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Terahertz time-domain spectroscopy and micro-cavity components for probing samples: a review

Key words: Terahertz (THz) time-domain spectroscopy; Micro-cavity; Metal holes array; Waveguide cavities; Spoof localized surface plasmons (LSPs)

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Introduction

- Introduce two sample detection methods: terahertz time-domain spectroscopy (THz-TDS) system and micro-cavity components
- To overcome the disadvantage of THz-TDS and increase detection sensitivity, three typical high quality (Q) micro-cavity devices are investigated: subwavelength metal holes array, waveguide cavities, and whisper gallery (WG) mode based on spoof localized surface plasmons (LSPs).

Main idea

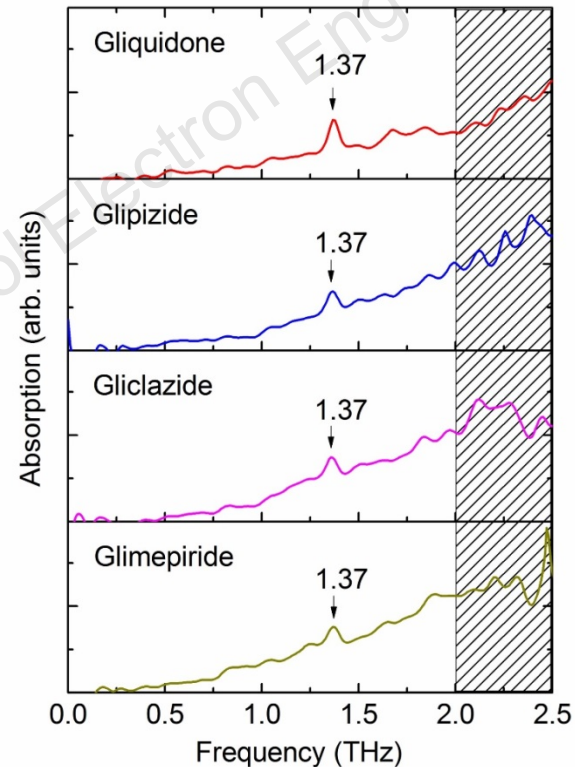
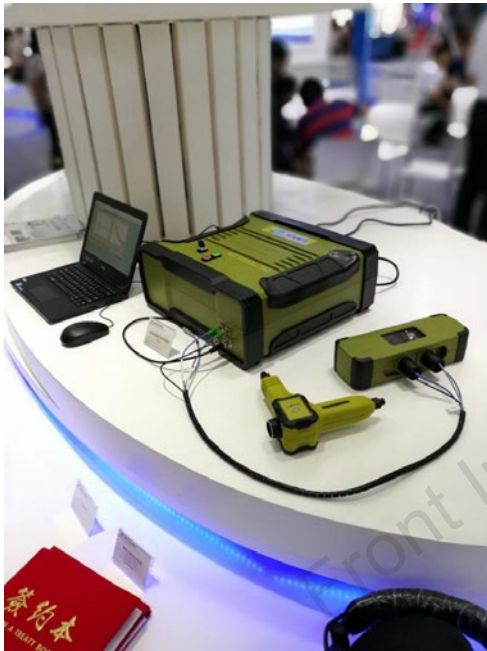
- Detect samples with broadband fiber TDS.
- Incident wave in metallic photonic crystal is sensitive to a change in the dielectric on the surface and can be implemented for THz sensing.
- Parallel plate waveguide (PPWG) cavities are suitable for flow monitoring.
- Whisper gallery mode micro-cavity induced by spoof localized surface plasmons can be more easily integrated compared with PPWG

Method

1. Using a fiber THz-TDS system to measure the fingerprints of samples
2. Through field localization enhancement, the sample is placed in a field enhanced area, such as a microcavity, to realize sample detection.

Major results (1/4)

- Fiber THz-TDS system can detect samples such as drug

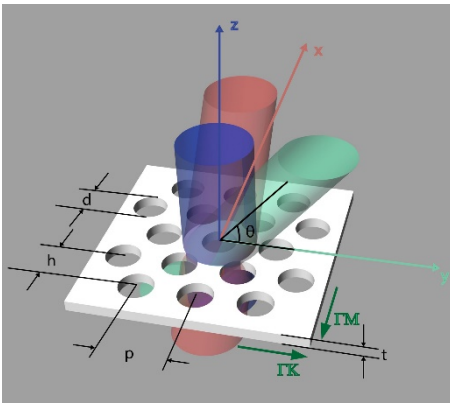


Main components to the fiber coupled time-domain spectrometer in operation

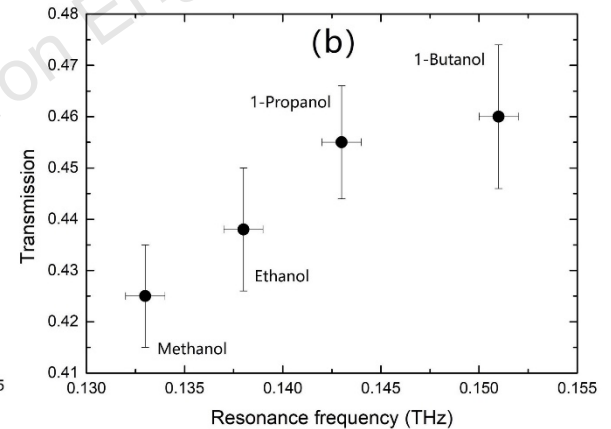
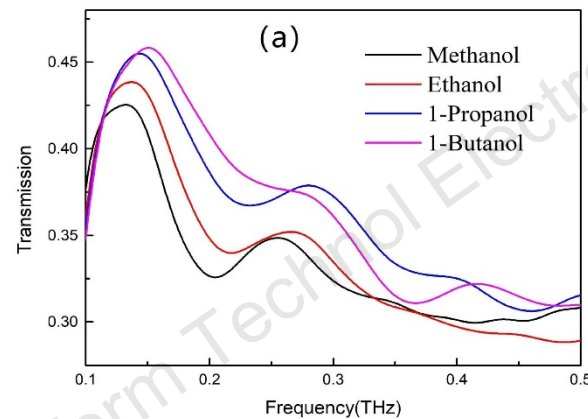
Experimental THz absorption spectra of gliquidone, glipizide, gliclazide, and glimepiride (Du et al., 2012)

Major results (2/4)

- Metallic photonic crystal for sample detection



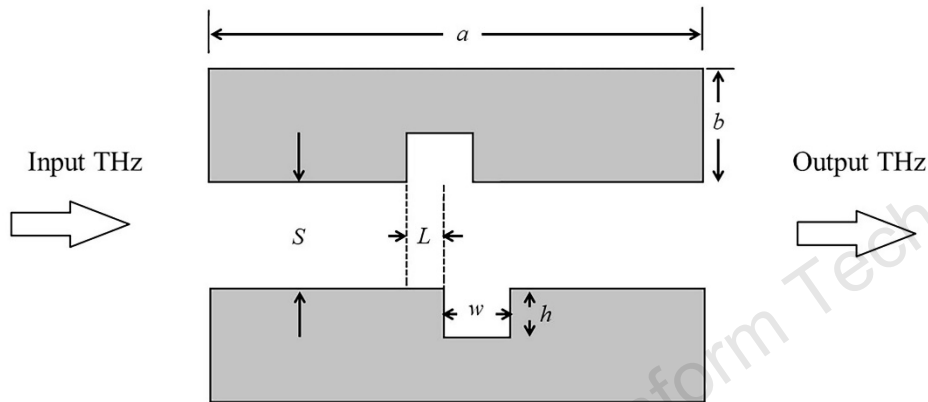
A photo of the aluminum PC plate



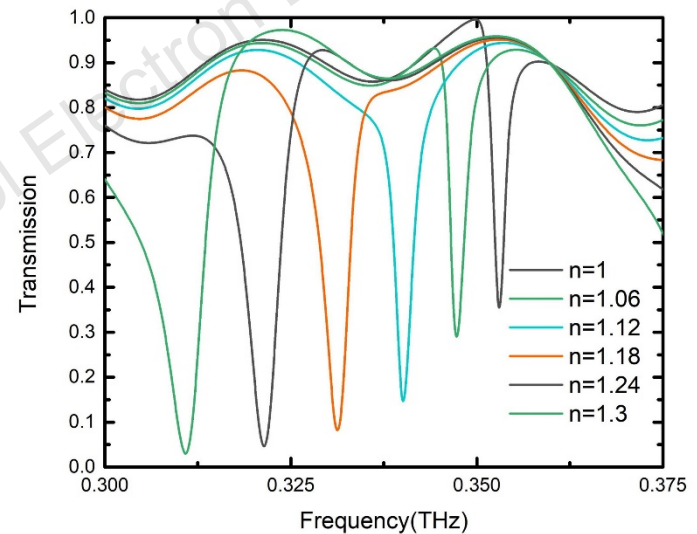
Measured transmission through metal holes array immersed in monohydric alcohols (a) and transmission and resonance frequencies of monohydric alcohols (b)

Major results (3/4)

- Parallel plate waveguide can work as a refractive index flow monitor



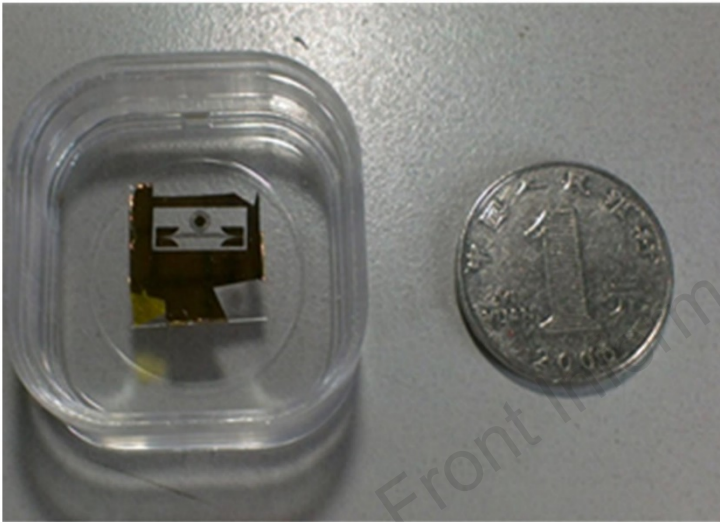
A general view of PPWG with two cavities



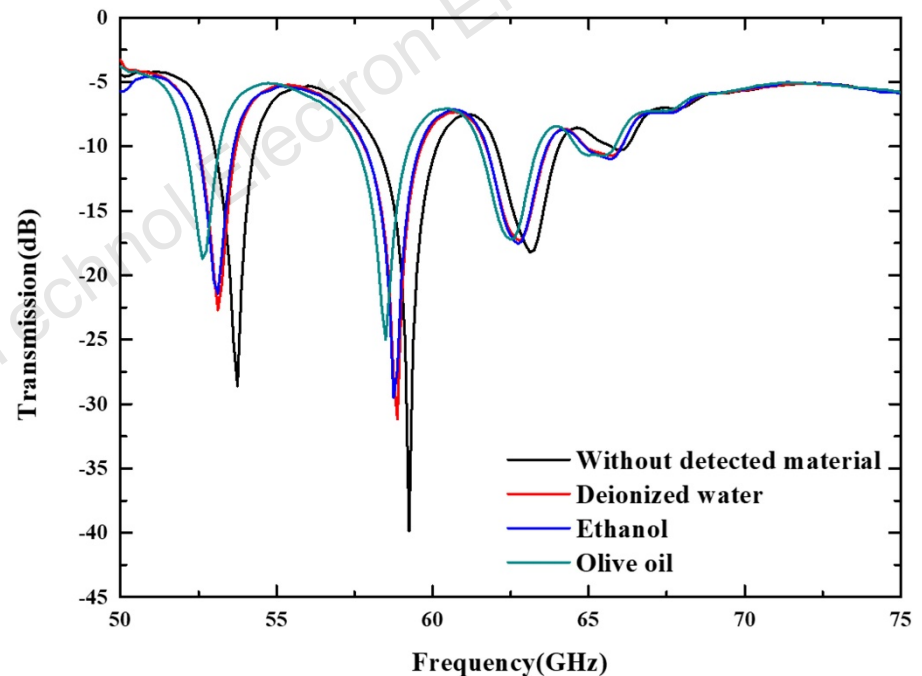
Transmission with different refractive indices for different frequencies around lower resonance dip

Major results (4/4)

- A tiny integrated chip like whisper gallery mode micro-cavity can realize sample detection



Picture under a microscope



Detection of different liquids in the corrugated disk groove

Summary

- The method of THz spectroscopy was used to generate wide frequency band THz wave for drug/cancer detection.
- Three general high Q micro-cavity components have been considered for tiny sample volume and for improving the signal-to-noise ratio (SNR) and enhancing sensitivity.