# Production and Characterization of Femtosecond Laser-Written Waveguides in a Tellurium-Zinc Glass

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## 1. Introduction

A considerable amount of investigation on the ability to locally modify the structure and refractive properties of optical glasses and other dielectrics via nonlinear absorption with femtosecond (fs) laser pulses has been conducted in recent years [1]. Because the pulse length of this type of laser is shorter than the electron phonon interaction, one can obtain a process without thermal effects and produce tiny structures, as waveguides, in transparent materials[2].

Channel waveguides written using ultrafast lasers in glasses have been demonstrated in a number of hosts, including heavy metal oxide doped glasses [3-5].
Heavy metal oxide glasses are interesting materials for photonic applications due to some properties as their high linear refractive index (~2) and high transmission window which is related to their lower cutoff phonon energy (<700 $cm^{-1}$) .

The aim of this work is to study the feasibility of direct waveguide writing in a $TeO_2$-ZnO glass using fs laser pulses and investigate the optical properties.

## 2. Experimental

2.1 *Preparation of glass*: The basic glass composition consisting of 17.0 mass fraction (wt%) of $TeO_2$ and 72.8 wt% of TeO. The glass was prepared by a conventional melting and quenching method.
2.2. *Waveguide writing:* The sample is mounted on a 3D translation stages system, perpendicular to the laser beam propagation direction. The parameters applied in the writing process were: pulse energy = 20 μJ, writing speed = 3.0mm/min, spot = 5.0 μm, pulse duration = 80fs, λ=800nm, polarization = circular and repetition rate = 4kHz.
2.3. *Waveguide Characterizations*: A typical near field pattern obtained by coupling 633 nm laser light into waveguides is presented in Figure 1. It can be observed a multimode profile.

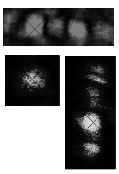

***Fig.1.*** *Near field pattern of the written waveguide.*

The refractive index change calculated as described in [6] and propagation losses at 632 nm estimated, following the schematic setting described in figure 2, are $10^{-4}$ and 19,5 dB/cm, respectively.

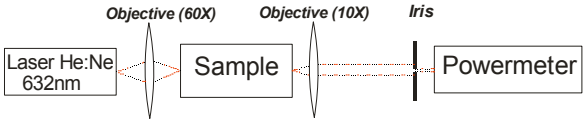


***Fig.2.*** *Schemactic representation of the arrangement for optical loss.*

## 3. Conclusion

This work has addressed the feasibility of waveguides in a Te/Zn heavy metal oxide glass doped by direct fs laser writing. The results obtained give a start point of future works on the optimization of direct fs laser writing.

## 4. Acknowledgments

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## 5. References

[1] M. Ams, G. D. Marshall, P. Dekker, J. A. Piper and M.J.Withford,"Ultrafast laser written active devices", Laser and Photonics Reviews,vol.3, n°6, 2009, pp.535–544.
[2] R. E. Samad, L. M. Machado, N. D. Vieira Jr and W. d. Rossi, "Ultrashort Laser Pulses Machining", in : I. Peshko (ed.) Laser Pulses – Theory, Technology, and Applications, InTech, 2012, pp. 143-174.
[3] L. Tong, R. R. Gattass, I. Maxwell, J. B. Ashcom, E. Mazur, "Optical loss measurements in femtosecond laser written waveguides in glass", Optics Communications vol. 259, 2006, pp.626-630.
[4] C. Jayakrishnan, S. Debbarma and K. Chalapathi, "Femtosecond laser written channel waveguides in tellurite glass ", Optics Express, vol.14, n°25, 2006, pp. 12145-12150.
[5] D.M. da Silva, L. R. P. Kassab, M. Olivero, T. B. N. Lemos, D. V. da Silva, A.S.L.Gomes, "$Er^{3+}$ doped waveguide amplifiers written with femtosecond laser in germanate glasses", Optical Materials vol.33, 2011, pp.1902-1906.
[6] D. Brooks and S. Ruschin, "Improved Near-Field Method for Refractive Index Measurements of Optical Waveguides", Photonics Technology Letters, vol. 8, n°2, 1996, pp.254-256.