

Trace Gas Detection with Differential Optical Absorption Spectroscopy Utilizing Antiresonant Hollow-Core Fibers

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In recent years antiresonant hollow-core fibers (ARHCFs) found their application in gas molecules detection. They are highly attractive for laser spectroscopy, since they can act as a low-volume absorption cell, at the same time providing long-distance interaction path of the laser beam in the gas mixture. However, ARHCFs are susceptible to mode coupling noise, which limits the precision of the sensor. Wavelength Modulation Spectroscopy (WMS) and other techniques relying on wavelength modulation are particularly exposed to that behavior.

The proof-of-concept of the ARHCF-assisted differential optical absorption spectroscopy (DOAS) is presented to reduce mode coupling interferences in ARHCFs and compensate variations in laser beam propagation through the fiber. Data acquisition is performed with self-designed boxcar averaging unit, which limits sensor noise liability, and therefore improves its detection limit.

Fig. 1(a) presents the experimental setup of the sensor. Acetylene (C_2H_2) detection was successfully performed in a self-fabricated 1.4 m long ARHCF for different concentrations. Fig. 1(b) illustrates the linear responsivity of the sensor, which confirms the validity of presented technique. Fig. 1(c) shows Allan deviation of the sensor background noise with the minimum detection limit (MDL) of 840 ppbv for 8 s integration time, which gives a noise equivalent absorption (NEA) coefficient of $4.83 \times 10^{-7} \text{ cm}^{-1}$.

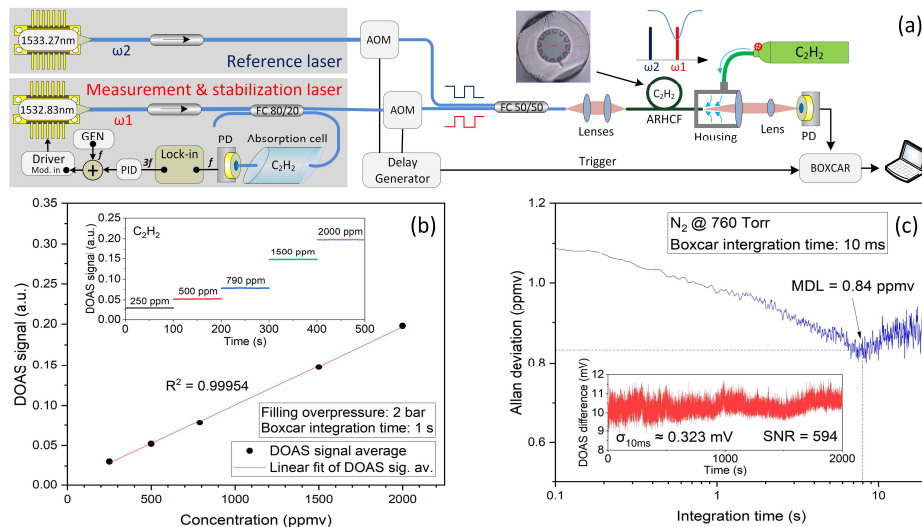


Fig. 1. (a) Schematic of the experimental setup. (b) Linearity of the of sensor to the C_2H_2 concentration. (c) Allan deviation calculated based on the sensor's background noise.

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