

TOROIDAL ABSORPTION CELL WITH MULTI-LAYER PATTERNS BY A SINGLE RING SURFACE

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We developed a type of toroidal multi-pass cell with multilayer patterns based on the off-axis model. The effective path length of the original toroidal multi-pass cell is extended several roundtrips in comparison with the single-layer pattern, since the inner surface of the toroidal multi-pass cell is more efficiently utilized. The light pattern has been achieved by using the simple ring surface, which is easy to fabricate. The exact analytical equations for the design of the toroidal multi-pass cell were derived based on analytical vector calculations. A homemade electronic system was designed for implementing a DFB diode laser controller, an analog lock-in amplifier, data acquisition, and communication. Calibration-free scanned wavelength modulation spectroscopy was employed to determine the concentration of the gas and reduce the random fluctuations from electrical noise and mechanical vibration. The measurement of CH₄ in ambient air was demonstrated using a DFB laser at 1.653 μm . The rise time and fall time for renewing the gas mixture are approximately 16 and 14 s, respectively. Vibration and temperature tests have been carried out for verifying the performance of the spectrometer, and standard deviations of 0.38 ppm and 0.11 ppm for 20 ppm CH₄ at different vibration frequencies and temperatures, respectively, have been determined. According to the Allan deviation analysis, the minimum detection limit for CH₄ can reach 22 ppb at an integration time of 57.8 s.