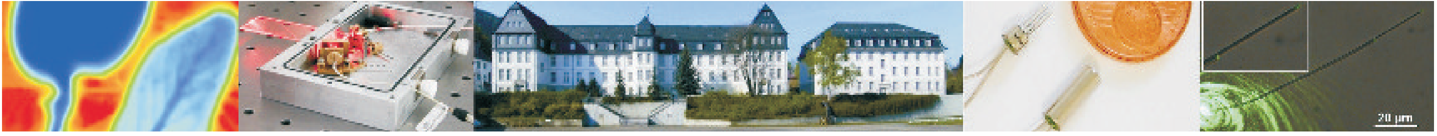

Fiber coupled microsensors for trace gas sensing

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Motivation

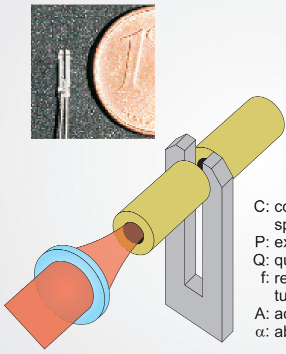
Trace gas analysis is an important field in today's metrology. Photoacoustic measurement techniques enable online monitoring of gas concentrations in a wide field of applications.

Instead of using a common microphone for the detection of the optically induced acoustic waves, tuning forks with their high Q-factors can be exploited. This technique named QEPAS (quartz-enhanced photoacoustic spectroscopy) was invented in 2002 by F. Tittel et al. and uses the piezoelectric properties of quartz to detect the motion of the small resonant element.

The TIPAS technique (Tuning fork enhanced interferometric photoacoustic spectroscopy) was developed in our department in 2010, using an optical interferometer to detect the tuning forks movement. TIPAS enables complete fiber-coupled sensor heads without any electronic components and energy source. The control unit contains the required lasers, detectors, and electronics. Single mode optical fibers connect both the sensor head and the control unit even over long distances.

Basics of resonant PAS

(PAS - Photoacoustic spectroscopy)

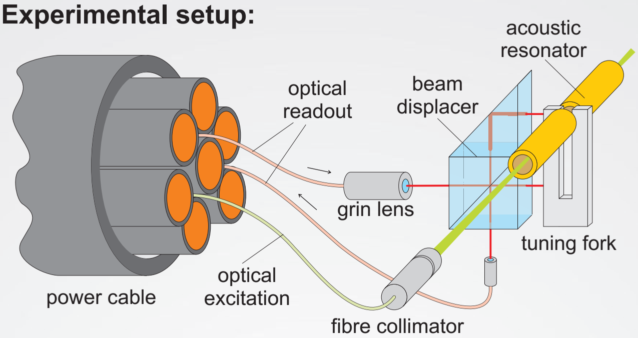


$$S \sim \frac{\alpha CPQ}{fA}$$

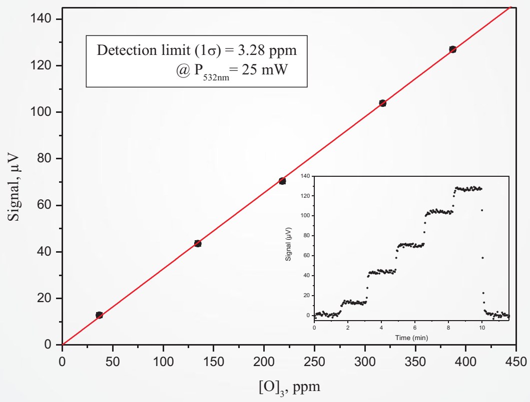
- C: concentration of the target gas species
- P: excitation laser power
- Q: quality factor of the system
- f: resonance frequency of the tuning fork
- A: acoustic resonator cross section
- α: absorption coefficient

TIPAS sensor for ozone detection

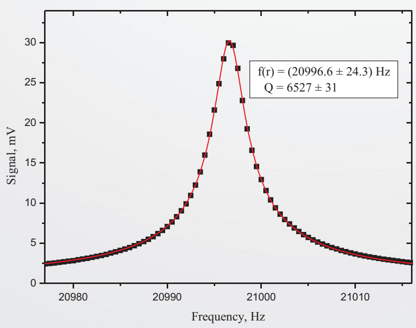
Experimental setup:

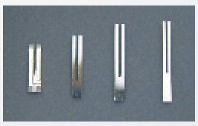


Calibration measurements:



Next generation of micro tuning forks:

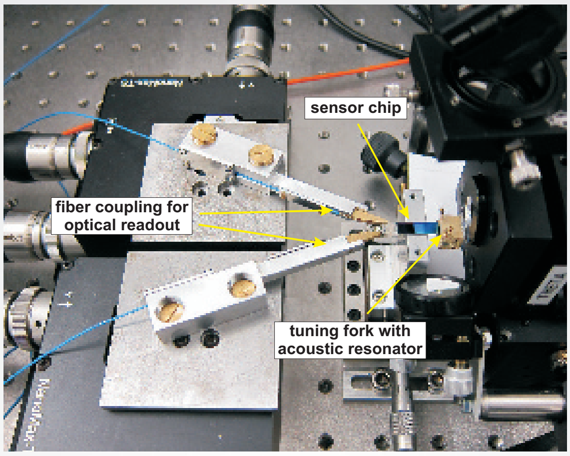




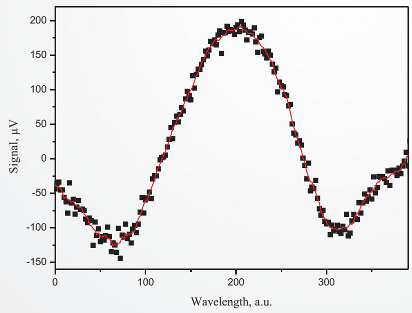
The tuning forks cut out of Si-(111) wafers show good resonance properties. Resonance frequencies from 56kHz down to 12kHz have been realized.

TIPAS sensor chip

Experimental setup:

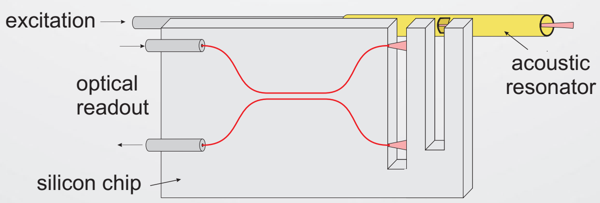


Oxygen measurements:



To prove the feasibility of a resonant photoacoustic chip sensor, the deflection of a quartz tuning fork was read out optically with an integrated Mach-Zehnder interferometer. Oxygen was detected in ambiant air using a DFB-diode laser at 763nm for photoacoustic excitation.

Design with off-beam resonator:



M. Köhring, A. Pohlkötter, U. Willer, M. Angelmahr, W. Schade; Applied Physics B, Tuning fork enhanced interferometric photoacoustic spectroscopy: A powerful method for trace gas analysis; 2010 (online first)