# S8-O2

# Development of a portable optoelectronic system for terahertz gas spectroscopy

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The terahertz (THz) band (0.1-10 THz) [1] enables high-resolution gas-phase spectroscopy because it coincides with rotational transitions of many polar molecules [2], allowing for precise “fingerprinting”. But current spectroscopic systems are often bulky, expensive and lab bound. To address portability need without losing sensitivity, this work focused on developing a portable optoelectronic spectroscopy system operating near 250 GHz.

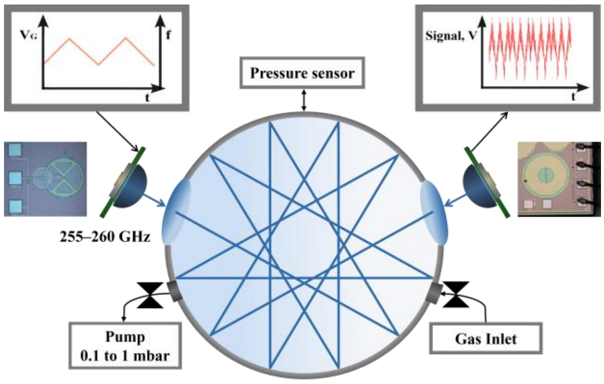


Fig. 1 Experimental spectroscopy setup employing CMOS-based emitter, detector, and a circular multipass gas cell.

The proposed system integrates a commercial complementary-metal-oxide-semiconductor (CMOS) based sub-THz emitter and a TeraFET (THz field-effect-transistor) detector (optopair) with a custom designed multipass gas cell (designed in collaboration with German Aerospace Center (DLR) and based on their design [3]). For optimal beam collimation and coupling into a cell, double-hyperbolic high-density polyethylene (HDPE) aspheric lenses (f=42 mm) were designed, and their focus was experimentally confirmed. The gas cell’s optical path length (OPL) was confirmed via frequency-modulated continuous wave (FMCW) radar technique to be 1.93 m (withing just ~1% of the 1.91 m from the theoretical model), while the cell had only 21.5 cm diameter. Proof-of-concept spectroscopy was conducted using methanol vapor at pressure from 0.1 to 1 mbar. The system successfully resolved multiple transmittance lines in the 255-260 GHz range, aligning well with the JPL spectroscopy database. At 1 mbar, the peak absorption coefficient was ~0.073 $m^{-1}$ for the strongest feature at 255.2 GHz. The system achieved a 600:1 signal-to-noise ratio (SNR) in a rapid 2 second single sweep.

These results successfully validate the feasibility of employing low-cost, room-temperature CMOS electronics with a circular multipass architecture for sensitive trace gas detection. This lays the basis for development of real-time, field-deployable THz gas systems for environmental monitoring, industrial safety, and non-invasive medical diagnostics.

## REFERENCES

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