

Optical Cavity-Enhanced Photoacoustic Technique Using Compact, Low-Power Lasers

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A photoacoustic resonator is a detector of the optical energy absorbed by gases when the energy is modulated at the resonance frequency. The sensitivity of the technique is limited by the strength and stability of the light source, the sensitivity and noise characteristics of the microphone, and the presence of synchronous background absorption. Small photoacoustic cells combined with compact light sources (such as diode lasers) are potentially more stable, safer, and easier to secure than conventional photoacoustic spectroscopy (PAS) systems. Tunable diode lasers used as light sources in PAS systems enable quantitative measurements of absorption bands and individual absorption lines in several regions of the visible and near-IR regions of the spectrum. Unfortunately, diode lasers with power greater than a few milliwatts are not available for all wavelengths. With conventional PAS, too little power in the source laser may be insufficient to achieve a desired detection limit. Conventional laser amplification systems such as fiber amplifiers and diode pumps are not available for all wavelengths, tend to be expensive, and may achieve only modest results. We have developed a novel cavity-enhanced PAS (CE-PAS) system prototype in which the photoacoustic cell is located *inside* of an optical cavity where the laser power is amplified about 100 times. With this approach, the laser amplification can in principle work with any wavelength laser, thus providing flexibility in laser selection. The photoacoustic resonator is an open PZT tube, which doubles as the acoustic detector; the resonator's open geometry eliminates synchronous background signals from windows present in conventional designs. The laser light (He-Ne) is intensity modulated at the acoustic resonance frequency with an acousto-optic modulator. The optical cavity length is locked to the laser with PZT-driven mirrors. We discuss the performance of this prototype CE-PAS system in terms of stability and measured detection limit using flowing nitrogen dioxide/nitrogen mixtures. Finally, we discuss the possibility of achieving amplification of the order 10,000:1 by combining high finesse optical resonators with next-generation ultra-narrow line width lasers.