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Non-Contact Vital Sensing: Investigating Biomedical Capabilities of Silicon Terahertz Technologies

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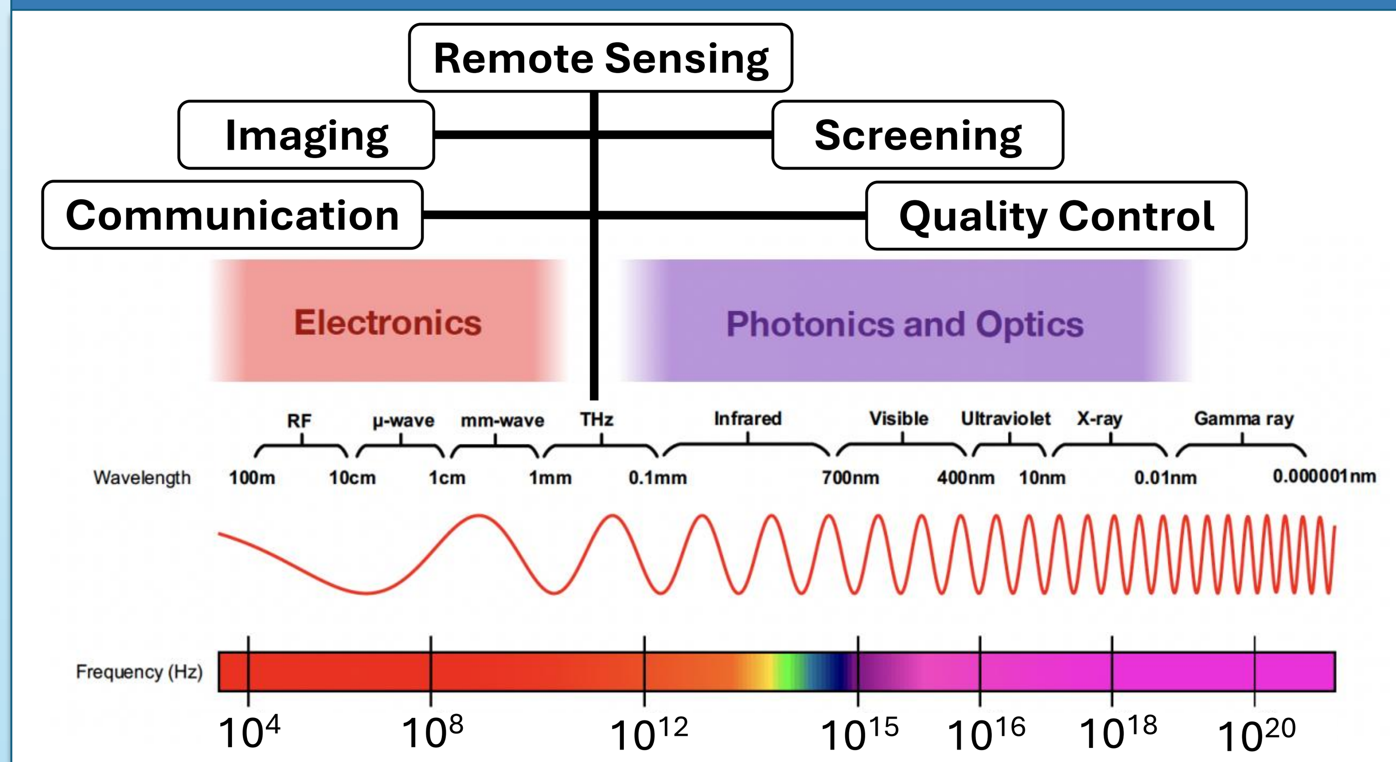
Introduction and Background



- Terahertz (THz) technology enables non-contact vital sign monitoring
- THz offers superior resolution & penetration through opaque materials compared to conventional methods
- Silicon THz is far cheaper & consumes less power because of extremely mature silicon technology
- **Objective:** Demonstrate the viability of the silicon THz technology for biomedical applications

Materials & Methods

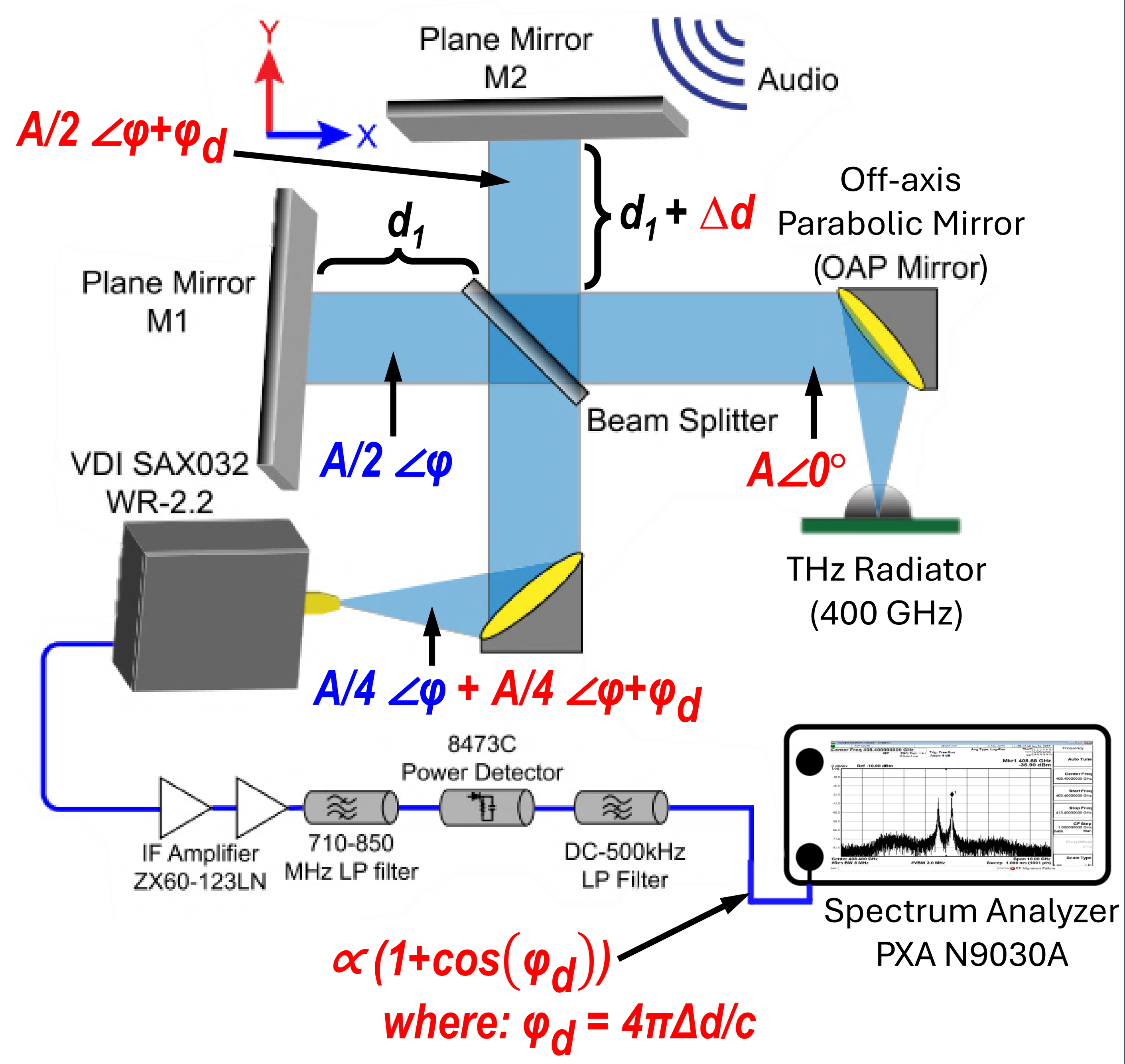


Fig. 1: Diagram of interferometry setup. THz signal is reflected off two plane mirrors and recombined to create the interference pattern, then filtered before being analyzed on the spectrum analyzer [1].

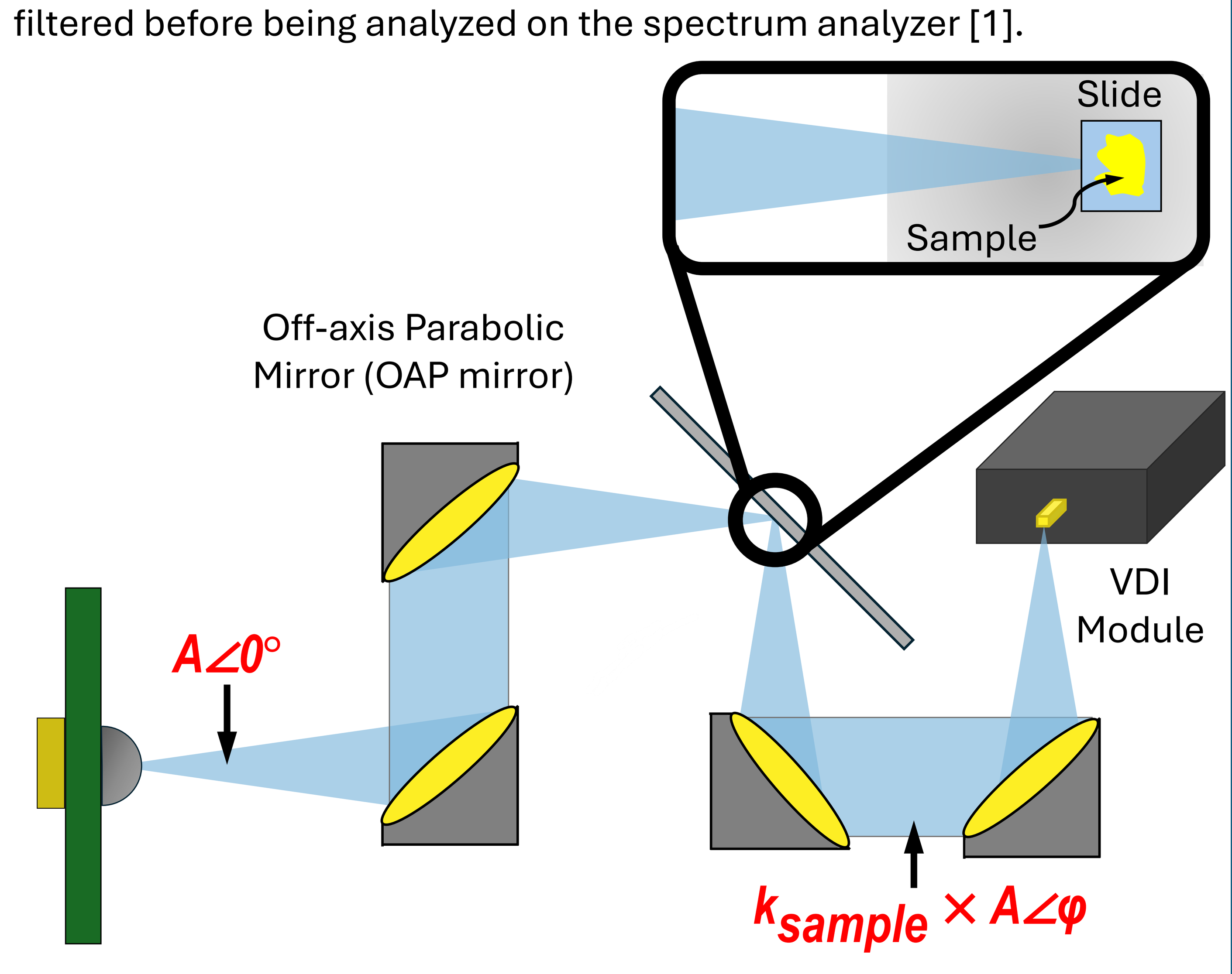


Fig. 2: Diagram of setup for biosample identification (reflectometry). A focused beam, operating at multiple frequencies around 400 GHz, illuminates the aqueous sample held within a stack of five slides. The reflected power is measured by the VDI module.

Vibration/Heartbeat Sensing (Vibrometry)

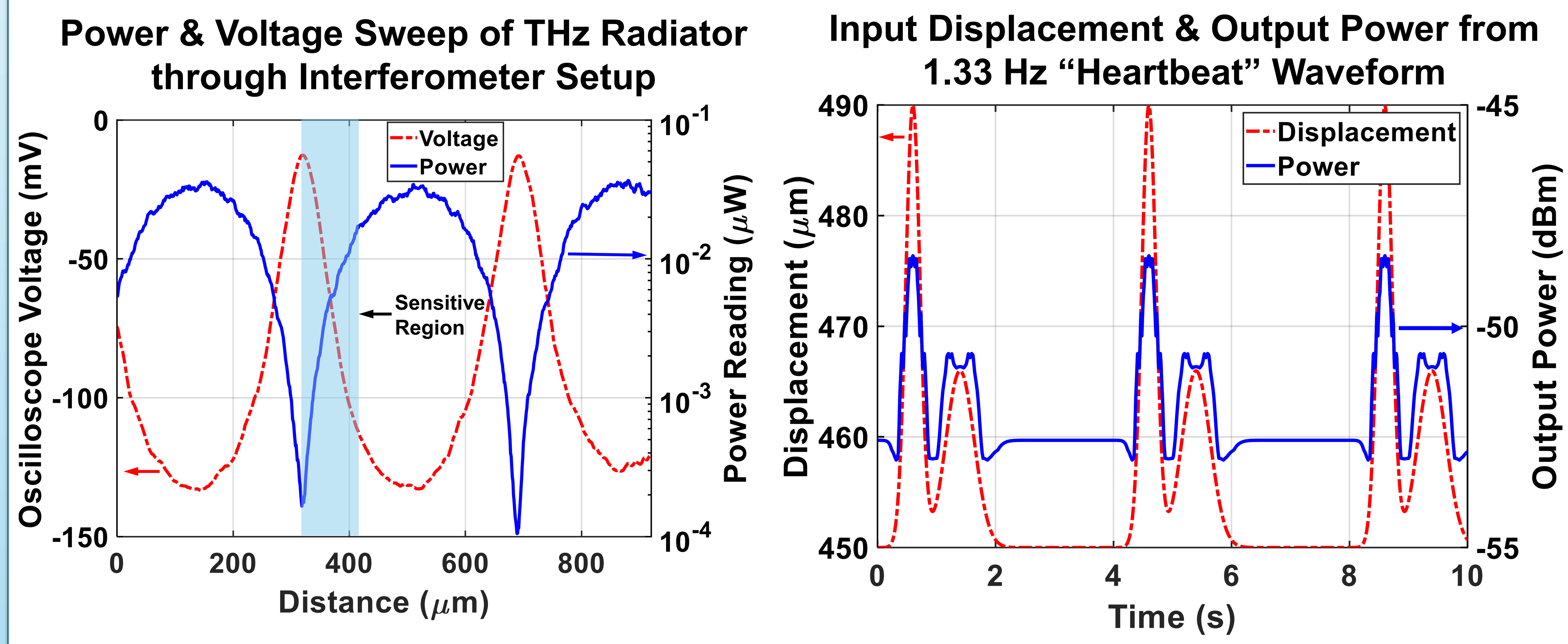


Fig. 3: (left) Behavior of measured power & voltage due to mirror displacement. (right) Time-domain power waveform of 1.33 Hz pulsed heartbeat signal recovered compared to input signal; the mirror to be vibrated was placed in the sensitive region.

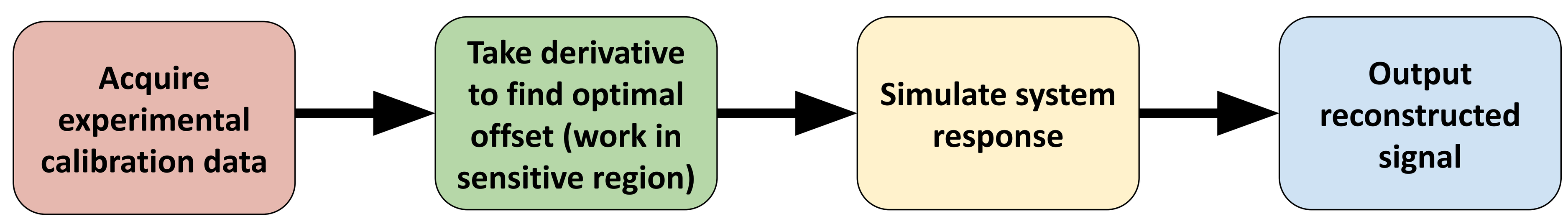


Fig. 4: Workflow of Simulation Using Experimental Calibration Curve Data

Material/Concentration Determination (Reflectometry)

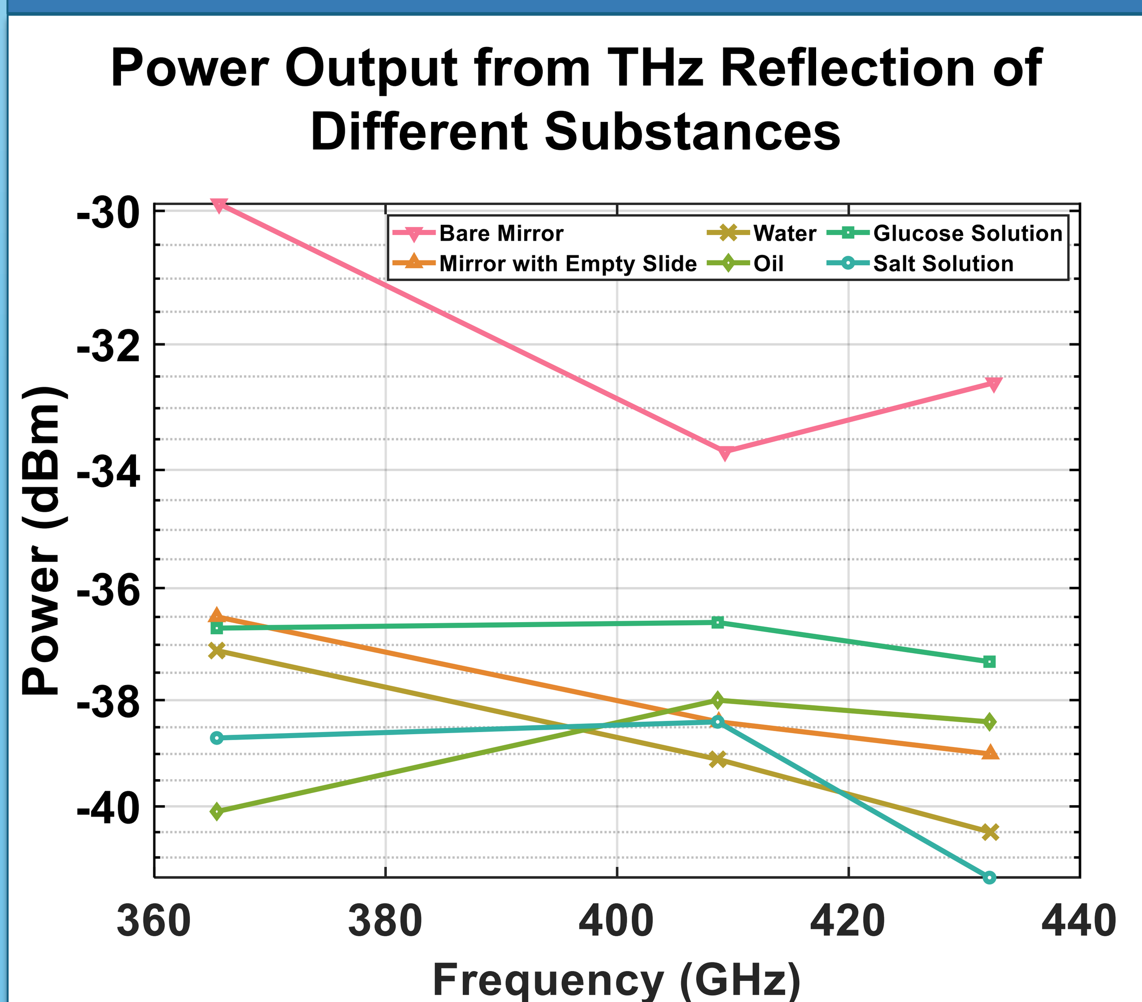


Fig. 5: Reflected power measurements from various substances measured at three frequencies. The system detects differences in power level allowing clear differentiation between some substances (especially at 432 GHz).

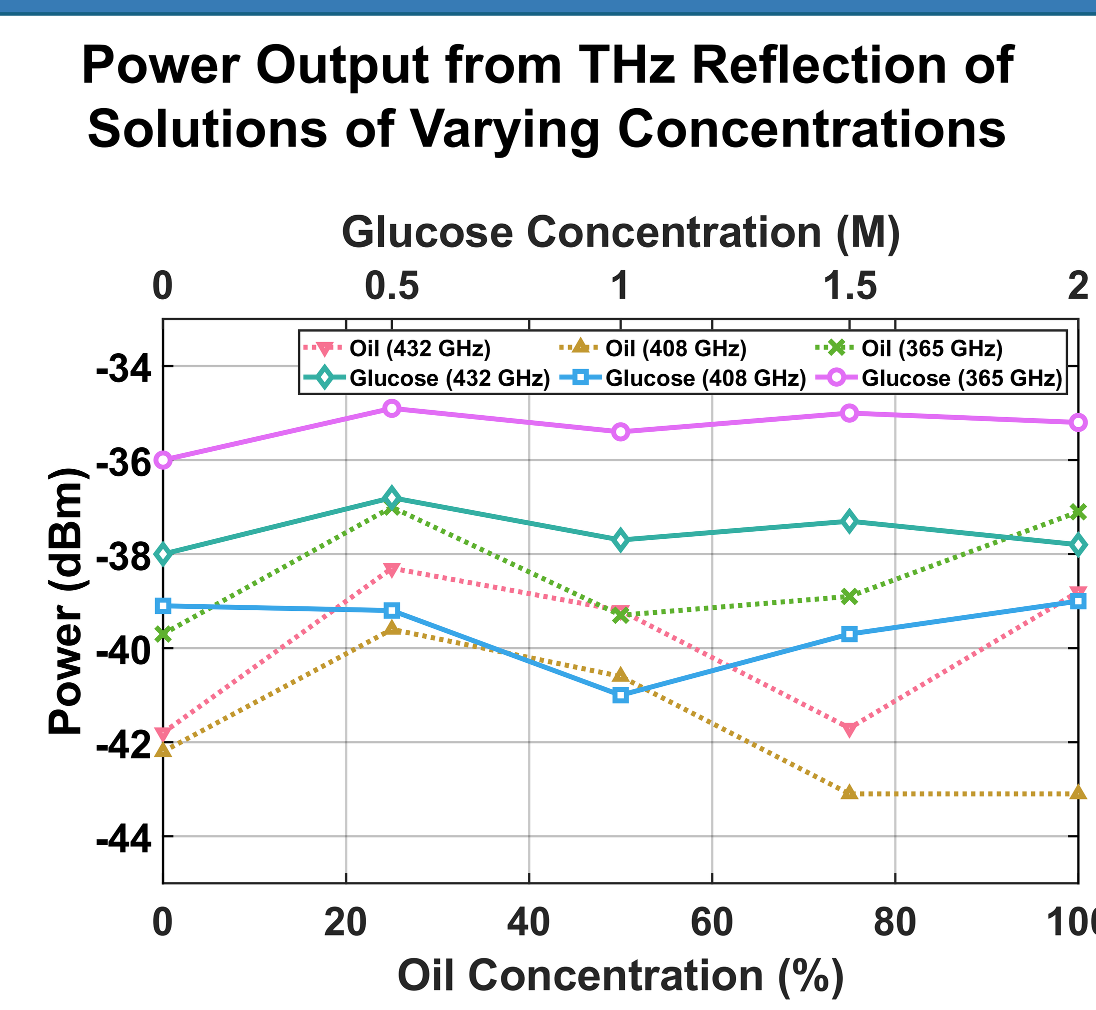


Fig. 6: Reflected power measurements for oil and glucose solutions. The system detects changes in oil concentration with a highly correlated pattern of peaks and troughs. For glucose, it identifies a unique absorption dip at 1M.

Conclusions & Future Work

- Demonstrated viability of THz band for vibration sensing at micrometer scale
- Successfully isolated concentrations of 1M glucose in solution
- Data for consistent concentration detection was inconclusive but spectral footprints seem promising
- **Challenges:** Beam alignment required high precision, weak signal, phase noise of free-running systems
- **Suggestions:** increase chip power, use of coherent (phase-locked) sources
- **Future Work:** in vitro and in vivo testing of vibration sensing and biosample identification

Acknowledgements

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References

[1] S. Razavian, S. Thomas, M. Hosseini and A. Babakhani, "Micro-Doppler Detection and Vibration Sensing Using Silicon-Based THz Radiators," in IEEE Sensors Journal, vol. 22, no. 14, pp. 14091-14101, 15 July15, 2022, doi: 10.1109/JSEN.2022.3183002.