Random laser properties changes in Rhodamine-B-doped organic/silica hybrid materials using femtosecond laser micromachining

Introduction

Organic/Silica hybrid materials have been investigated to several technological applications. These materials can be easily doped with organic chromophores, increasing the interest in the optical and photonic fields. Furthermore, hybrid materials present advantages over fused glasses, such as easiness of processing and low cost of production. On the other hand, fs-micromachining allows the fabrication of microstructures inside the volume of a material without damaging its surface. Due to its features, fs-laser micromachining has been used in a broad variety of materials to increased performance in optical and photonic systems. In this work we studied the influence of evenly spread scatterers produced by fs-laser micromachining on the random laser properties in monoliths of Rhodamine-B-doped organic/Silica hybrid materials. Rhodamine-B doped GPTS/TEOS-derived organic/Silica were prepared by sol-gel process, starting from the hydrolysis of 3-glycidoxypropyltrimethoxysilane (GPTS) and tetraethylorthosilicate (TEOS), yielding a clear sol doped with Rhodamine-B [1].

Random laser (RL)

RL is a special case were laser emission can be obtained in a physical system without the conventional optical cavity. In this kind of laser, light scattering plays a key role along with the gain medium [2]. A major advantage of RL over regular lasers is that their production is cheap and the required technology relatively simple. Moreover, materials can be produced on a large scale and have a high emission efficiency.

The experiment

Sample preparation

The final Rhodamine-B doped GPTS/TEOS-derived organic/Silica samples, prepared by sol-gel technique, presented high mechanical and chemical stability, as well as excellent optical quality in UV-Vis [1]. Rhod-B was also used as dopant in a polymeric material (SR-386/SR-499), prepared by photopolymerization [4].

Femtosecond microfabrication setup

The microstructures were produced using extended-cavity fs-laser irradiation (50-fs, 800-nm, 5.1 MHz). Samples up to 3 layers were produced.

Fluorescence emission setup

The luminescence of the samples was observed using pulsed frequency-doubled Nd:YAG pulsed laser (8-nm, 532-nm, 10 Hz), and the signal was analyzed by a CCD-compact spectrophotometer. A spherical lens was used to focus the beam on the sample face with the incidence angle near normal to the sample surface [2].

Results

Depending on the distance between the scattering centers desired, we use shutter (higher separation) or the pulse picker (smaller separation) is used. Besides, we also used different matrices: GPTS/TEOS produced by sol-gel technique and SR-368/SR-499 produced by photopolymerization technique.

The pulse energy used was 2 μJ. We observe that the collective effect of the scattering center contribute to the laser-action observed, when compared with the non-microstructured region.

Conclusions

✓ We succeed in produce a excellent samples, with good optical quality in the UV-Vis, and we were able to produce 3D μ-structured samples;
✓ The microfabrication process does not produced any cracks in the sample as usual in sol-gel samples;
✓ Random laser-action shown different results of when comparing the microstructured and non-microstructured region. Further investigations are needed relating distance among dots and random laser-action.

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References