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Performance of Bloch-like surface wave refractometers based on laterally polished photonic crystal fibers with single-layer coatings: From nanolayer to nanostrip

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INTRODUCTION

Bloch-like surface wave (BLSW) refractometers represent a promising alternative to surface plasmon resonance (SPR) sensors, offering comparable sensitivity but higher figures of merit. This study analyzes side-polished photonic crystal fibers (PCFs) coated with titanium dioxide (TiO_2), exploring how the transition from dielectric nanolayers to nanostrips influences sensor sensitivity, resonance sharpness, and overall performance.

METHOD

The sensor was designed using FIMMWAVE for modal analysis and FIMMPROP with eigenmode expansion for propagation. The structure is based on a commercial photonic crystal fiber (PCF) LMA-05, side-polished into a D-shaped configuration. A 31 nm titanium dioxide (TiO_2) coating was deposited on the polished surface and reduced into nanostrips of varying widths for comparison.

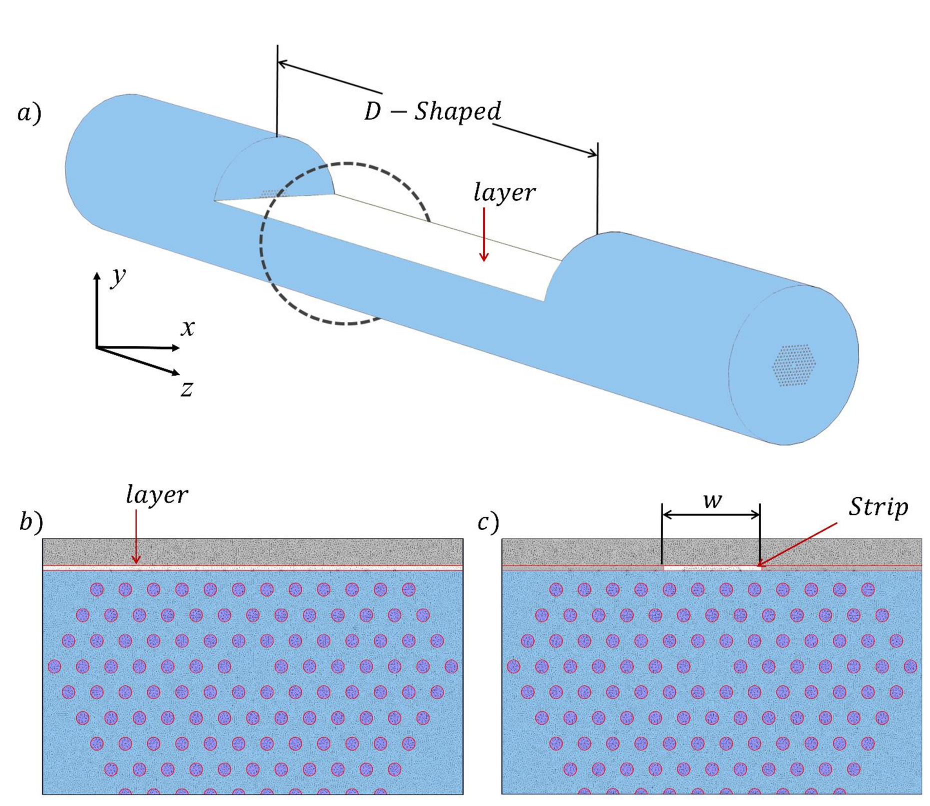

Figure 1. Configuration of the proposed sensor: (a) D-shaped structure; (b) cross section with the coating layer; (c) cross section with the nanostrip.

RESULTS & DISCUSSION

Transmission spectra demonstrate linear resonance shifts with external refractive index. This confirms the sensor's ability to detect subtle RI variations with high precision, validating its potential for refractometric sensing

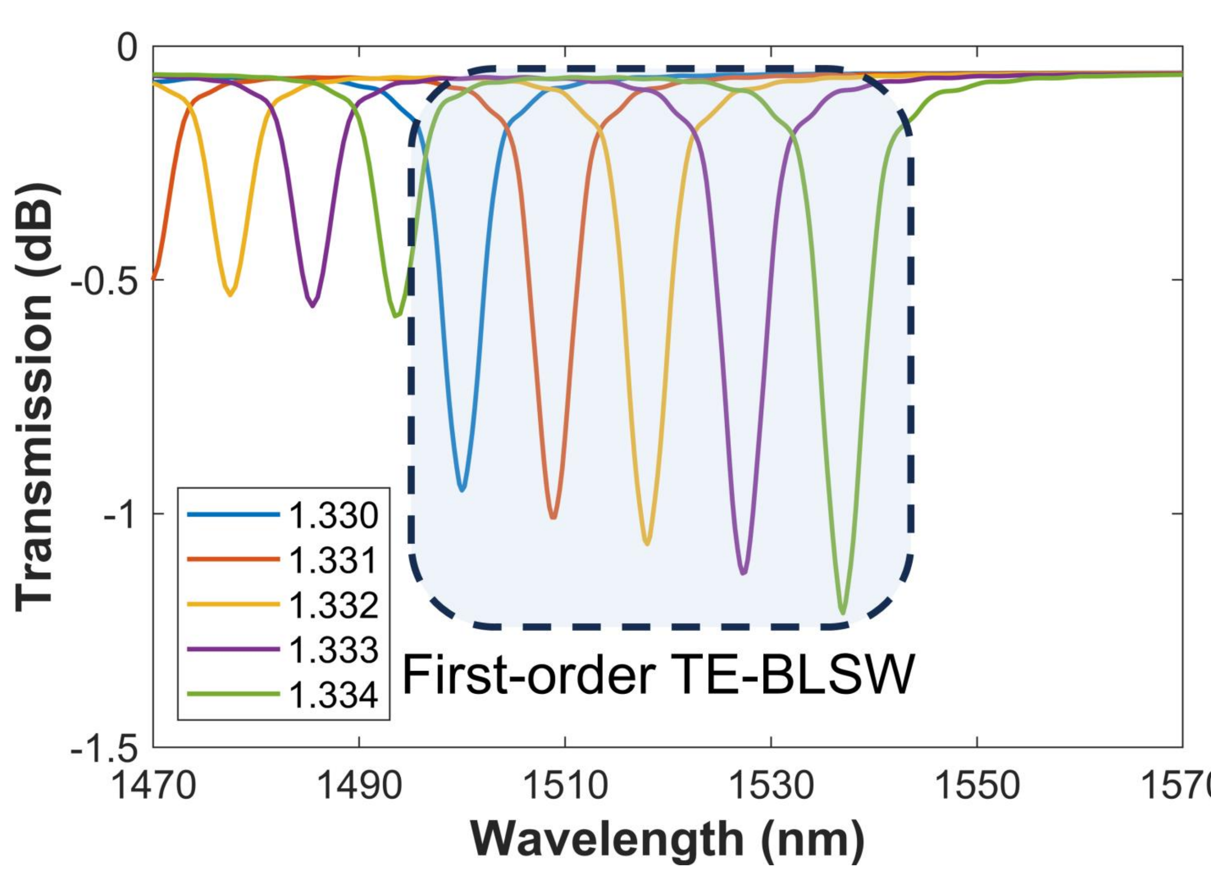

Figure 2. Refractometric response of the proposed sensing configuration with a 20 mm long D-shaped section for de TE-BLSW.

Varying TiO_2 nanostrip width reveals a trade-off: narrower strips reduce sensitivity but sharpen peaks. Geometry strongly influences sensor performance and must be optimized for balanced refractometric operation

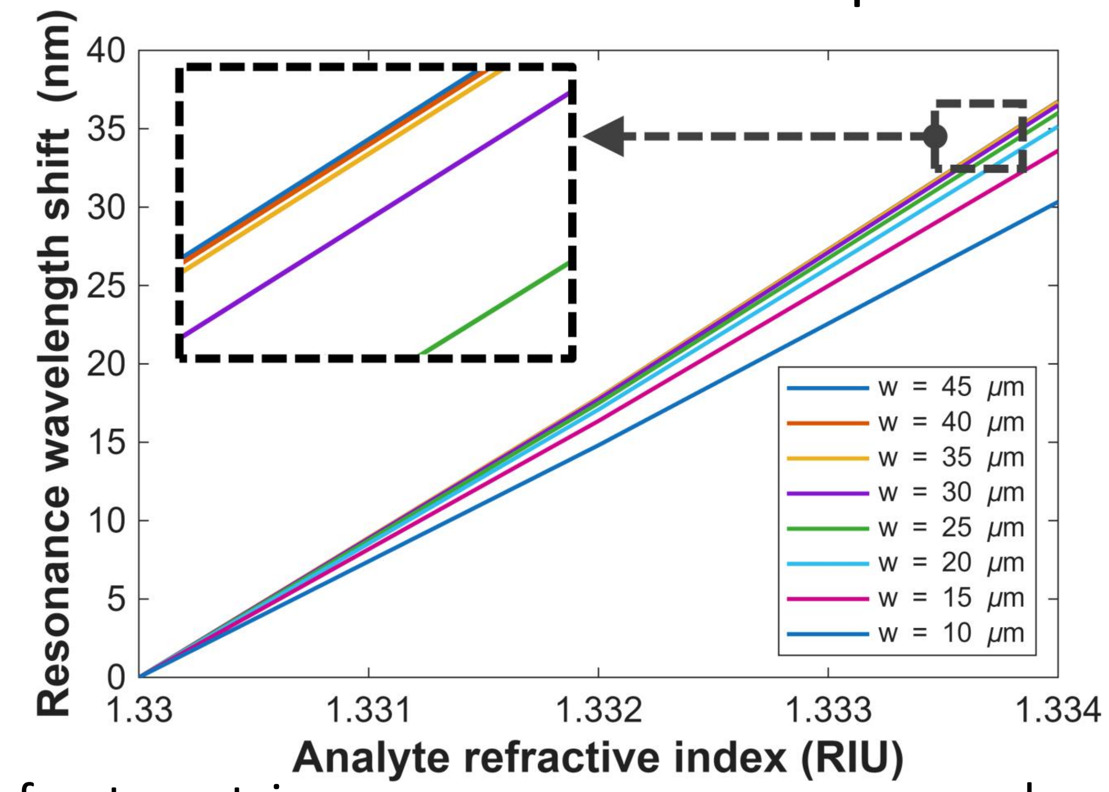

Figure 3. Refractometric response: resonance wavelength shift as a function of analyte refractive index.

Reducing nanostrip width narrows resonance peaks, lowering the full width at half maximum (FWHM) and increasing the figure of merit (FOM). Stronger lateral confinement also deepens resonances, further improving spectral distinction. As a result, the relative figure of merit (RFOM) grows. However, for widths below 15 μm, reduced evanescent interaction limits resonance depth, causing RFOM stagnation and defining practical optimization boundaries.

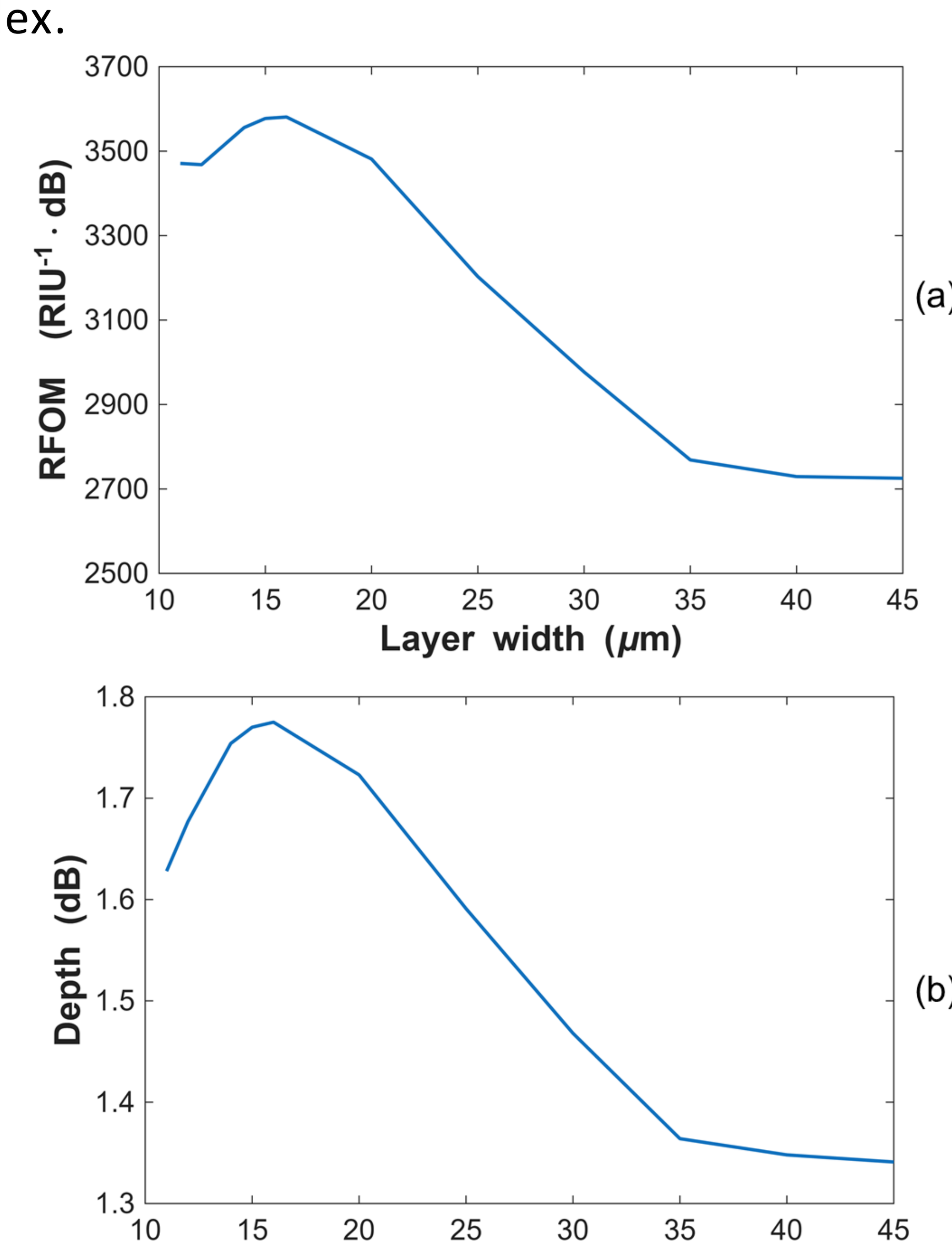

Figure 5. Refractometric analysis of the D-shaped sensor: (a) Resonance depth; (b) RFOM.

CONCLUSION

BLSW refractometers in PCFs show high sensitivity and ultra-high FOM. Proper geometric optimization achieves balanced performance, enabling compact devices with reliable detection capabilities for biosensing and refractive index measurement applications

REFERENCES

[1] Gonzalez-Valencia, E.; Reyes-Vera, E.; Del Villar, I.; Torres, P. Side-Polished Photonic Crystal Fiber Sensor with Ultra-High Figure of Merit Based on Bloch-like Surface Wave Resonance. Opt Laser Technol 2024, 169, 110129, doi:10.1016/j.optlastec.2023.110129.