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Photonic Bandgap Bragg Waveguide-based Terahertz Microfluidic Sensor

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Terahertz (THz) waves has been emerged as a promising tool for sensing due to its low photonic power and unique spectral fingerprints. In biological and chemical applications, the THz microfluidic sensing for tracking the characteristic change of liquid analyte in very small proportion is critical. In this work, we investigated a 3D printed THz photonic bandgap (PBG) Bragg waveguide-based sensor both theoretically and experimentally. Compared with the metamaterial-based sensors where the effect of slight variation in the thickness of the analyte affects the accuracy, the PBG Bragg waveguide-based sensor features high reliability and sensitivity.

The proposed PBG Bragg waveguide features a square-shaped hollow core with the side length of 4.5 mm and surrounded by a cladding region consisting of ten alternating bilayer sequences which act as Bragg gratings. Each period includes a high-RI layer and an air layer with thickness of 0.8 mm. The PBG Bragg waveguide is fabricated using fused deposition modeling (FDM) 3D printing technology in polylactide (PLA) with high structural stability and satisfied geometrical accuracy. The position of the liquid channel and the waveguide length are optimized to attain noticeable bandgap and anticrossing phenomenon in the measured transmission spectra for microfluidic sensing. Then, a continuous wave (CW) THz spectroscopic system is used to probe the response of a 10-cm long PBG Bragg waveguide (without defect) to the injected liquid analytes and the variations in the transmission amplitude and phase changes are recorded. To suppress the disturbance of the standing wave and instability in the laboratory environment, the measured spectra around the anticrossing frequency range are fitted into Lorentz and Boltzmann curves. A linear shift of these two kinds of frequency signatures with the increase of the RI of injected liquid analytes in the range between 1.465 and 1.545 was clearly observed from the fitted curves. Consistent with the theoretical results, the sensitivity of ~110 GHz/RIU is measured by tracking the shift of these anti-resonant features with increasing RI of analytes. Due to its low fabrication cost, capability of in-situ probing and high sensitivity, the proposed microfluidic microfluidic sensor opens new perspectives in application of chemical and biological fields.

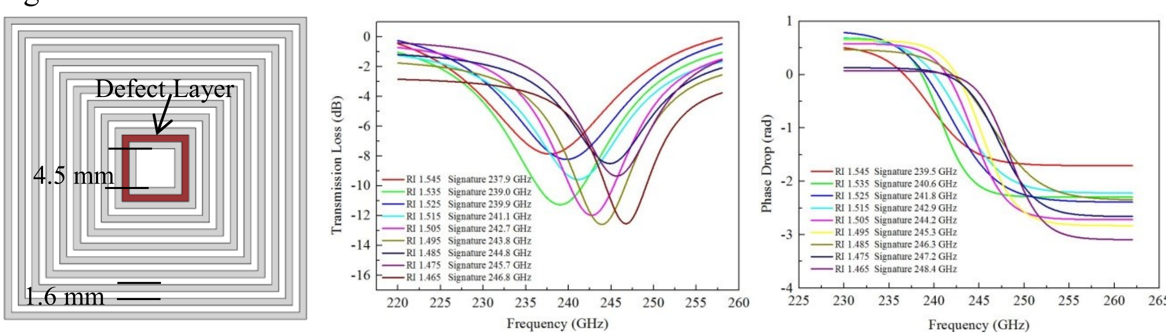

Fig. 1 Left panel: The cross section of the defected PBG Bragg waveguide; Middle panel: The fitted Lorentzian curves for the measured transmission dips corresponding to different-RIs analyte; Right panel: The fitted Boltzmann curves for the measured phase drops corresponding to different-RIs analyte.

References

[1] Y. Cao et al., “3D-printed Terahertz Photonic Bandgap Bragg fiber based resonant microfluidic sensor,” *arXiv preprint*, arXiv: 1810.05625.