Optical Feedback Cavity-Enhanced Absorption Spectroscopy with a 3.24 µm Interband Cascade Laser

K.M. Manfred[1], G.A.D. Ritchie[1], N. Lang[2], J. Röpcke[2], J.H. van Helden[2]
[1]*Department of Chemistry, Physical and Theoretical Chemistry Laboratory, University of Oxford, South Parks RD, Oxford OX1 3QZ, United Kingdom*
[2]*Leibniz Institute for Plasma Science and Technology, Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany*

The development of interband cascade lasers (ICLs) has made the strong C-H transitions in the 3 µm spectral region increasingly accessible. We present the first, to our knowledge, demonstration of a single mode distributed feedback ICL coupled to a V-shaped optical cavity in an optical feedback cavity-enhanced absorption spectroscopy (OF-CEAS) experiment. A typical cavity transmission spectrum averaged over 100 scans of a 25 kPa sample with 180 ppb CH_4 is shown in Fig. 1(a). Over 20 ms, the ICL locked to 40 successive cavity modes with a locking time, estimated by the FWHM, of 120 µs, much longer than the ring-down time (typically 3.2 µs). The time between modes was ~ 300 µs (Fig. 1(b)). We achieved a minimum detectable absorption coefficient, α_{min}, of (7.1 ± 0.2) x 10^{-8} cm^{-1} for a spectrum of CH_4 at 3.24 µm with a two second acquisition time (100 scans averaged). This corresponds to a detection limit of 3 ppb CH_4 at atmospheric pressure, which is comparable to previously reported OF-CEAS instruments with diode lasers or quantum cascade lasers [1, 2]. The ability to frequency lock an ICL source in the important 3 µm region to an optical cavity holds great promise for future spectroscopic applications.

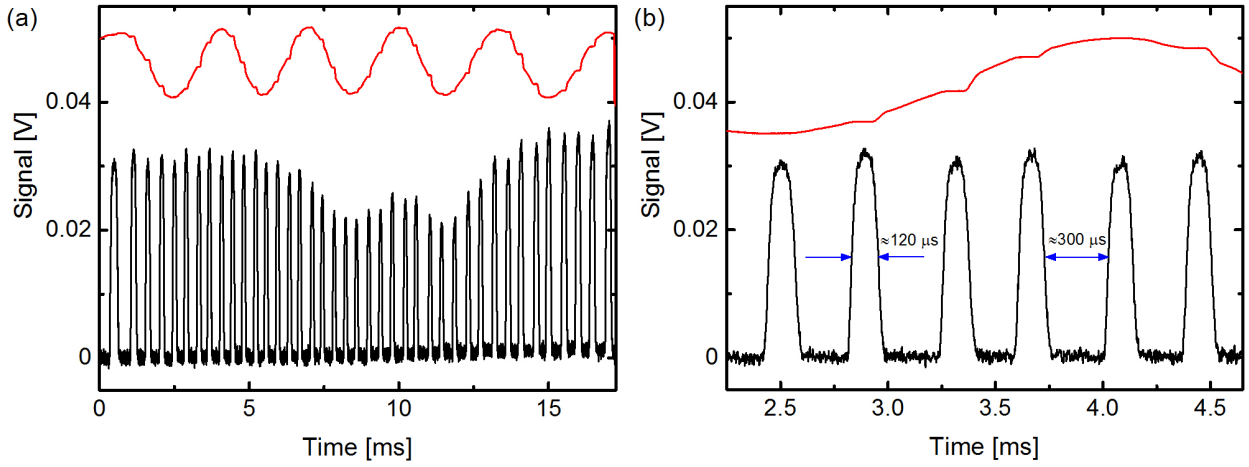

Fig. 1: (a) Cavity transmission for 180 ppb CH_4 in buffer gas at a total pressure of 25 kPa while the laser is scanning to lower wavenumber. This transmission spectrum is the average of 100 scans. (b) A magnification of the modes around 3 ms. In both figures, the upper trace is an etalon trace showing flat sections when locking to the modes occurs (shifted for clarity).

References

[1] D. Romanini, M. Chenevier, S. Kassi, M. Schmidt, C. Valant, M. Ramonet, J. Lopez, and H.-J. Jost, Appl. Phys. B 83, 659 (2006).
[2] D. J. Hamilton, and A. J. R. Orr-Ewing, Appl. Phys. B 102, 879 (2011).