Waveguide amplifiers produced by femtosecond laser in doped heavy metal glasses

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ABSTRACT

Waveguides are very suitable structures for integrating optics in miniaturized systems such as those involved in microfluidics. With them, it is possible to stimulate reactions using light and collect information from optical signals from specific points of a given system. Thus, for example, it is possible to transport light from an external source to a microreactor within a microfluidic system and/or collect the emission of any reagent or reaction from any point in the system. In this context, several kinds of research have been carried out for the development of waveguides in transparent materials suitable for use in microfluidic systems such as lab-on-a-chip. A widely used way of producing such guides is through the focusing of ultrashort laser pulses (fs) inside transparent materials. In this case, the intensity is adjusted so that the absorbed energy is sufficient to change the crystalline arrangement in the focal region, but not enough to cause catastrophic damage, that is, that there is no rupture of bonds between atoms. This change in the local arrangement of atoms (or ions) leads to a localized change in the index of refraction, which can be used to refract light. If a line of such regions, or points, has an index of refraction greater than that of the surrounding medium, then it is possible to guide light within it as in an optical fiber. If the index of refraction changes to a value less than that of the neighboring medium, then it is only possible to guide the light between two or more of these lines.

This work describes the development and characterization of waveguides produced with two lines by processing heavy metal oxide glasses with a femtosecond laser. Tellurite (TeO2-ZnO) and germanate (GeO2-PbO) glasses were used [1,2], pure and also doped with rare earth. Raman spectroscopy shows a decrease in the photoinduced refractive index, from $-7.4\text{x}10^{-3}$ to $1\text{x}10^{-5}$, depending on the material and processing conditions. Thus, it is not possible to guide light inside a single line and, therefore, two of these lines were used for this purpose, with the guidance being done between them. The work details the laser machining process, the physical and spatial characteristics of the guides produced, the characteristics of the guided spatial mode, such as the M^2 parameter, the transmission losses, and the gain obtained when glasses doped with rare earths are used.

Keywords: fs laser processing; heavy metal oxide glasses, double line waveguide, optical component.

germanate glasses; fs laser processing; double line waveguide; active optical component; Ag nanoparticles.

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Biography: Wagner de Rossi completed his doctorate in Nuclear Technology at the University of São Paulo, Brazil, in 1995. He is currently a supervisor at the University of São Paulo, and senior technologist of the National Nuclear Energy Commission, where is head of the Center for Lasers and Applications at IPEN. He has published 68 articles in specialized journals and 227 papers in annals of events. He has 9 book chapters and 1 published book; participated in the development of 15 technological products and 31 processes or techniques. Among completed or ongoing supervision are 25 master's dissertations, 8 doctoral theses, and 6 post-doctoral supervisions. Between 1982 and 2022, he participated in 36 research and technological development projects in the field of lasers, specializing in manufacturing processes.