

Femtosecond laser writing of a Fabry-Perot cavity in a Polarizing Maintaining fiber: towards an all-fibered photonic cell for future atom cooling applications

Alain Abou Khalil¹, Michaël Berisset¹, Luna Gibert, Christophe Pierre, M.J. Milla, Thomas Billotte, Foued Amrani, Maciej Popenda, Frédéric Gérôme^{2,3}, Benoît Debord^{2,3}, Fetah Benabid^{2,3}, Marc Castaing

1. ALPhANOV, 33400 Talence, France

2. GPPMM Group, XLIM Institute, CNRS UMR 7252, 87060, Limoges, France

3. GLOphotonics, 87060, Limoges, France

Recently, quantum technology has gained a lot of interest knowing that this field is expected to provide new opportunities, especially regarding high sensitivity and precision in sensing applications. However, despite the efforts, most quantum sensors are still bulky and hardly operate outside a dedicated environment. In this paper, we present a new approach and the first step in paving the way for an all-fibered cell for alkali atom cooling aiming toward miniaturization of the quantum sensors. The fibered cell consists of a hollow-core photonic crystal fiber (HCPCF) based on a Kagome-Tubular Hybrid cladding [1] placed between two solid Polarizing Maintaining (PM) fibers with high reflection Fiber Bragg Gratings (FBGs) forming a Fabry-Perot (FP) cavity.

Several methods exist to create FP cavities in fibers [2,3]. Hereby, we use the femtosecond laser writing technique (fs-LW) to create our cavity. Fs-LW is a well-established technique for the creation of 3D optical components in transparent substrates such as glasses. It allows high flexibility in the creation of customizable (wavelength, length, apodization profile...) and through-coating FBGs in any solid fiber.

Two high-reflection FBGs were written using fs-LW inside a Polarizing maintaining fiber (Fig. 1.a.b) forming a FP cavity (FP#1). Then, anti-reflection coated mode field adapters were created and spliced to each solid fiber end to adapt the mode to the HCPCF. Afterwards, the HCPCF was placed in between the 2 FBGs, forming a new FP cavity (FP#2) that is characterized as shown in Fig. 1c. The measured finesse of the cavities FP#1 and FP#2 are 80 and 8 respectively.

The following results presented at a wavelength of 1550 nm are a first step leading toward the development of an all-fibered photonic cell for Rubidium atoms cooling inside the HCPCF at a wavelength of 780 nm.

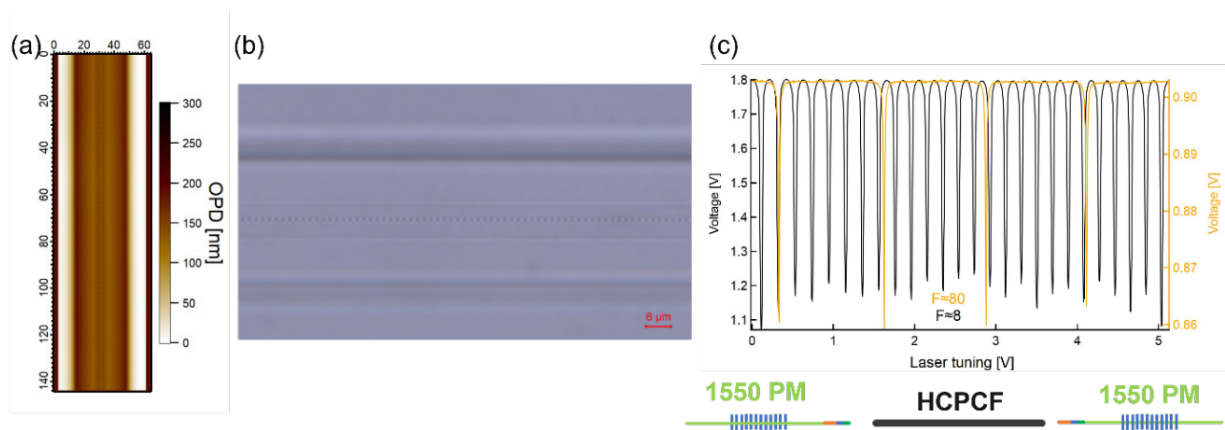


Fig. 1: (a) Phase image of the Bragg grating in PM fiber (b) Bright-field image of the Bragg grating in PM fiber (c) The Fabry-Perot Reflection signal of (orange) the two High Reflection Fiber Bragg Gratings in PM fiber exhibiting a Finesse of ~80 and (black) after placing the Hollow-core fiber between the Fiber Bragg gratings with a Finesse of ~8. Schematic presentation of FP#2.

References

1. F. Amrani, J. H. Osório, F. Delahaye, F. Giovanardi, L. Vincetti, B. Debord, F. Gérôme, and F. Benabid, "Low-loss single-mode hybrid-lattice hollow-core photonic-crystal fibre," *Light Sci Appl* **10**, 7 (2021).
2. M. Ding, M. Komanec, D. Suslov, D. Dousek, S. Zvánovec, E. R. N. Fokoua, T. D. Bradley, F. Poletti, D. J. Richardson, and R. Slavik, "Long-Length and Thermally Stable High-Finesse Fabry-Perot Interferometers Made of Hollow Core Optical Fiber," *Journal of Lightwave Technology* **38**, 2423–2427 (2020).
3. Y. Zhao, R. Lv, Y. Ying, and Q. Wang, "Hollow-core photonic crystal fiber Fabry-Perot sensor for magnetic field measurement based on magnetic fluid," *Opt Laser Technol* **44**, 899–902 (2012).