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# Quartz-enhanced photoacoustic spectroscopy: shrinking the spectroscopic gas sensor

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Latest progress in quantum electronics resulted in availability of compact and powerful tunable laser sources both in the near-IR and mid-IR regions. In order to take full advantage of these devices for chemical sensing applications, an equally compact absorption detection module (ADM) is required. Photoacoustic spectroscopy (PAS) based on the detection of sound generated in the media upon absorption of modulated optical radiation allows low detection limits to be reached with a small sample volume, typically starting from ~10 cm$^3$. However, PAS performance can be strongly degraded by ambient acoustic noise which prevents its widespread use in the design of portable gas sensors.

A novel variation of PAS called Quartz-Enhanced PAS, or QEPAS [1], allows to overcome this drawback with an additional advantage of dramatically reduced sample volume. This technique is based on a quartz tuning fork (TF) used as a resonant acoustic transducer. The TFs are designed to be used as frequency standards in electronic clocks, resonating at $f$~32 768 ($2^{15}$) Hz. QEPAS makes use of the extremely high $Q$-factor of these quartz vibrators, which allows the signal build-up during (1-3)_$10^4$ modulation periods. The largest dimension of a TF is typically <5mm, thus matching the size of a semiconductor laser source.

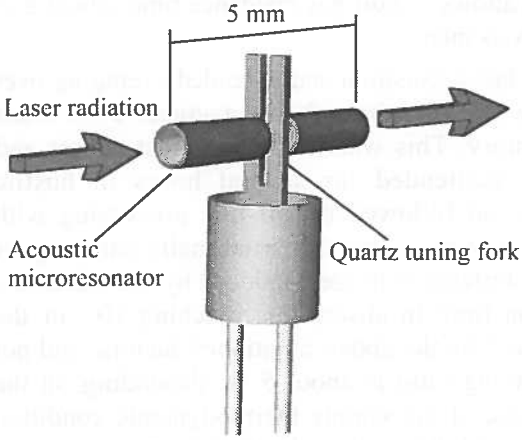


Fig. 1. QEPAS ADM.

A configuration of the QEPAS based ADM in shown in Fig. 1. Acoustic microresonator consisting of two glass tubes with a combined length equal to a half sound wavelength at 32.76 kHz is added to the TF for sensitivity enhancement.

Trace gas sensing experiments based on QEPAS were performed for a number of species both in near-IR and in mid-IR spectral regions [2]. Normalized QEPAS sensitivity achieved to date in $NH_3$ detection experiments is 5.4_$10^{-9}$ cm$^{-1}$W/√Hz, which is comparable to or better then the sensitivity reported for conventional PAS-based ammonia sensors.

## References

[1] A. A. Kosterev, Yu. A. Bakhirkin, R. F. Curl, and F. K. Tittel, *Optics Letters* **27**, 1902–1904 (2002).

[2] A. A. Kosterev, F. K. Tittel, D. Serebryakov, A. Malinovsky, and I. Morozov, to be published in *Rev. Sci. Instr.*, April 2005.