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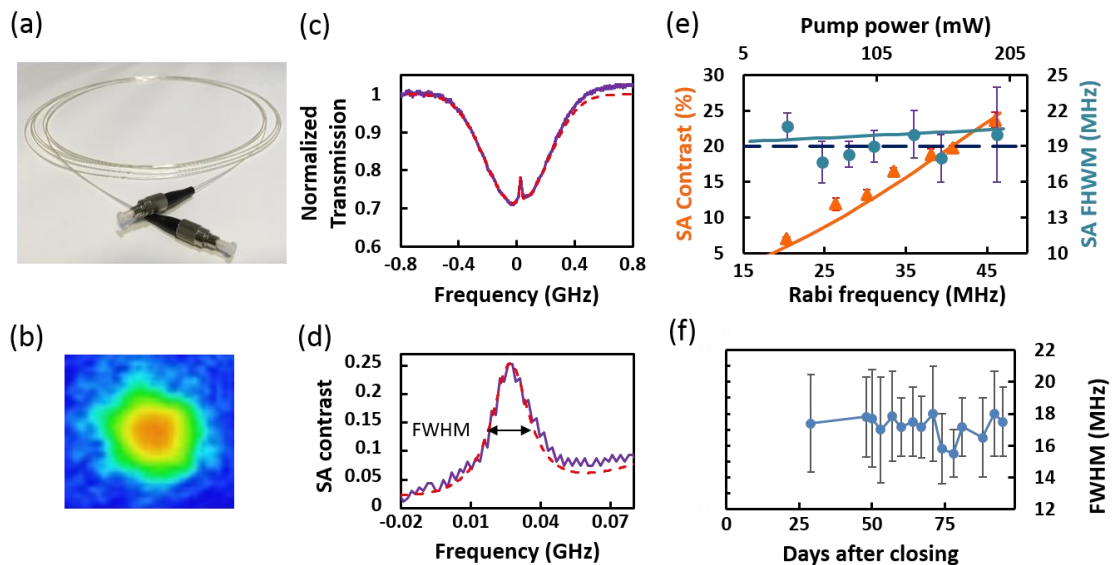
# Assembly process and sub-Doppler spectroscopy of end-capped photonic micro-cell

T. Billotte<sup>1</sup>, M. Chafer<sup>1,2</sup>, M. Maurel<sup>1,2</sup>, F. Amrani<sup>1,2</sup>, F. Gerome<sup>1,2</sup>, B. Debord<sup>1,2</sup>, F. Benabid<sup>1,2</sup>

1. GPPMM Group, Xlim Research Institute, CNRS UMR 7252, University of Limoges, 87060 Limoges, France

2. GLOphotonics SAS, 123 avenue Albert Thomas 87060 Limoges Cedex

Generation of sub-Doppler spectral lines in compact devices is very useful in bringing functionalities such as laser-frequency stabilization, slow light application or quantum sensing to a wider and friendlier use. An all-fiber Photonic MicroCell (PMC), which consists of a gas-filled hollow core photonic crystal fiber (HCPCF) hermetically spliced to a solid optical fiber [1], is one of the most promising of such devices because of its ultra-long interaction length. Thus far, the PMC assembly processes are either limited to a short range of HCPCF core diameter [2], or entails the use of glue [3], or exhibit high injection losses ( $\sim 10$ dB) [4]. Here, we report on a 7-meter contaminant free and single-mode  $C_2H_2$ -PMC. The process consists of end-capping a  $80\mu\text{m}$  acetylene-filled HCPCF via heat-collapsing a fused borosilicate sleeve on the two HCPCF tips. The process requires no helium gas [2] nor glue [3], which are potential pollution sources, and keeps the physical integrity of the HCPCF intact. The used HCPCF exhibits a novel cladding lattice and operates in a robust single-mode fashion [5]. The fiber has a  $30\mu\text{m}$  core diameter, a  $10\text{dB/km}$  transmission loss at  $1540\text{nm}$ . The resulted PMC has polished and mounted ends to FC/APC connectors for integration (Fig. 1(a)), exhibits a total insertion loss of  $\sim 2\text{dB}$  and a motion-resistant single-mode guidance (see reconstructed near field in Fig. 1 (b)). The PMC was then used to generate saturable absorption spectroscopy (SAS) measurement (Fig. 1 (b-c)). The observed saturable absorption peak reaches 25% contrast and  $20\text{MHz}$  linewidth (FWHM) for  $\sim 190\text{mW}$  of pump power that is the highest observed contrast in a fully sealed PMC [6]. The evolution of the SA peak characteristics over pump power are represented in Fig. 1 (e), and shows for pump power of less than  $100\text{mW}$  a transit-time limited linewidth ( $19\text{MHz}$ ), thus indicating no additional collisional dephasing that could be induced by contaminant during the assembly process. The linewidth was monitored over 3 months for  $23\text{mW}$  pump power with no significant variation (Fig.1(f)), demonstrating thus its hermeticity, and its suitability for long time and mobile applications.



**Fig. 1.** (a) FC/APC patch-cord like final PMC. (b) Near field intensity profile at the output of polished PMC. (c) Normalized SAS measurement on P9 absorption line of acetylene ( $1530.371\text{nm}$ ) in purple line, simulation of SAS signal for  $31\mu\text{bar}$  pressure in dashed line. (d) SA contrast zoomed in SA peak with numerical calculation in dashed line. (e) Experimental (dots) and calculated (line) SA transparency peak contrast and linewidth evolution with pump power. The dashed line correspond to the transit time limit. (f) Evolution of SA FWHM during 95 days for a pump power of  $23\text{mW}$ .

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