

## **Trace Gas Sensing based on Quartz Enhanced Photoacoustic Spectroscopy**

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This talk will focus on recent opportunities and challenges for the development of compact trace gas sensors based on quartz enhanced photoacoustic spectroscopy. The detection and quantification of trace chemical species in the gas phase find applications in such diverse fields as in environmental monitoring, industrial process control, air quality assessment in spacecraft habitats and medical diagnostics. Ultrasensitive chemical analysis of gases based on molecular absorption laser spectroscopy is a well-established approach [1]. Recent advances of semiconductor lasers has resulted in compact and powerful infrared laser sources both in the near-infrared (molecular overtones) and mid-infrared (fundamental molecular absorption bands) regions. An ideal absorption detection scheme should meet the following requirements:

- 1) Sensitivity scales with laser power
- 2) Physical dimensions match the dimensions of the spectroscopic laser source
- 3) Performance does not degrade in a real-world environment (acoustic noise, mechanical vibrations, and temperature drifts)

Photoacoustic spectroscopy satisfies the first and in some cases the second requirements. However, it is usually sensitive to environmental noise which prevents its widespread use in the design of portable gas sensors. A recent modification of the conventional photoacoustic technique called Quartz Enhanced Photoacoustic Spectroscopy (QEPAS) which was proposed in 2002 [2,3] is free of this shortcoming, and offers an added advantage of the very small sample volume required for analysis (ultimately  $\sim 1 \text{ mm}^3$ ). The basic idea of QEPAS is utilization of a quartz tuning fork (TF) as a resonant transducer for the detection of laser-excited sound (see Fig. 1). The sharply resonant nature of a TF ( $Q > 10\,000$ ) as well as its acoustic quadrupole geometry result in its outstanding immunity to environmental acoustic noise. The fundamentals and technical details of QEPAS implementation will be described. Recent results on QEPAS-based trace-gas detection will be presented.

### References

1. R. F. Curl and F. K. Tittel, "Tunable infrared laser spectroscopy", *Annu. Rep. Prog. Chem., Sect. C*, **98**, 219–272 (2002)
2. A.A. Kosterev, Yu.A. Bakirkin, R.F. Curl, and F.K. Tittel, "Quartz-enhanced photoacoustic spectroscopy," *Optics Letters* **27**, 1902-1904 (2002)
3. Rice University Laser Science Group website: <http://ece.rice.edu/lasersci/>

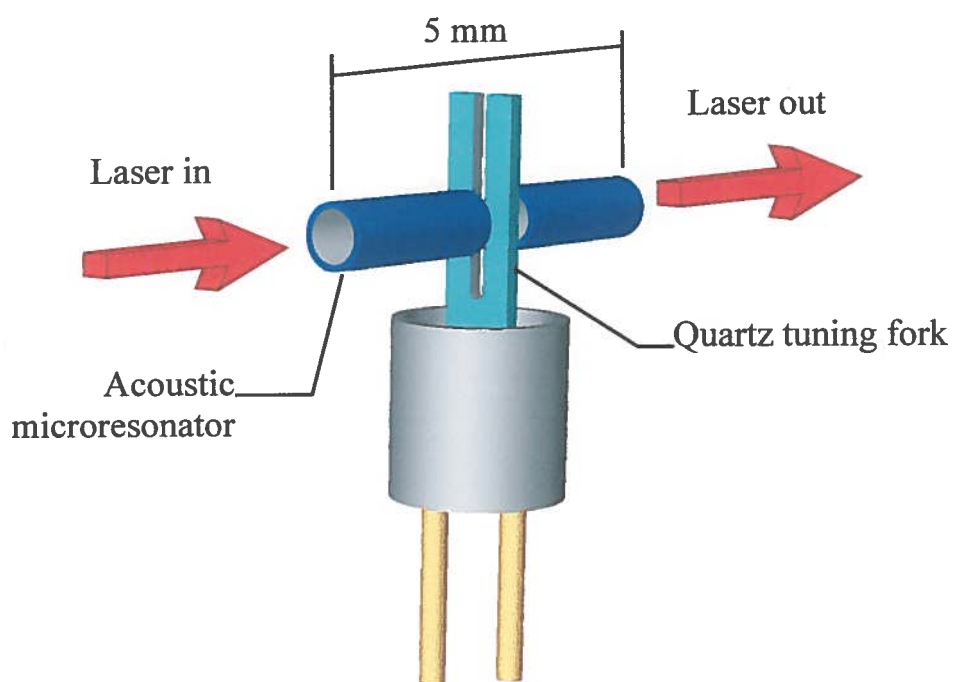


Fig.1 Architecture of QEPAS sensor module consisting of a quartz tuning fork and an acoustic micro-resonator