Laser Action at the Critical Regime of Localization

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Abstract: This paper studies the random lasing at the critical regime of localization. A strongly disordered optical medium composed of core-shell nanoparticles (TiO_2@Silica) suspended in ethanol solution of Rhodamine 6G conform the random laser material. Narrow peaks of approximately equal intensity are observed on top of the classical super-fluorescence band of random laser, indicating suppression of the interaction between the peaks modes (localized modes). The linewidth of these peaks is lower than that of the passive modes of the scattering medium. The classical super-fluorescence band of the random laser was measured separately by collecting the emission at the back of the samples, showing a linear dependence with pumping fluence without gain depletion. However, frontal emission of the random laser showed saturation.

Introduction

Disordered optical media have attracted much attention in recent years, ranging from potential applications in solar energy, photocatalyzers, and random lasers [1-3] to investigations into fundamental topics, such as localization of light [4,5]. Localization of light and a wide variety of associated phenomena have greatly attracted the attention of researchers in the past decades. In a previous work [5], we reported several pieces of experimental evidence of localization transition in a colloidal suspension composed of TiO_2@Silica nanoparticles (Nps) in ethanol solution. By using a Stöber method [6], TiO_2 NPs were coated with a homogeneous silica shell of ~40 nm thickness. The silica coating with thicknesses around or above 40 nm prevents the "optical" junction of the TiO_2 scattering surfaces (steric "optical" effect) [7], decreasing considerably the near-field coupling, which decreases the scattering strength [8], and could hamper localization. We called this property optical colloidal stability [7].

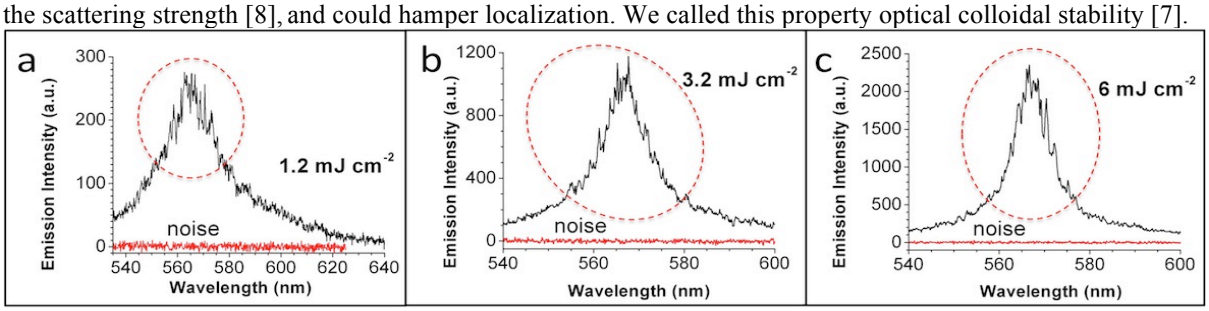

Fig. 1. Emission spectra of random laser collected from a small micrometric volume (<4μm diameter and depth) for pumping fluencies of: a) 1.2 mJ cm^{-2}, b) 3.2 mJ cm^{-2} and c) 6 mJ cm^{-2}. The diameter of the pumping spot is 3 mm. The red solid lines represent the noise signal. The dashed red circles highlight peaks emerging in the RL emission spectrum. Emission spectra were collected integrating 21 laser shots.

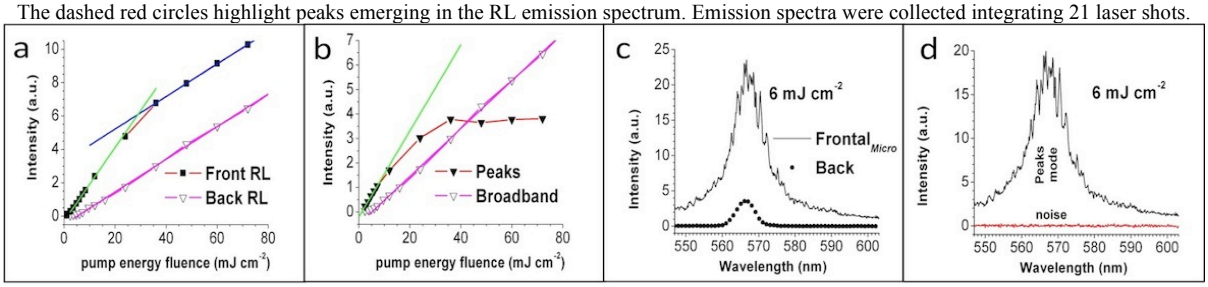

Fig. 2. Influence of the pump fluence on: a) emitted peak intensity for frontal and back collection, b) emitted peak intensity of RL back-collection and difference between frontal and back collection. c) The emission spectra for fluence of 6 mJ cm^{-2} recorded by back-collection (dots) and the frontal collection in a small micrometric volume (fig. 1c), and d) difference between both spectra.

References

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