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Laser inscription of integrated Bragg grating architectures in photosensitive glasses.

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Novel integrated and/or bulk photonics components are highly demanded to develop photonic integrated circuits, or sensing applications with lab-on-chip or lab-on-fiber approaches. Femtosecond laser inscription has demonstrated to be a very attractive approach being highly versatile as well as compatible with laser manufacturing technological transfer. In this framework, some of the innovations to come will result from optimized laser-based processing in prepared materials with a designed photosensitivity enhancement under laser irradiation.

We recently demonstrated a new type of refractive index modification [1], based on the femtosecond laser induced photochemistry of silver species inserted in the melting glass preparation, leading to positive modification referred as Type-A modification (A for *Argentum*) and allowing for a new type of waveguides with remarkable sensing ability [2]. Some of the inner features of the refractive index structures show mesoscale dimensions of a few hundreds of nanometers, which is of interest for produce sub-wavelength modifications.

We addressed the mask-less production of both waveguide Bragg gratings (WBGs) and volume Bragg gratings (VBGs) for the red/near-IR range. On the one hand, we have obtained WBGs showing transmission attenuation down to more than 20 dB, which corresponds to very strong back-coupling constants, up to 6 mm⁻¹ depending on the chosen Bragg grating geometry (Fig. 1-left). Such strong back-coupling constants appear relevant for applicative perspectives in integrated optics such as integrated passive or laser-active cavities. Detailed description of these silver-sustained WBGs will be provided, including the spatial distribution of silver clusters and the associated index modulation [3]. On the other hand, VBG production is generally highly demanding in terms of time-processing and process stability. Here, we report on the first demonstration of type-A based VBG in silver-containing glasses by femtosecond laser writing, reaching 94% first-order diffraction at 633 nm (Fig. 1-right). Different approaches will be discussed, including the plane-by-plane direct inscription with a Bessel beam [4].

This work opens promising perspectives in terms of laser production of WBGs for sensing applications and/or integrated lasers, and of VBGs with high throughputs compatible for industrialization especially in the mid-IR.

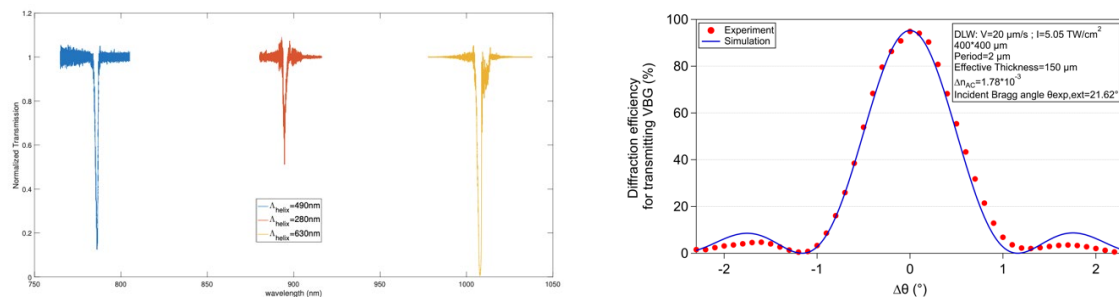


Fig. 1 (left) Type-A based waveguide Bragg grating resonances in the red/near-IR under different diffraction orders. (right) Type-A based volume Bragg grating showing 94% 1st order diffraction efficiency at $\lambda = 633$ nm.

References

- [1] A. A. Khalil, J. Bérubé, S. Danto, J. Desmoulin, T. Cardinal, Y. Petit, R. Vallée, and L. Canioni, "Direct laser writing of a new type of waveguides in silver containing glasses," *Sci. Rep.* 7(1), 11124 (2017).
- [2] A. A. Khalil, P. Lalanne, J.-P. Bérubé, Y. Petit, R. Vallée, and L. Canioni, "Femtosecond laser writing of near-surface waveguides for refractive-index sensing," *Opt. Express* 27(22), 31130–31143 (2019).
- [3] R. Laberdesque, L. Loi, T. Guérineau, A. Abou Khalil, S. Danto, T. Cardinal, L. Canioni and Y. Petit, Three-dimensional femtosecond laser inscription of Type A-based high-efficiency first-order waveguide Bragg gratings, *J. Avd. Opt. Tech* 2023 (to appear in press).
- [3] J. Harb, L. Talbot, Y. Petit, M. Bernier, L. Canioni, Demonstration of *Type A* volume Bragg gratings inscribed with a femtosecond Gaussian-Bessel laser beam. *Opt. Expr.* 31(10), 15736-15746 (2023).