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Abstract: We report on the design and development of microstructured phosphate glass optical fibers for minimally invasive diagnosis and therapy. We discuss preliminary results of fiber drawing and characterization.

1. Introduction

Phosphate glasses have been used in several applications, from the storage of radioactive wastes to the generation and amplification of laser light in the near infrared wavelength region [1]. One field of great interest which has triggered the development of novel custom phosphate glass compositions is biomedicine: bioresorbable calcium-phosphate glasses have been studied for scaffold in soft and hard tissue engineering [2]; more recently, new optically transparent glass compositions have been developed and engineered for fiber drawing [3]. The so-obtained optical fibers displayed low loss and the possibility to modulate the dissolution rate in biological fluids by varying the composition of the constituting glasses.

In this work we designed and developed microstructured optical fibers able to provide multiple functions, combining light injection and collection with drug delivery and activation. The fabrication of preforms with complex shapes is achieved through an extrusion system, supported by the results of a Computational Fluid Dynamics (CFD) model.

2. Experimental

Two configurations were studied: a first configuration was obtained using a single glass type (cladding glass) which was then drawn into a fiber by stack-and-draw of capillary tubes; a second configuration featured a solid core glass for light guiding and a hollow channel for drug distribution, combined into a preform by rod-in-tube technique. The core and cladding glasses were fabricated by melt-quenching, with the core glass obtained by casting the molten glass from the crucible into a cylindrical mold. The cladding glass samples were cast into billets which were then shaped into a tube for the first configuration and into a two-hole cross-section for the second one, respectively. Both configurations were obtained by high temperature extrusion, using an in-house developed extruder.

2. Results

The extrusion process was optimized by developing a Computational Fluid Dynamics model in order to increase the correspondence between the designed configurations and the fabricated preforms, minimizing distortions. An example of the results obtained in terms of velocity of the flow of glass during the extrusion process is reported in Fig. 1. The results were useful to tailor the die structures to the desired fiber configurations.

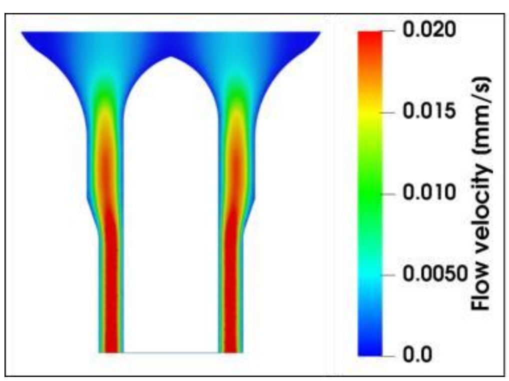
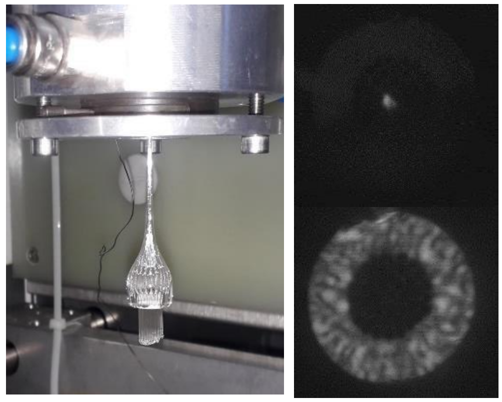


Fig 1. Incompressible isothermal viscous flow model. The following conditions were assumed: fixed inlet velocity; free outlet pressure; no-slip condition on lateral walls.

Optical fibers were successfully drawn using a fiber drawing tower equipped with an induction heated furnace operating at a temperature of about 550 °C and a fiber drawing speed between 5 and 9 mm/min.



a) b)

Fig 2. **(a)** Drawing of the microstructured preform obtained by stacking the cladding tubes; **(b)** near-field image of the so-obtained microstructured optical fiber.

Fig. 2a reports the drawing process of the microstructured fiber preform obtained by stack-and-draw. The so-obtained fibers were then characterized in their morphology and optical properties. Fig. 2b shows the near-field image of the microstructured fiber taken at the wavelength of 1320 nm.

3. References

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