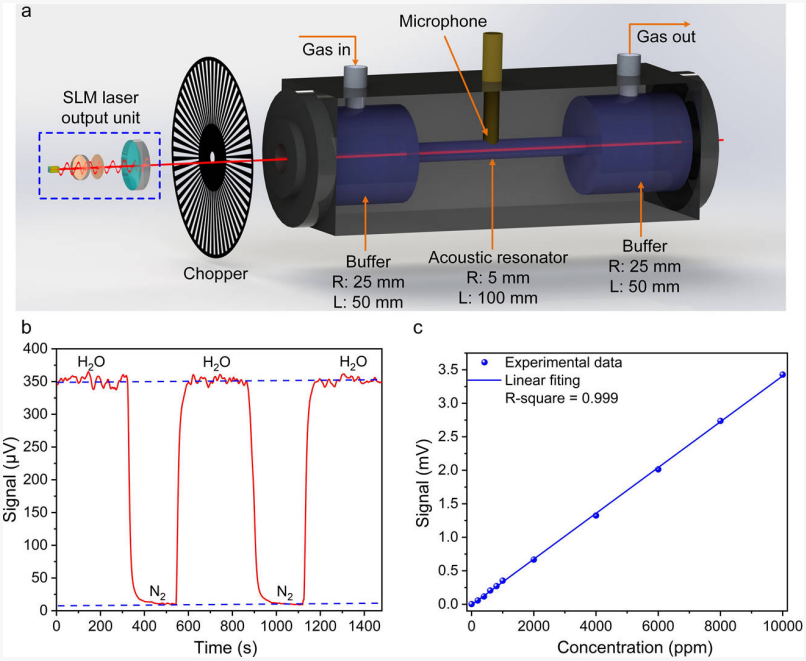
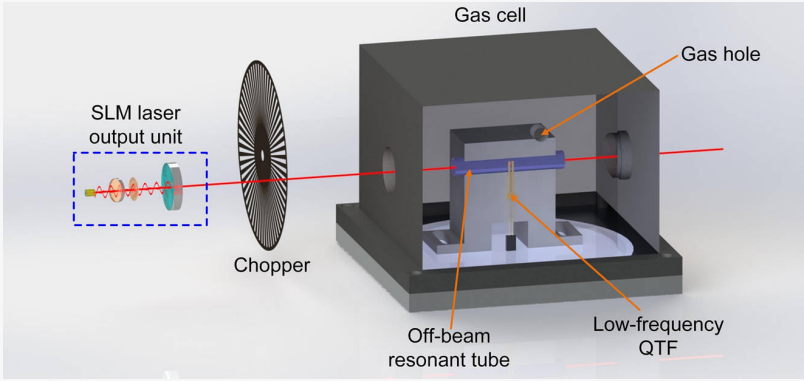
Photoacoustic spectroscopy-based sensitive dual gases detection with a solid-state laser

USA, September 1, 2024 /EINPresswire.com/ -- A long-wave, high-power, wide-tunable, single-longitudinal-mode solid-state laser was designed as light source in photoacoustic gas detection technology. The laser emits at ~2 μm with an excellent wavelength and power stability. The wide wavelength tuning range of 9.44 nm covers absorption spectra of water and ammonia, allowing dual gases detection with a single laser. The laser was used in three different photoacoustic detection technologies proving that solid-state laser is an attractive excitation source in photoacoustic spectroscopy.



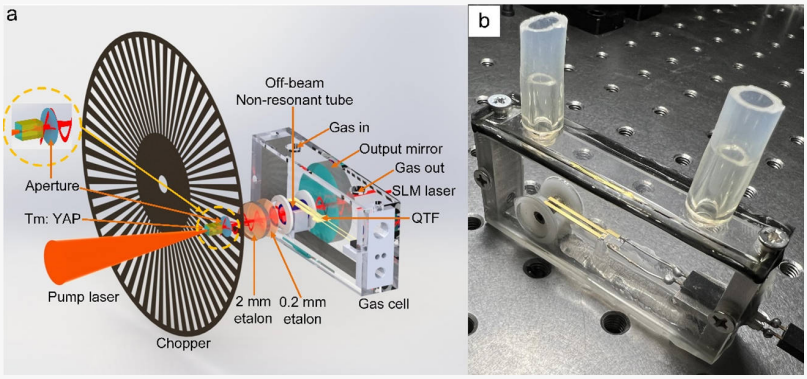
Solid-state laser-based PAS detection.



Solid-state laser-based external-cavity QEPAS detection.

Photoacoustic spectroscopy (PAS) as a highly sensitive and selective trace gas detection technique has extremely broad application in many fields. The laser sources as the core unit in PAS plays a decisive role in the detection performance of the system. At present, light excitation sources commonly used in PAS are distributed feedback (DFB) diode lasers and quantum cascade lasers (QCLs). DFB diode lasers have typical output power of tens of milliwatts and QCLs usually have poor beam quality and harsh working requirements due to the short cavity length and fragile chip. Both source types share a narrow wavelength tuning range, limiting multi-gases detection with a single laser source.

In a new paper (https://doi.org/10.1038/s41377-024-01459-5) published in Light Science & Applications, a team of scientists, led by Professor Yufei Ma from National Key Laboratory of Laser Spatial Information, Harbin Institute of Technology, Harbin, China, and co-workers have developed an ultra-highly sensitive dual gases detection based on photoacoustic spectroscopy by exploiting a long-wave, high-power, wide-tunable, single-longitudinal-mode solid-state laser. Compared to the laser sources of DFB diode laser and QCL, the solid-state laser self-built in the reported system achieved high optical power (~136 mW) and long output wavelength (~2 μm) while maintaining excellent beam quality and avoiding harsh working conditions. It is much suitable as the excitation source in the PAS which can excite a strong and stable photoacoustic signal thereby achieving good performance for the detection of trace gas. Moreover, the single-longitudinal-mode solid-state laser provided a wide tuning range of 9.44 nm which allows to target absorption spectral features of H2O and NH3. The solid-state laser was used as the light source in: (i) a conventional PAS setup employing a microphone as acoustic detector; (ii) an external-cavity QEPAS system employing a custom-made QTF in off-beam resonant configuration; and (iii) an intra-cavity QEPAS system, where the QTF was located inside the laser cavity due to its advantage of small size. This study proves that solid-state laser is an attractive excitation source in PAS and the solid-state laser-based intra-cavity QEPAS provides new ideas for the design of PAS systems.



Solid-state laser-based intra-cavity QEPAS detection.

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