J. Wójcik, P.Mergo, J. Klimek, M. Makara
Laboratory of Optical Fiber Technology,
Maria Curie Sklodowska University, Lublin, Poland

TECHNOLOGY OF ELLIPTICAL CORE HOLEY FIBERS AND THEIR SENSOR PROPERTIES

The elliptical core high birefringence index guiding holey fibers were manufactured and their sensor properties were measured in polarimetric set. The measured pressure sensitivity is similar to the pressure sensitivity of the standard polarization maintaining fibers but temperature sensitivity is extremely small. The strong influence of the protective coating on the temperature sensitivity was found.

1. Introduction

Paper presents experimental results of pressure and temperature sensitivity of the high birefringent holey fiber with elliptical core prepared in our laboratory.

Technology of this fiber is similar to technology of low birefringence index guiding holey fibers published earlier [1].

The pressure sensitivity was measured in polarimetric set at wavelength equal to 820nm. Obtained results were comparable with results earlier published.

For the same holey fiber temperature sensitivity was measured. The measurement was done in polarimetric set at wavelength 820nm. In accordance with theoretical forecasting the temperature sensitivity is very small.

The temperature sensitivity was measured for fiber covered and non-covered with polymer coatings. The conclusions are related to earlier published negative influence of polymer coatings on pressure and temperature sensitivity of high birefringence optical fibers especially side hole fibers [2].

2. Project and technology of the fiber

TECHNOLOGY

The technology of the high birefringence holey fibers is analogous to technology of low birefringence holey fibers [1]. The difference depends on placed in the center of structure three small diameter rods instead of one – see fig.1.

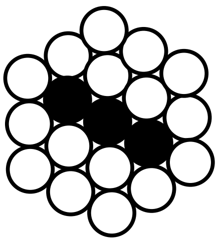

Fig. 1. Schema of center of high birefringent holey fibers

Technology of elliptical core high birefringence photonic crystal fibers production consists in accurate execution of the following stages:

1. Purchase of silica glass tubes and rods – we used tubes made of silica glass, type IV, made from silicon tetrachloride by its reaction with oxygen in plasma burner. It is a commercially available product named "Heralux S";

2. Calibration of tubes in order to achieve suitable wall thickness and optional collapse to obtain rods. These operations were made using MCVD preform lathe.

3. Drawing of capillaries and rods using a drawing tower with graphite resistance furnace at purity class 10000.

4. Stacking capillaries and rods inside a silica glass tube made manually in laminar chamber, maintaining high purity class (1000).

5. Soaking at temperature from 400°C to 800°C in atmosphere consisting of chlorinating agents and oxygen in order to eliminate heterogeneous impurities in MCVD apparatus.

6. Pre-fusion for joining components of the structure in MCVD preform lathe. The prapreform I is obtained.

7. Zonal thermal cycling with pressure control for precise mutual fusing of components of the structure in a graphite resistance furnace. Thinning-out of the obtained prapreform in drawing tower for optical fibers the prapreform II is obtained.

8. Overcladding i.e. fusing the prapreform II into a silica glass tube for correction of lattice constant and diameter of holes in the meaning of the designed external diameter of the fiber.

9. Drawing of the fiber with simultaneous coating with UV-cured material in drawing tower for optical fibers.

Fig. 2 presents microscopic photo of the high birefringent holey fiber.

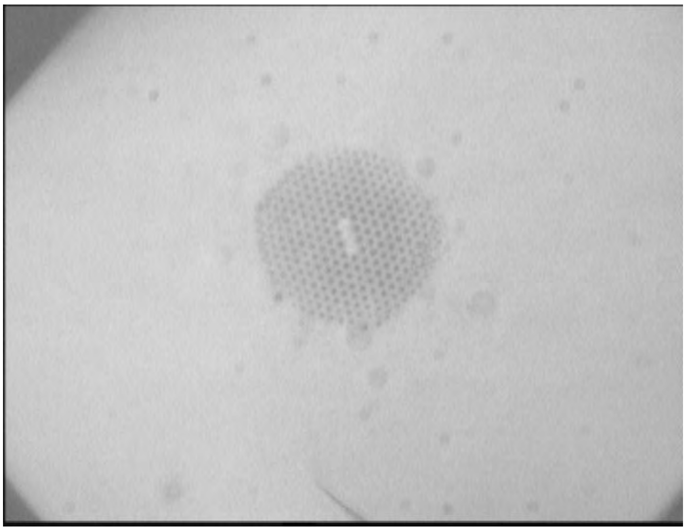

Fig. 2. Microscopic photo of manufactured elliptical core high birefringent holey fiber

Fig. 3 presents atomic force microscopy photo of fiber cross section.

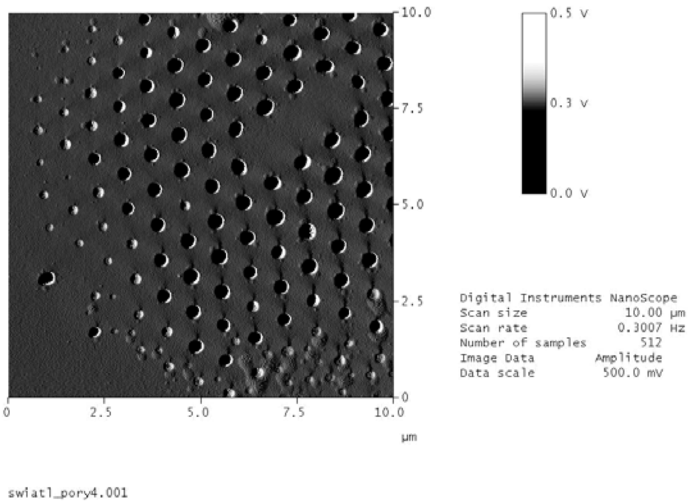

Fig. 3. Atomic force microscopy photo of fiber cross section

Geometrical and optical measurements were done for this fiber from photos in Fig. 2 and 3. Manufactured HB holey fiber is characterized by: core dimensions: 4,8µm x 1,4µm, fiber diameter - 125µm, diameter of part with holes - 26µm, hole diameter – 0,5µm, lattice constant – 0,9µm.

Fig. 4 presents spectral attenuation of manufactured fiber measured with cut-back method.

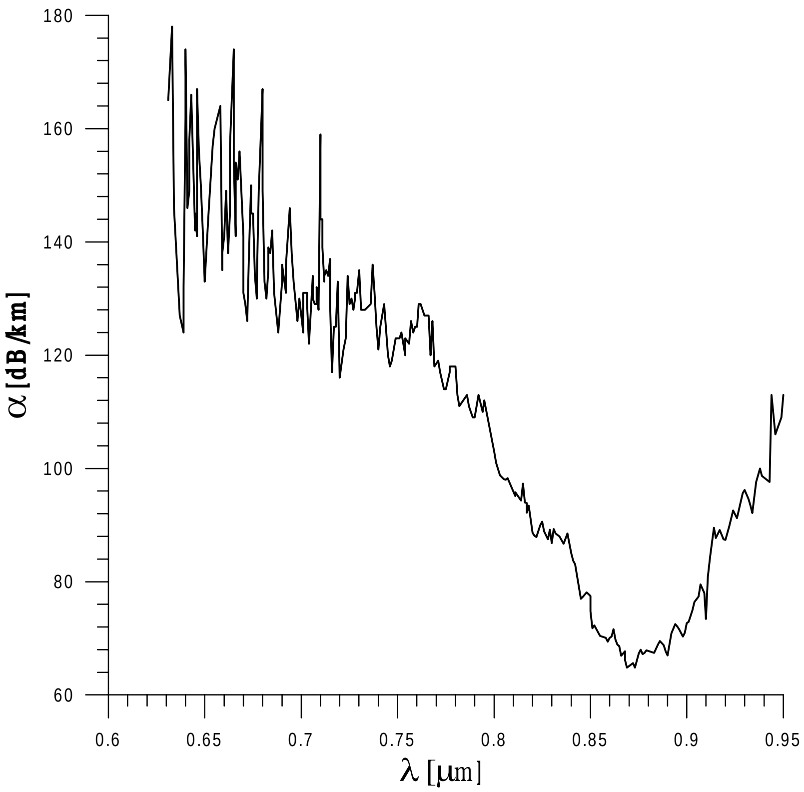

Fig. 4. Spectral attenuation of manufactured HB holey fiber with elliptical core

3. Measurements of temperature and pressure sensitivity

Measurements of temperature and pressure sensitivity were done in polarimetric set. Wavelength was equal to 820 nm. Temperature sensitivity was measured in temperature range from 300 to 360 K. Pressure sensitivity was measured in pressure range from 0,1 to 8 MPa. Fig. 5 presents schema of measurement set

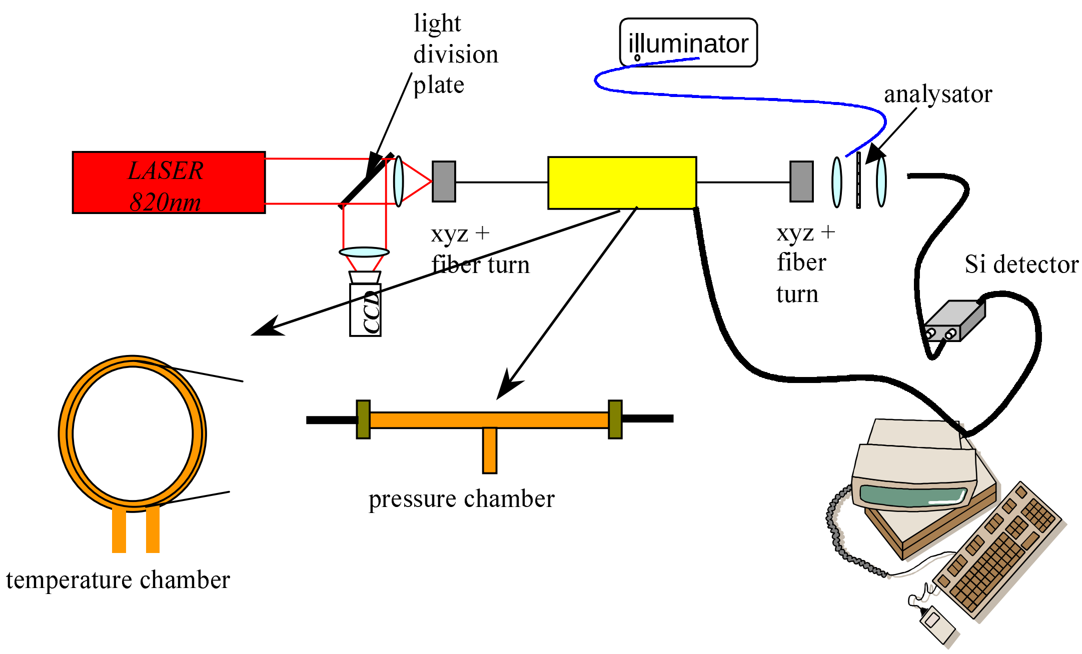

Fig. 5. Schema of measurement set

Fig. 6 presents dependence of the temperature increase on the phase change. Fig. 7 presents dependence of the temperature decrease on the phase change. The shapes of dependences of temperature on phase change for fiber with protective coatings is not regular. The temperature sensitivity was estimated rather than calculated. This effect is caused by negative influence of protective coating on the temperature sensitivity [2].

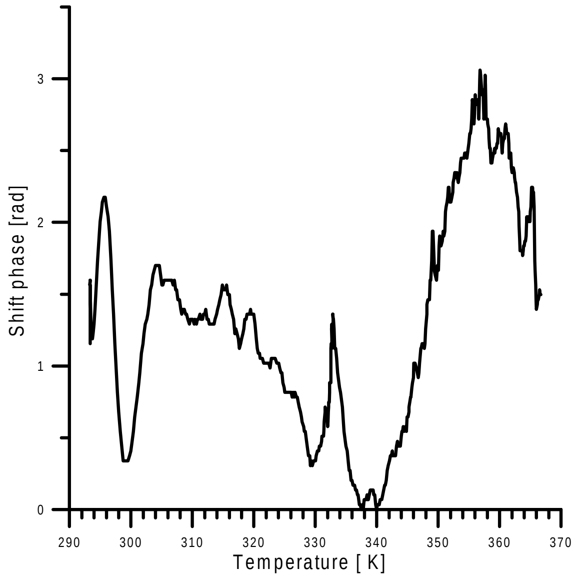

Fig. 6. Dependence of temperature increase on the phase change – fiber with protective coating

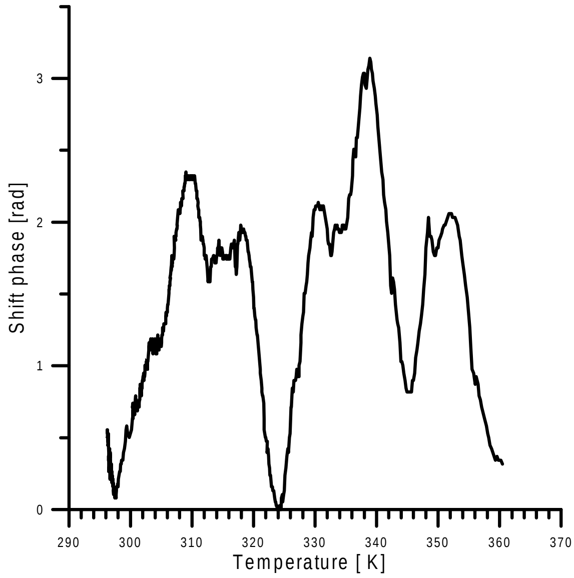

Fig. 7. Dependence of temperature increase on the phase change – fiber with protective coating

Next measurements of temperature sensitivity were done for fiber without protective coatings. Fig. 8 presents dependence of temperature increase on the phase change for fiber without protective coatings. Fig. 9 presents dependence of the temperature decrease on the phase change. These graphs are regular. It makes possible to approximate this dependence to sinus shape and calculate value of the temperature sensitivity. Calculated temperature sensitivity from this dependences is equal to 0,015rad/K*m.

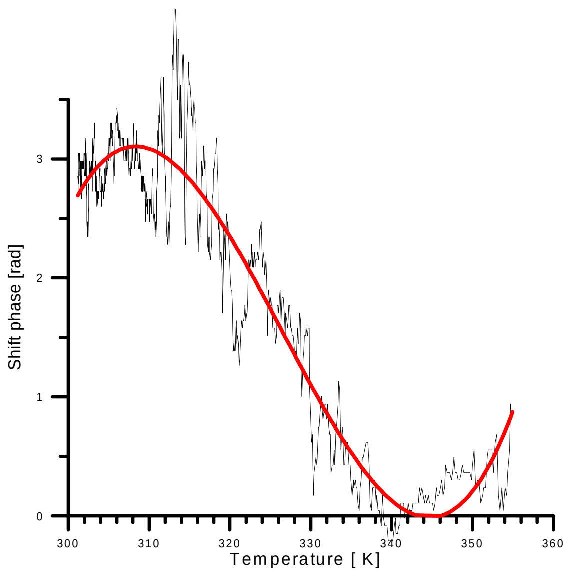

Fig. 8. Dependence of temperature increase on the phase change – fiber without protective coating

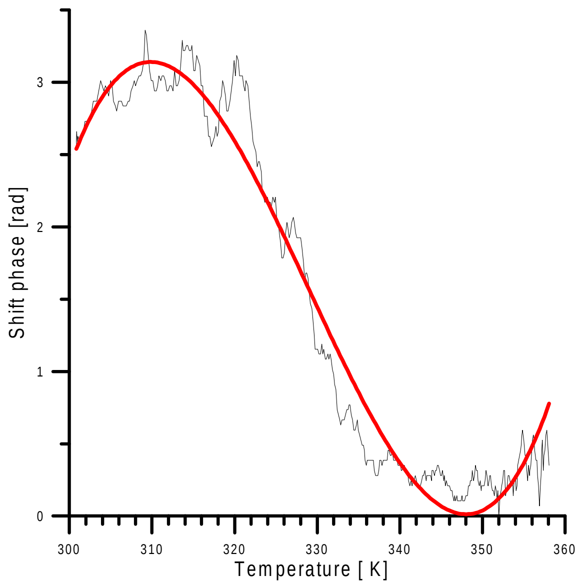

Fig. 9. Dependence of temperature increase on the phase change – fiber without protective coating

Fig. 10 presents dependence of pressure increase on phase change. Calculated pressure sensitivity from this dependence is equal to 3,5 rad/MPa*m.

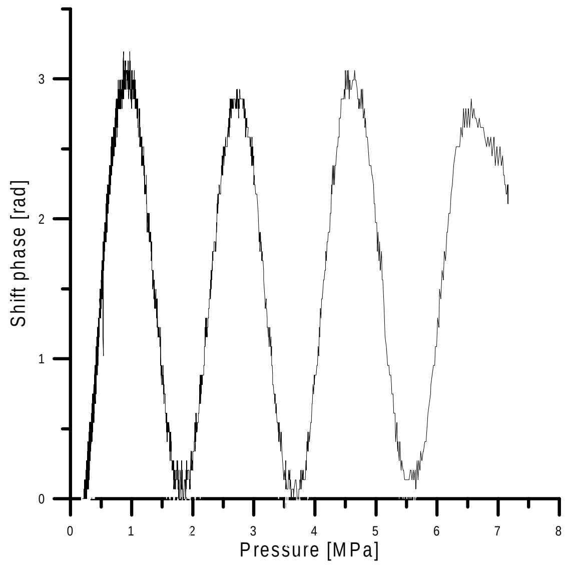

Fig. 10. Dependence of pressure increase on the phase change

4. Summary and conclusions

The high birefringent holey fiber with elliptical core was manufactured.

The technology of this optical fiber is similar to technology of the low birefringent holey fibers.

The measurements of the temperature and pressure sensitivity in polarimetric set were done.

The measurements of the temperature sensitivity were done for the holey fibers with and without protective coating.

The shape of dependence of temperature on phase change for fiber with protective coating is not regular. The temperature sensitivity was estimated rather than calculated. This effect is caused by negative influence of protective coating on the temperature sensitivity. This effect was expected according with our pervious investigations of the technology of side-hole optical fibers.

The graph of the dependence of temperature on the phase shift for fibers without protective coating is regular. It makes possible to approximate this dependence to sinus shape and calculates value of the temperature sensitivity.

Selectivity of the fiber on pressure measurement versus temperature is equal to 20. It is 10 times smaller then that for side-hole HB optical fibers.

However for the sake of small temperature sensitivity is advisable examination of application these photonic crystal fibers to construction of pressure sensors.

1. J. *Wojcik, K. Poturaj, B. Janoszczyk, P. Mergo, M. Makara "Experimental structures of silica holey fibers with triangular lattice", Proceedings SPIE, 5576, (2004), 102 – 107.*

2. *J. Wojcik, B. Janoszczyk, M. Makara, K. Poturaj, W. Spytek, A. Walewski, W. Urbanczyk, W. J. Bock, Experimental investigation of the effect of protective coatings on temperature sensitivity of side - hole optical fibers, Proceedings SPIE, 3189 (1997), 38 – 43.*