新型石英音叉与长光程吸收赋能的高灵敏度激光光谱气体传感器

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近年来，基于光致热弹光谱 (laser-induced thermoelastic spectroscopy, 简称 LITES) 的气体传感技术发展十分迅速，随着研究的深入，LITES 已被证明是一种稳定且灵敏度高的气体传感技术。优化创新系统结构、提高检测灵敏度，是推动 LITES 技术进一步发展的必由之路。

哈尔滨工业大学马欲飞教授团队在其前期扎实的研究基础上，对 LITES 气体传感系统的结构进行了优化创新，从增大激光功率、增加气体吸收程和使用新型低频石英音叉探测三个维度对系统进行升级，实现了对气体的高灵敏度测量。该系统选择乙炔作为目标检测气体，选取了其位于 1530.37 nm 处的吸收线，并使用了一台掺铒光纤放大器 (Erbium-doped fiber amplifier, 简称 EDFA) 对激光功率进行放大。

依据测试结果，EDFA 输出功率在 300~1000 mW 范围内变化时，LITES 系统信噪比随功率的增加而增大。为了在增加气体有效吸收程的同时不增加系统体积，该系统使用了一个新型的光斑密集型光学多通池 (multi-pass cell, 简称 MPC) 作为气体吸收池，该气体吸收池能够提供 37.7 m 的有效吸收程，并且其光程体积比高达 13.8 cm-2。该工作从激发、吸收、探测三个维度对基于 LITES 的气体传感系统进行优化，使得系统探测性能显著提升，能够有力地推动光致热弹光谱技术的进一步发展。

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A high-sensitivity LITES-based gas sensor empowered by a novel quartz tuning fork and a multi-pass cell with dense spots pattern

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Laser-induced thermoelastic spectroscopy (LITES)-based gas sensing technology has developed very rapidly. With in-depth research, LITES has been proved to be a stable and sensitive gas sensing technology. Optimizing the structure of the innovative system and improving the detection sensitivity is the way to promote the further development of LITES technology.

The research group of Prof. Yufei Ma has optimized and innovated the structure of the LITES-based gas sensing system. The system was upgraded by increasing laser power, enhancing gas absorption range, and using a novel low-frequency quartz tuning fork (QTF) detector, which realized the high sensitivity measurement of the target gas. An erbium-doped fiber amplifier (EDFA) was employed to amplify the optical power so that the signal level was further enhanced.

This work optimizes the LITES-based gas sensing system in three dimensions: excitation, absorption, and detection, resulting in a significant improvement in detection performance. The detection performance of this system can be further enhanced by designing MPCs with a larger RLV and adopting laser with better output beam quality. In addition, research on the design of new QTFs with low resonance frequency and high *Q*-factor can further promote the development of LITES technology.

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