Internship 2021-2022

Institut Fresnel – Marseille

3D laser printing of fused silica fiber preforms

Keywords: laser material interaction, laser fabrication, optical components

Scientific background

The structure of a conventional optical fiber is based on a core-cladding structure, the core (diameter of 10 µm) has a higher refractive index than the cladding (diameter of 125 µm) in order to ensure guidance by Total Internal Reflection. Recently, a new fiber architecture has been proposed to guide light [1]. It is based on a random distribution of holes throughout the cross section of the fiber (see figure). The light is then trapped "between" the holes by Anderson's localization mechanism. Light guiding along the fiber is ensured by keeping the transverse distribution of the holes invariant longitudinally. Such a fiber offers new perspectives, in particular in the field of medicine and the realization of a fiberscope (see figure).

The "stack and draw" process commonly used to prepare microstructured fibers leads to a distribution of the holes, of similar size, in a hexagonal network . The fiber of reference [1] was obtained by drawing a preform containing air bubbles which limits the usable length to a few centimeters. The 3D printing process offers an exceptional opportunity thanks to the possibility of designing a tailor-made distribution of cylindrical holes along the drawing axis, therefore being able to be elongated along the entire length of the fiber.

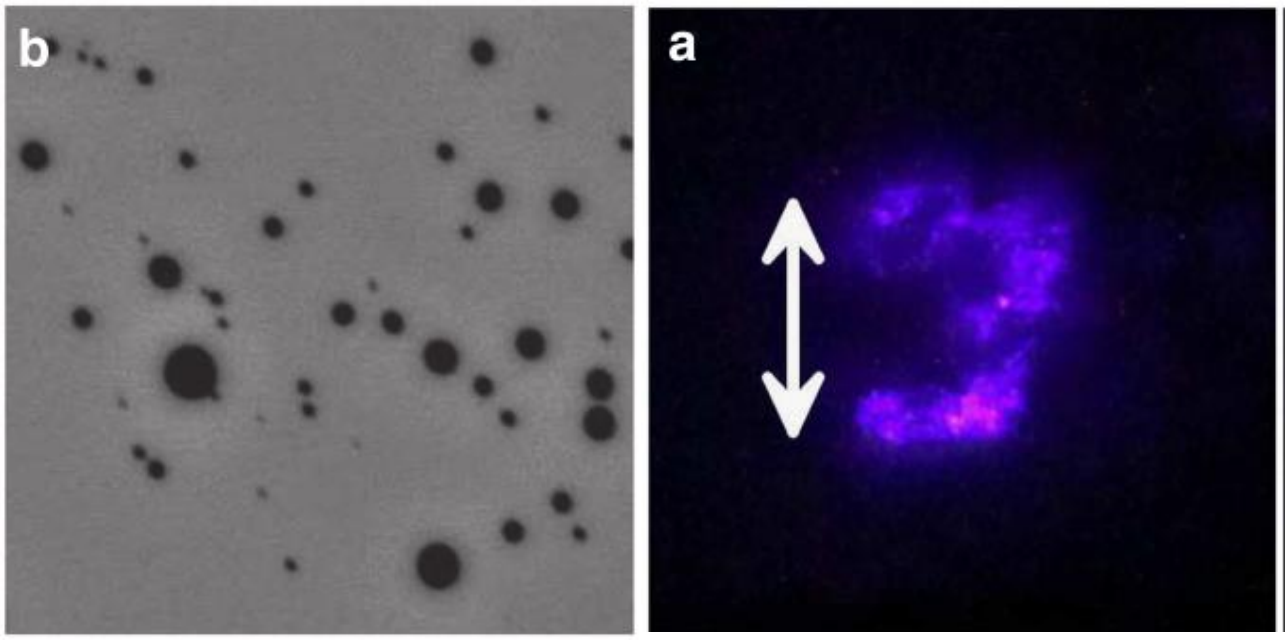

Figure: (left) scanning electron microscopy image of a silica-based fiber containing holes (in black) randomly distributed in the transverse section. Diameter of the largest hole is ~2µm. (right) transported image through a disordered fiber (scale bar = 60 µm). [1]

Subject

In order to manufacture the preforms, the student will be involved in the development of an innovative 3D printing process relying on multiphoton-induced polymerization to produce complex three-dimensional (3D) glass parts [2]. It is based on a focused, intense laser beam to polymerize a transparent resin, loaded with additives and silica nanoparticles, through nonlinear absorption processes. The object is created directly in the volume, overcoming the limitation of the layer-by-layer process. The process enables the production of silica parts, with consecutive debinding and sintering processes, with bulk silica density and a resolution that depends on the laser spot size. Typically, 3D objects of centimetric dimensions are obtained.

The work is mainly experimental, with the investigation of suitable laser processing parameters with parametric studies and optical/material characterization. Knowledge in photonics and lasers is required.

[1] S. Karbasi et al., "Image transport through a disordered optical fiber mediated by transverse Anderson localization", Nature Communications, 5(2014) 3362

[2] T. Doualle, J.C. André, L. Gallais, 3D printing of silica glass through a multiphoton polymerization process, Optics Letters 46 (2021) 364.

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