# Optical bio and chemical sensor in a one-dimensional photonic structure with bound states in the continuum

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## Introduction

- Bound states in a continuum (BIC) can be considered as a resonant mode with an infinite quality factor Q in an open system.
- When the symmetry of the structure is broken or the diffraction channel is opened, BICs transform into quasi-BICs.
- The refractive index (RI) contrast between substrate and superstrate breaks the flip symmetry and transforms the off-Γ BIC into a resonant state with a finite, but high, Q factor [1], which makes it possible to design sensors with high sensitivity [2].
- Most of the works are devoted to structures that support only in-BIC, which appear at normal incidence of beam. In our research, we investigate the resonance shift of off-Γ BIC depending on the RI contrast between substrate and superstrate in a dielectric grating and calculate the sensitivity and FOM of the sensor.

## Methods

- Optical response of the sensor was calculated by Fourier Modal Method [3].
- The field profile was obtained on the COMSOL Multiphysics Software[4].
- Sensitivity was calculated by the resonance shift $\Delta\lambda$ and change on refractive index of analyte $\Delta n_a$ as

$$S = \frac{\Delta\lambda}{\Delta n_a}$$

- Figure of merit (FOM) was found by following expression:

$$FOM = \frac{S}{\delta\lambda},$$

where $\delta\lambda$ is resonance width [1].

## Results

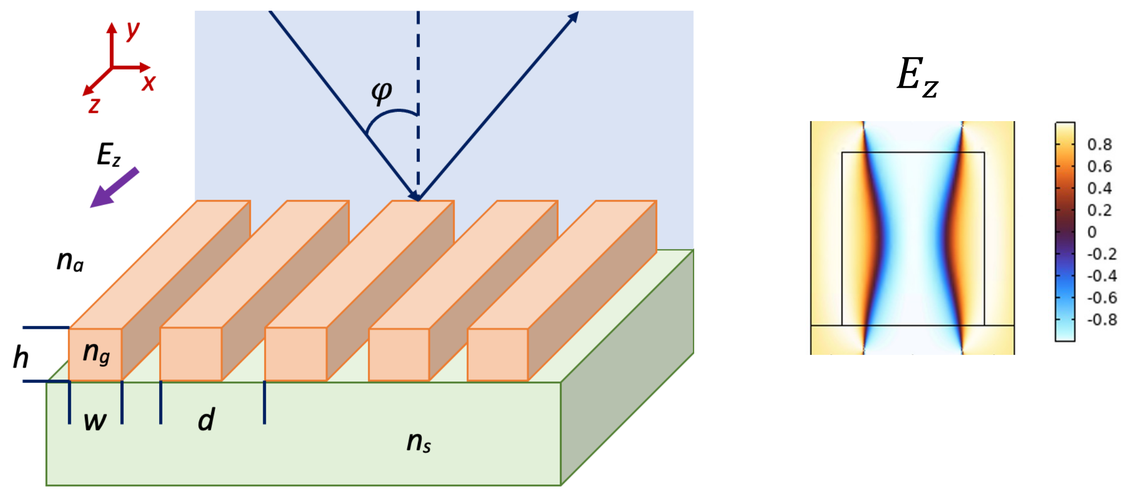


**Fig.1.** Illustration of the sensor with $d$=0.5μm, $w$=0.35μm, $h$=0.425μm and $n_g$=3.17,which is located on a substrate with $n_s$=1.75 and normalized $E_z$ of the BIC

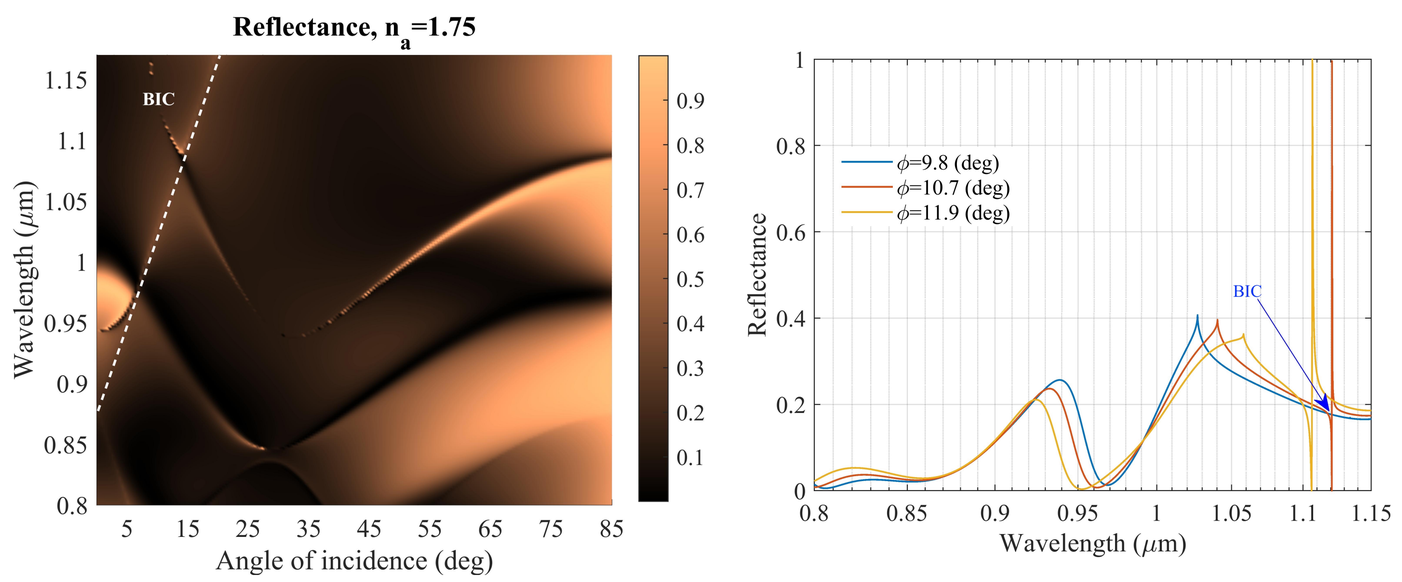


**Fig.2.** Dependence of reflectance on incident angle and the wavelength and its spectrum in the vicinity of the BIC

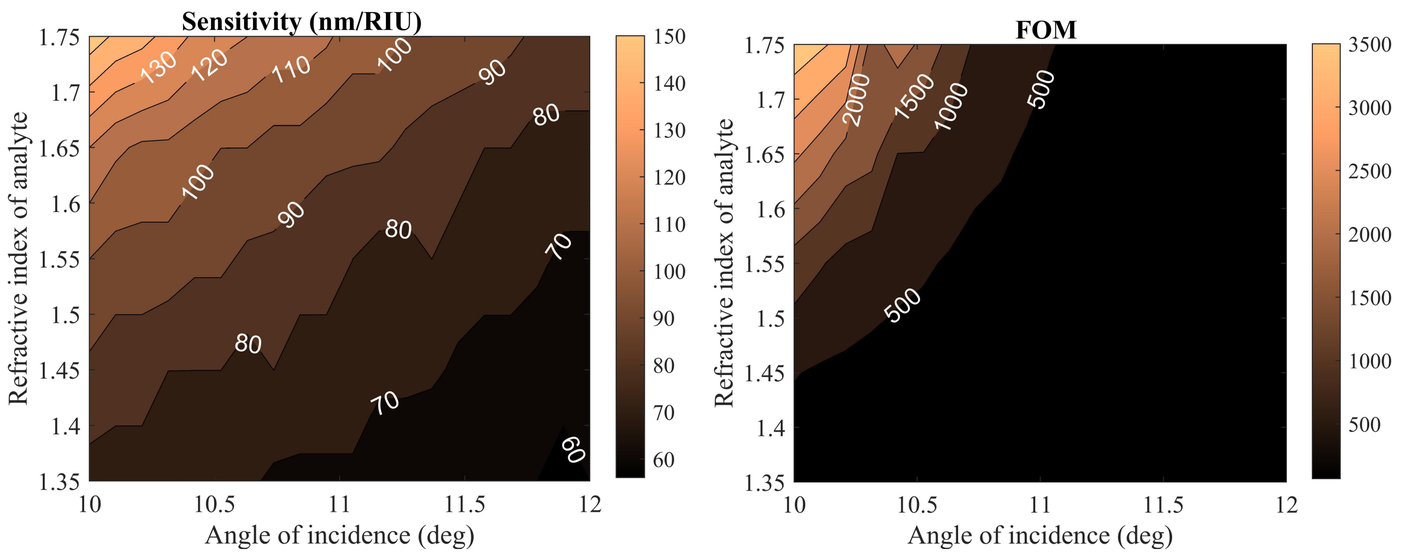


**Fig.3.** Sensitivity and FOM of the sensor in the vicinity of the BIC

## Conclusion

In this research, we considered a one-dimensional photonic structure that supports BIC out the Γ point. We found that:

1. The sensitivity for off-Γ BIC is 150 nm/RIU, while the FOM value reaches 3500 (Fig.3), which is higher than 135 nm/RIU (for in- BIC, 1.75 [2]) and $10^3$ [1] . Moreover, based on the review of the literature, we did not find a study that involved on the applicability off-Γ BIC in sensors.
2. The maximum sensitivity, which can be found as $S = {}^{\lambda_{BIC}}/_{n_a}$ and for $n_a = 1.75$ is equal to 650 nm/RIU. One way to achieve maximum sensitivity is to increase the refractive index of the analyte relative to the refractive index of the substrate [2]. Moreover, the narrow Fano resonances that occur in the vicinity of BIC make it possible to detect a small change in the refractive index in biological or chemical environment.

## Acknowledgments

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## References

[1] https://doi.org/10.1364/OE.411749
[2] https://doi.org/10.1103/PhysRevA.105.033518
[3] https://github.com/aashcher
[4] https://www.comsol.com/