Center for Advanced Diffusion-Wave and Photoacoustic Technologies-CADIPT
WM-DPTR Biosensors for Noninvasive Analyte Detections

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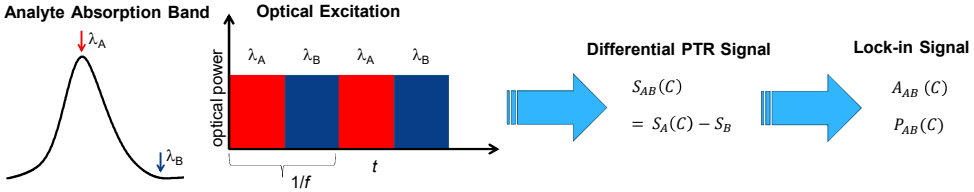
Introduction / Overview

WM-DPTR
Wavelength-Modulated Differential Photothermal Radiometry

Special features
Noninvasive and non-contacting, suitable for measuring minute absorptions of low-concentration solutes in strongly absorbing fluids like water and blood in the mid-infrared (MIR) spectral range.

Applications
Biosensors for: Blood glucose monitoring; Blood alcohol detection; Blood cannabis detection

Principle
Out-of-phase modulated laser-beam excitation at the peak and the baseline wavelengths of the target analyte absorption band, λ_A and λ_B. Real-time differential measurement (S_{AB}) subtracts background and generates two-channel signals, differential amplitude A_{AB} and phase P_{AB}, at the wavelength modulation frequency f, sensitive to the analyte concentration C



Methods/Experimental Approaches

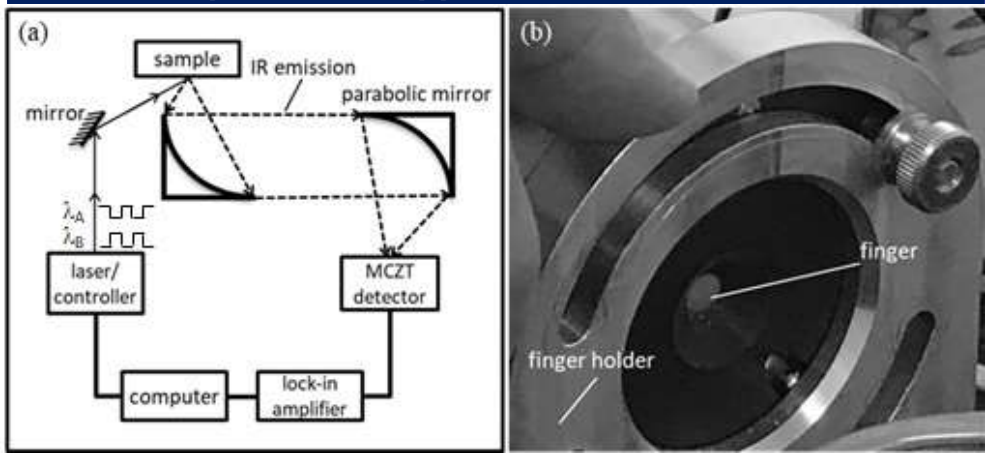
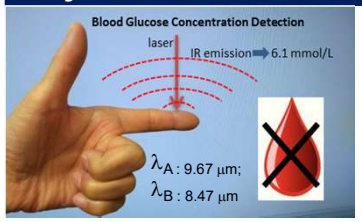


Fig. 1 WM-DPTR system. (a) schematic diagram of system setup: The modulated laser beams from two Quantum Cascade Lasers (QCLs) are steered to sample (finger) surface; the generated IR emission is collected by a MCZT detector through a pair of off-axis paraboloidal mirrors and then sent to a lock-in amplifier for demodulation; the amplitude and phase of the PTR signal are sent to a computer for further processing; (b) finger holder used for in-vivo measurements: a flat region of the finger back is exposed to the laser beam through a measurement window.

Major Outcomes/Results/Impact



Improving diabetes management

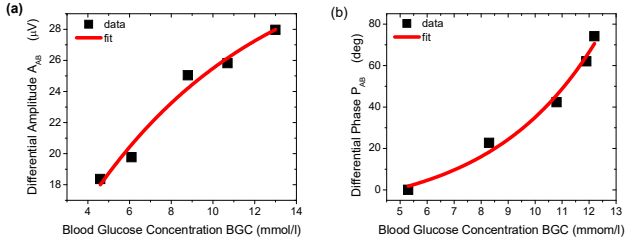
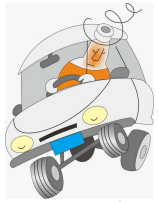


Fig. 2 WM-DPTR signal, A_{AB} (a) and P_{AB} (b) vs. blood glucose concentration BGC measured with a finger-breaking glucometer



Blood Alcohol Detection

λ_A : 9.56 μm;
λ_B : 9.77 μm

Preventing drunk driving

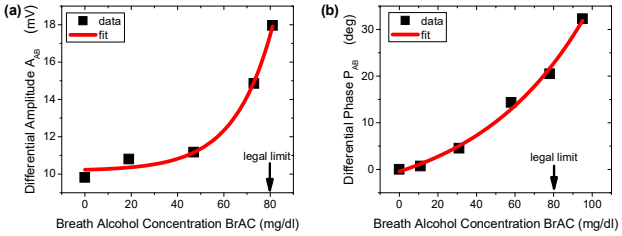


Fig. 3 WM-DPTR signal, A_{AB} (a) and P_{AB} (b) vs. alcohol concentration BrAC measured with a breath analyzer

The Future: Challenges & Opportunities

- *In-vivo* noninvasive WM-DPTR measurements were performed on fingers of volunteers in the MIR range to detect interstitial fluid glucose concentration, alcohol concentration and cannabis psychoactive component concentration.
- The measurement results demonstrated the feasibility of WM-DPTR for sensitive non-invasive glucose sensing, alcohol sensing and cannabis sensing, if they are tuned to the optimal absorption bands of the target analyte
- WM-DPTR equipped with a tunable laser can be developed as a stand-alone bioanalyzer roadside police inspection tool, in the work place, or in hospitals and clinics ("Method of performing wavelength modulated differential photothermal radiometry with high sensitivity", Inventors: Andreas Mandelis and Xinxin Guo, US patent 8,649,835 B2, issued February 11, 2014)
- The future work is to find cheap laser source, such as LED, to replace current expensive QCLs and develop wearable noninvasive devices

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