VII Encontro Brasileiro de Espectroscopia Raman
VII EnBraER
05 a 08/12/2022, São Pedro – SP

Influence of Ag nanoparticles in waveguides on doped germanate glasses

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Palavras Chave: *Nanoparticles, Raman, Doped glasses*

Highlights

Femtossecond laser writing causes structural changes inside GeO_2-PbO glasses for waveguiding and Ag nanoparticle clustering for improved emission. Changes are characterized by Raman Spectroscopy.

Resumo/Abstract

Writing by using femtossecond (fs) laser enables fast prototyping and has low complexity compared to other fabrication methods. For materials that do not allow light confinement and propagation, waveguiding by double-line technology is necessary. Previously, we demonstrated waveguiding in double-lines for undoped germanate and tellurite glasses, as well as GeO_2-PbO doped with Er^{3+}/Yb^{3+} and Nd^{3+}. The results for the Nd^{3+} glass were promising for the fabrication of integrated amplifiers, lossless components and lasers. This motivated the present investigation, where silver (Ag) nanoparticles (NPs) were added to the Nd^{3+} doped GeO_2-PbO bulk in order to enhance its guiding capabilities.

Raman measurements were made with a LabRam HR Evolution – HORIBA, using a 532 nm laser with 100 mW power and a 10 x objective lens with 0.25 NA. An integration time of 1 second and 15 accumulations was used to reduce noise and make the observed peaks clearer.

First, the Raman spectrum was measured for the bulk (*b*) glass (Fig. 1a) and between the written lines (Fig. 1a). There are no substantial changes between these, indicating, as expected, that there are no relevant structural changes in the guiding region between the two lines. However, comparing the bulk region (Fig. 1a) with the inside of the written line with 4 superimposed lines (Fig. 1b), there are major changes in some of the peaks. The peak at 411.2 cm^{-1} (*b*) shifted to 433.9 cm^{-1}, indicating modification in the symmetric stretching vibrations of the Ge-O-Ge bonds. The peak at 517.5 cm^{-1} (*b*) to 508.1 cm^{-1} shows changes in the symmetric stretching vibrations along the Ge-O-Ge chain, demonstrating lower density of these bonds in the irradiated region. A slight change of the 782.3 cm^{-1} and 867.4 cm^{-1} (*b*) are also verified, and are related to the Ge-O^- and Ge-O-Ge symmetric stretching vibrations in the GeO_4 tetrahedral units and asymmetric stretching vibrations of the Ge-O-Ge bonds, respectively. These changes are larger than the ones previously shown for the same material without the Ag NPs, which shows the influence of the nanoparticles during the writing process.

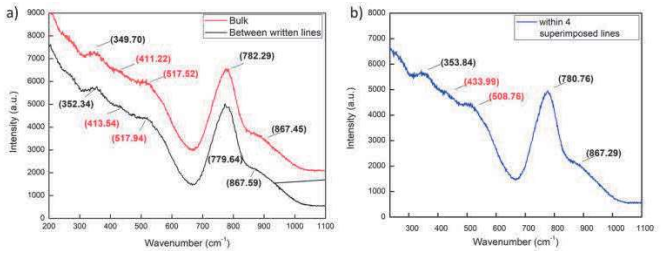

Figure 1: Raman spectrum of the (a) glass bulk and the region between the double waveguide; and (b) inside the four overlapping written lines region.

Agradecimentos/Acknowledgments

We'd like to thank FAPESP (2019/06334-4, 2016/02326-9, 2017/10765-5 and 2013/26113-6, EMU 2018/19240-5, 2017/50332-0) and from INCT/CNPq 465.763/2014 (INCT de Fotônica), Grant: 302532/2019-6, IPEN/CNEN 2020.06.IPEN.33.PD and Grant: SISFÓTON-MCTI 440228/2021-2 (Sistema Nacional de Laboratórios de Fotônica).