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# Ultracompact Photoacoustic Sensor Based on a Quartz Tuning Fork

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Photoacoustic spectroscopy (PAS) is a highly sensitive technique for detecting weak optical absorption in media, particularly in gases. PAS is based on sensing an acoustic wave originating from the heating of media by modulated laser radiation. A common approach used to detect a photoacoustic signal in a weakly absorbing gas utilizes an acoustic resonator filled with the target gas [1]. The absorbed laser power is accumulated in the acoustic mode of the resonator for $Q$ oscillation periods, where $Q$ is the quality factor of the resonator. Intrinsic losses in gas media limit the typical $Q$ value for a gas-filled PAS resonator to ~40 to 200.

A novel approach to detection of a photoacoustic signal will be reported. The basic idea is to accumulate the acoustic energy not in the gas but in a quartz crystal, which is also used as a microphone [2]. Piezoelectric crystal quartz is widely used in various frequency standards. We have selected watch tuning forks (TF, nominal resonant frequency $f$ = 32,768 Hz) from a range of available quartz elements as most suitable for novel PAS detection. These TFs have recently been introduced in atomic force and optical near field microscopy [3]. Therefore their properties have been carefully analyzed. A typical watch TF has a $Q \approx 10{,}000$ at normal atmospheric pressure. A schematic of our PAS detection setup based on a TF sensor is shown in Fig. 1. To suppress signals originating from non-selective absorption of laser radiation by the TF itself, the laser was wavelength-modulated at half the TF resonant frequency.

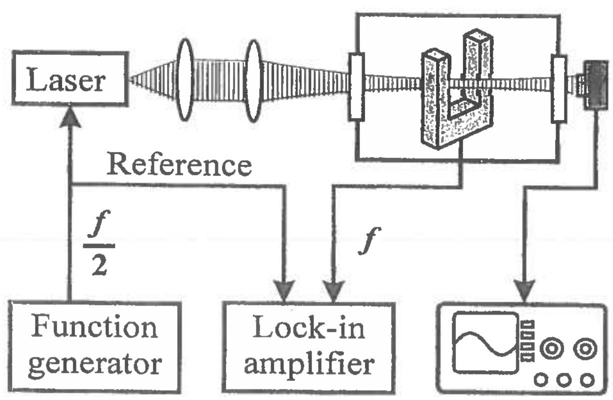


Fig. 1

The main advantages of using TF for PAS are the immunity to ambient acoustic noise and ultra-small gas sample volume necessary for analysis. Since no external acoustic resonator is required, the sample volume is ultimately limited by the space between the TF prongs, which is less than 1 mm$^3$. The sensitivity obtained to-date with a TF-based PAS in feasibility experiments is $1.2\times10^{-7}$ cm$^{-1}$W/√Hz. Future development and applications will be discussed.

References

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