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

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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 (~ 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 10dB/km transmission loss at 1540nm . 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 20MHz 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 100mW a transit-time limited linewidth (19MHz), thus indicating no additional collisional dephasing that could be induced by contaminant during the assembly process. The linewidth was monitored over 3 months for 23mW pump power with no significant variation (Fig.1(f)), demonstrating thus its hermeticity, and its suitability for long time and mobile applications.

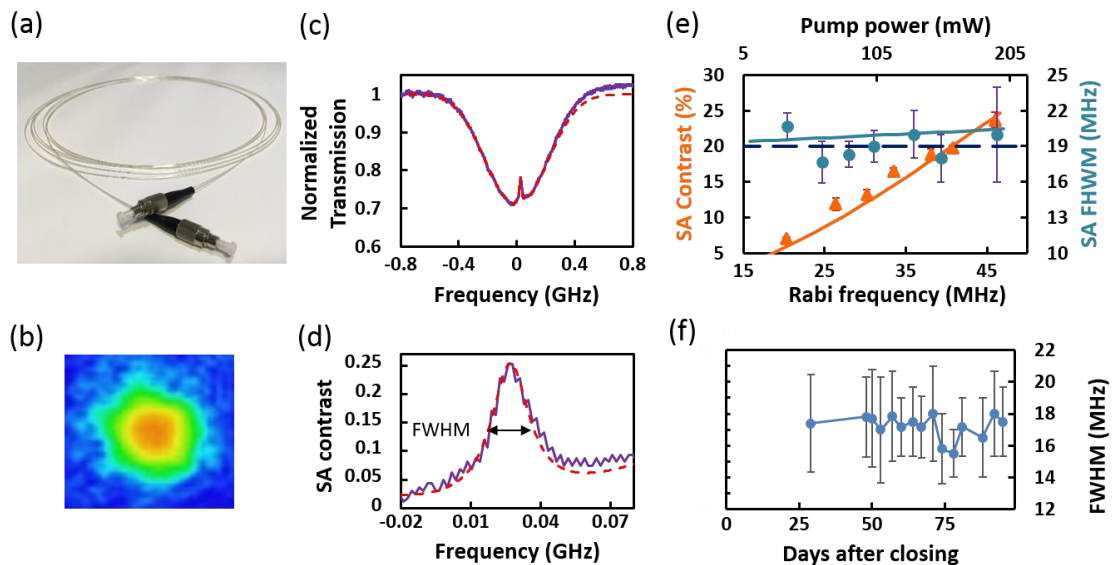


Fig. 1. (a) FC/APC patch-cord like final PMC. (b) Near field intensity profile at the output of polished PMC. (c) Normalized SAS measurement on P9 absorption line of acetylene (1530.371nm) in purple line, simulation of SAS signal for $31\mu\text{bar}$ pressure in dashed line. (d) SA contrast zoomed in 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 23mW .

References

- [1] F. Benabid, F. Couny, J. C. Knight, T. A. Birks, and P. S. J. Russell, "Compact, stable and efficient all-fibre gas cells using hollow-core photonic crystal fibres," *Nature*, **Vol. 434**, No 7032, 488 (2005).
- [2] P.S. Light, F. Couny, F. Benabid, "Low optical insertion-loss and vacuum-pressure all-fiber acetylene cell based hollow-core photonic crystal fiber" *Opt. Lett.* **Vol 31**, No 17, 2538 (2006).
- [3] M. Triches, A. Bruschi, J. Hald, "Portable optical frequency standard based on sealed gas-filled hollow-core fiber using a novel encapsulation technique" *App. Phys.* **121**, 251 (2015).
- [4] F. Couny, P.S. Light, F. Benabid, P.S.J. Russell, "Electromagnetically induced transparency and saturable absorption in all-fiber devices based on C_2H_2 -filled hollow core photonic crystal fiber." *Opt. Com.* **263**, 28 (2006).
- [5] F. Amrani, J.H. Osorio, F. Delahaye, F. Giovanardi, L. Vincetti, B. Debord, F. G erome, F. Benabid, "Low-loss single-mode hybrid-lattice hollow-core photonic crystal fiber", arXiv:2006.06375 (2020).
- [6] N.D. Wheeler, M.D.W. Grogan, P.S. Light, F. Couny, T.A. Birks, F. Benabid, "Large-core acetylene-filled photonic microcells made by tapering a hollow-core photonic crystal fiber" *Opt. Lett.* **Vol 35**, No 11, 1875 (2010).