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Editorial

Quartz-Enhanced Photoacoustic and Photothermal Spectroscopy

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Special Issue
Quartz-Enhanced Photoacoustic and Photothermal Spectroscopy

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Editorial

Quartz-Enhanced Photoacoustic and Photothermal Spectroscopy

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1. Introduction

The development of innovative gas-sensing systems is fundamental in diverse research fields such as physics, chemistry, biology, medicine and environmental science [1–3]. Sensors based on quartz-enhanced photoacoustic spectroscopy [4,5] or photothermal spectroscopy [6,7] have the merit of combining high spectral selectivity provided by laser sources, high sensitivity guaranteed by sharply resonant quartz tuning forks (QTF), and a field-proven level of robustness and compactness. These characteristics—together with the no-cost impact of QTFs employed as sound and/or light detectors, and their capability of efficiently working in harsh environments—make sensors relying on tuning forks the leading-edge technologies for in-situ and real-time detection of gas species [8,9]. Hence, we dedicated a Special Issue to the most recent advances and state-of-the-art applications of quartz-enhanced photoacoustic and photothermal spectroscopy. A total of 15 paper submissions were received. Among them, one manuscript was rejected by the editor in the initial checking process, and two manuscripts were rejected by the reviewers. The remaining manuscripts underwent a peer-reviewing process and were evaluated by at least two reviewers widely acknowledged as experts in their research. Finally, 11 manuscripts were accepted for publication in Applied Sciences—Basel. We would like to sincerely thank for their effort these numerous reviewers from across the world—in particular, from China, the USA, Italy and Germany—who contributed to the high quality and success of this Special Issue.

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2. Main Content of the Special Issue

The recent advances in, and development of, custom quartz tuning forks and laser sources, as well as narrowband laser absorbers, has opened up new opportunities for gas sensing and detection techniques based on quartz-enhanced photoacoustic spectroscopy (QEPAS) and/or quartz-enhanced photothermal spectroscopy (QEPTS). Therefore, the research papers published in this Special Issue mainly focus on novel approaches exploiting QTFs as core sensitive elements, and their implementation in real world applications.

In particular, three articles of the Special Issue investigate and exploit the photothermal effect. The first article, authored by S. Li et al. presents a non-destructive method to analyze the thermodynamics of polymer microwire samples, bridged across the prongs of the tuning fork, at the nanogram level [10]. Compared with the traditional method, the analysis method exposed in this paper does not require annealing before measurement, which is an essential process for conventional thermal analysis, and results in a fast analysis time. The second article, submitted by H. Zheng et al., reports on an original approach for trace-gas detection, by combining photo-thermal and photo-acoustic spectroscopy, and relying on a quartz tuning fork as a light-intensity and sound-wave detector, simultaneously [11]. In the third article, authored by G. Lan et al., a narrowband perfect absorber based on a dielectric-metal metasurface for wide-band surface-enhanced infrared sensing was investigated.

This study offers a promising approach to designing high-performance surface-enhanced resonators to be employed as optical detectors in the infrared region [12].

Two manuscripts were dedicated to the design, development and optimization of high-performance electronics devoted to the QTF piezo-current transduction in a voltage signal. Piotr Z. Wieczorek et al. analyzed the influence of the crucial parameters of the low-noise operational preamplifier design, and discussed the characteristics of transimpedance and voltage configurations [13]. G. Menduni et al. investigated the possibility of using a differential input/output configuration with respect to single-ended configuration, and discussed the related signal-to-noise ratios in QEPAS spectra obtained by means of a water vapor sensor [14]. Two more articles focus on the physical interaction between the target analyte excited and the gas matrix. The manuscript authored by J. Hayden et al. explains the peculiar trend of carbon monoxide QEPAS signals in a nitrogen-based gas matrix, obtained by changing the water vapor concentration. The kinetic model, discussed in detail, can be used to identify optimized experimental conditions for sensing CO, and can be readily adapted to include further collision partners [15]. The effects of gas-matrix variations are also addressed in the article authored by M. Mordmueller et al., who reported on the latest results obtained with an auto-triggered QEPAS approach. This configuration works without external frequency generators, and ensures permanent locking to the current resonance frequency of the tuning fork [16]. The phase-optimized photoacoustic technique mentioned above avoids a calibration procedure and permits the continuous monitoring of a targeted trace gas. The remaining three papers all focus on optimized configurations of the laser beam shape and improved acoustic detection modules, mounting custom QTFs to further enhance the sensitivity of QEPAS-based sensors [17–19]. These new results set the basis for a further twist in the development of technology, to more efficiently address the challenges provided by the sensor market and environmental monitoring applications.

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