random lasers. On application of nanoparticles the LC devices produce very strong light scattering which were used to enhance absorption of dye molecules, producing strongly random lasing, such as poly-dispersed liquid crystal with Ag nanoparticles[14], nematic liquid crystal with Ag NPs and suspensions of ZnO nanoparticles in LCs [15]. So far random lasing in a gain meduim of negative liquid crystals or mixing liquid crystals doped with CdS nanoparticles has not been demonstrated yet. In this letter, we present negative (mixing) liquid crystal random lasers which combine semiconductor CdS NPs with an efficient organic dye in the visible wavelength region directly dispersed in solution. The study of the scattering properties in negative (mixing) liquid crystals containing CdS NPs offers a great way to improve the DDLC random laser. The scattering strength can be adjusted by the anisotropic distribution or the disorder degree of the liquid crystal to control the DDLC random laser emission characteristics. Our approach is based on the lasing characteristic measurement and associated discussion describing the characterization of the lasing modes in LCs with CdS nanoparticles or without CdS nanoparticles. By optimizing the CdS NPs, the outcome of our experiments show that the CdS NPs also are a promising LCs random laser platform that is convenient for investigating the mechanism of CdS lasers[19, 20].

2. Experiment

We have prepared devices, which are very simple, low cost and reliable method fabricating dye doped negative liquid crystals (Negative liquid crystal refers to liquid crystal molecules of which the dielectric constant of the long axis direction is less than the node constant of direction of the short axis $\epsilon_{\parallel} < \epsilon_{\perp}$, which was purchased from Beijing Jinxunyang guang Electronic Materials Technology Co., Ltd, $n_e = 1.5778, n_o = 1.4833, \triangle n = 0.0945, \epsilon_{\perp} = 11.545, \epsilon_{\parallel} = 5.169, \triangle\epsilon = -6.386$, colorless transparent liquid, 1.97g, $C_7H_{16}F_2O$)with

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