Fabrication of all-fibre gas reference cells for laser frequency stabilization

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Growing concerns about global climate change have motivated the need for active remote sensing for an enhanced monitoring of atmospheric gas species such as carbon dioxide, methane or water vapour [1]. This can be achieved using space-borne trace gas remote sensing instruments based on a DIfferential Absorption Lidar (DIAL) approach. Since a DIAL scheme requires operation at an accurate optical frequency, a reference laser frequency-stabilized to a molecular transition is needed. Reference cells made of photonic crystal fibres (PCFs) are a very attractive option for such space applications since they are much more lightweight (a 10-m long all-fibre connectorized gas cell typically weighs less than 10 g), compact, and robust than bulk glass or metal gas cells.

To fabricate an all-fibre gas cell, one end of the PCF is first fusion-spliced to a standard single mode fibre using a tailor-made splicing programme. The pigtailed PCF is then placed in a hermetic gas chamber (Fig. 1(a)) for air evacuation followed by gas filling of the holes of the PCF at a targeted low pressure with the desired gas sample. The last step involves another fusion splice at the other end to hermetically seal the PCF. To prevent air contamination in the filled PCF, the latter is loaded with helium at high pressure (above atmospheric pressure) before being taken out from the gas chamber, such that this slight helium overpressure prevents air from entering in the fibre holes during the final splice [2]. Within several hours, the helium diffuses out the fibre due to its high permeation coefficient through silica, leaving only the low pressure gas inside the cell.

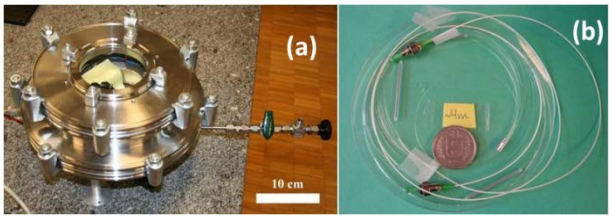

Fig. 1: (a) Hermetic chamber used for the fabrication of (b) an all-fibered, compact and ultra-light gas reference cell pigtailed at both ends allowing simple connection to optical components.

Using this protocol several fibre gas cells (Fig. 1(b)), made of different types of PCFs (hollow-core and solid-core holey fibres), have been fabricated for various research works [3-4]. Currently, a CO_2-filled PCF that will be used for frequency stabilisation of a laser onto the R(30) $^{12}CO_2$ line at 2.05 μm is being fabricated.

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[2] P.S. Light *et al*, Opt. Lett. **31**, 2538 (2006)
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[4] I. Dicaire *et al*, Appl. Opt., **49**, 4604 (2010).