Microstructured optical fibers based on chalcogenide glasses for Mid-IR supercontinuum generation

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SUPUVIR
SUPercontinuum broadband light sources covering **UV** to **IR** applications

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Objectives

- The ESR is involved in the WP 2 and 3. The main objectives of the ESR are to realize high quality infrared (in the $2-12$ µm wavelength range) fibers with tailored dispersion by combining glass sciences and innovative fiber shaping techniques. The fiber design has to be a best compromise between nonlinear parameters (core size, chalcogenide composition), ZDW (depending on desired pump wavelength), power handling and IR transmission edge. The fibers fabricated will be tested and used for SCG at CNRS by ESR 4. The work of the ESR is done in a strong collaboration with Selenoptics (partner organization), more particularly for the microstructured fiber shaping and drawing.

Expected results

- The expected attenuation in $2-12$ µm range is < 0.5 dB/m with a minimum of attenuation near the pump wavelength around $0.1-0.2$ dB/m. The diameter of the fibre core has to be in the $1.5-3$ µm range. The ZDW must be adapted to pump wavelength around $3-4$ µm (pump is an optical parametric oscillator). With such fibres mid-IR SC in the $2-12$ µm range is feasible with an average output of dozens of mW.

Secondments

- A secondment at ITME, Warsaw was done by ESR 10 between April 16 and 27, 2018. The results obtained up to now are described in the "Summary of the obtained results" section of this poster. The research on the topic of graded index chalcogenide fibers is going on in strong cooperation between UR1 and ITME. A joint publication on the topic is planned in the future.

- A secondment at Femto-ST, Besançon has been planned for the December 3-22, 2018 period. During this secondment ESR 10 will cooperate with the Femto-ST for the characterization of chalcogenide microstructured fibers and tapers. Depending on the obtained result, the possibility of a joint publication will be considered.

- As for the project proposal, a secondment at the University of Cambridge should be planned for month 31 of the project, on the topic of "hands-on fluorescence microscopy with UV-visible sources".

Summary of the obtained results - I

- A comparative study of different routes for the purification of Ge-As-Se ternary glasses has been performed, using $Ge_{10}As_{22}Se_{68}$ glass for the testing. Different chemical getters have been considered for the removal of impurities: Al, Mg, Ni, Zr for removing oxygen and $TeCl_4$, $SbCl_3$, $SeCl_4$, $GaCl_3$ for removing hydrogen. The result of this study have been accepted for publication.

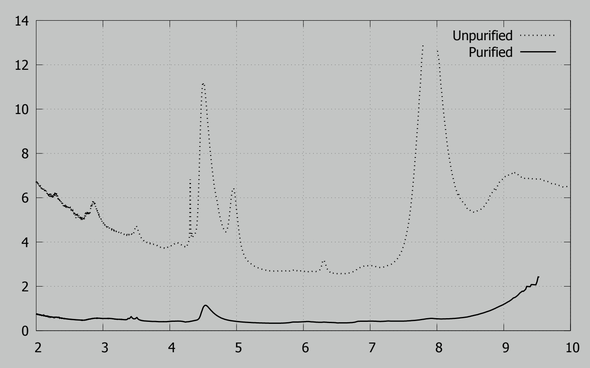

Figure: Attenuation spectra of $Ge_{10}As_{22}Se_{68}$ with and without purification

- Using the best fabrication protocol found up to now, a chalcogenide PCF with three rings of holes has been produced with a loss of less than 0.5dB/m between 3 and 8.5 µm, which is lower than any similar fiber documented before (see Figure on top right).

- The effect of tapering on different types of fibers is also being studied, in order to achieve the desired core size without a too large increment in losses.

Summary of the obtained results - II

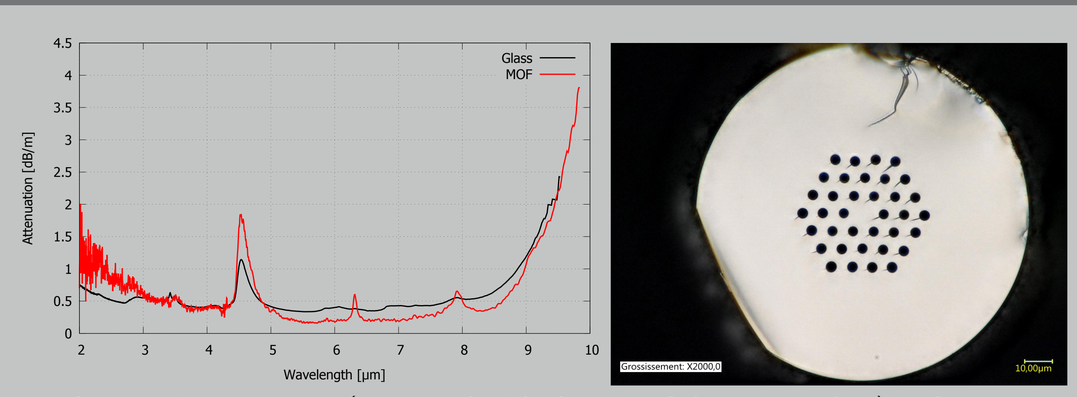

Figure: Attenuation spectrum (compared with the one of the parent glass) and cross section image of a $Ge_{10}As_{22}Se_{68}$ microstructured fiber.

- Research on the fabrication of a chalcogenide microstructured graded index fiber has started during a secondment at, and is being conducted in close cooperation with ITME, Warsaw. In case of success, it would be the first instance of such a fiber being produced.

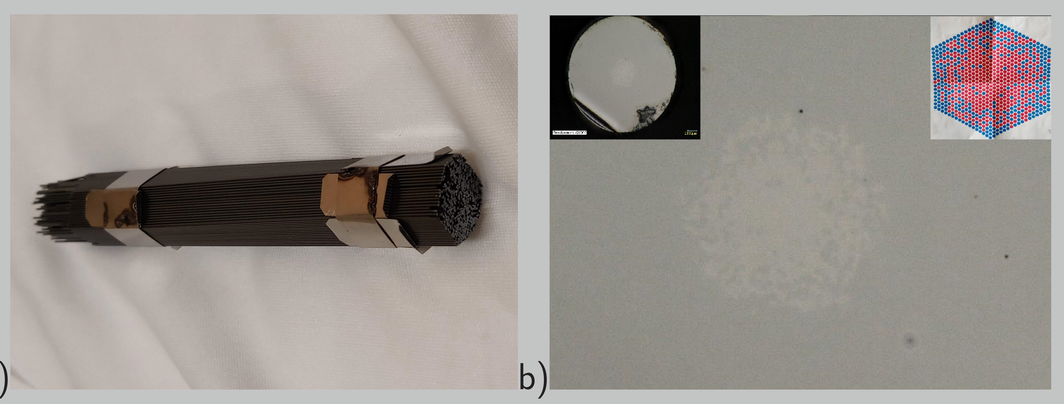

Figure: a) Stack of chalcogenide rods of two different composition, to be used as a preform for the fabrication of the core of the graded index fiber;
b) Core of the fiber obtained as a first attempt of drawing a chalcogenide graded index fiber, with image of the fiber cross-section (top-left) and of the desired structure (top-right).

- Given the results obtained up to now, the confidence in the achievement of the desired core size and losses is strong.

Dissemination

- As of now, the following publications and communications have been produced during ESR 10 work:
  - Y. Wu, M. Meneghetti, J. Troles, J. Adam, *Chalcogenide Microstructured Optical Fibers for Mid-Infrared Supercontinuum Generation: Interest, Fabrication, and Applications*, Applied Sciences 2018 8(9), doi: 10.3390/app8091637 (**review paper**)
  - M. Meneghetti, C. Caillaud, R. Chahal, E. Galdo, L. Brilland, J. Adam, J. Troles, *Purification of Ge-As-Se ternary glasses for the development of high quality microstructured optical fibers*, Journal of Non Crystalline Solids, (Accepted September 2018) (**regular paper**)
  - J. Troles, C. Caillaud, M. Meneghetti et.al., *Elaboration of chalcogenide microstructured optical fibers for generation of mid-IR supercontinuum*, WSOF 2017 (**invited talk**)
  - M. Meneghetti et.al., *Synthesis of high purity chalcogenide glasses for Mid-IR applications*, WSOF 2017 (**poster presentation**)
  - J. Troles , C. Caillaud, M. Meneghetti et.al., *Fabrication of tapered chalcogenide microstructured optical fibers for enhancing the non linear properties*, ACERS GOMD 2018 (**oral communication**)
  - J. Troles, M. Meneghetti et.al., *Fabrication of chalcogenide microstructured optical fibers for the 2-10 m Mid-IR window*, Advanced architectures in photonics 2018 (**invited talk**)
  - M. Meneghetti et.al., *Synthesis of high purity chalcogenide glasses for Mid-IR applications*, JED3M 2018 (**poster presentation**)
  - M. Meneghetti et.al., *Fabrication of high optical quality GeAsSe glasses for the development of lowloss microstructured optical fibers*, SPIE Photonics West OPTO (submitted July 2018) (**oral communication**)

Acknowledgments

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