High Q-factor all-dielectric metasurface for refractive index sensing

O. McCormack[1,2], J. Dobie[1,2], X. Zhang[1], A. L. Bradley[1,2]

[1]*School of Physics and AMBER, Trinity College Dublin, College Green, Dublin 2, Ireland*
[2]*IPIC, Tyndall National Institute, Cork, T12 R5CP, Ireland*

mccormoi@tcd.ie

Though plasmonic metasurfaces have been at the forefront of research as a platform for sensors due to their high field enhancements, they historically suffer from low Q-factors, high ohmic losses and reduced specificity [1]. All-dielectric metasurfaces are an alternative low ohmic loss platform which also exhibit greater manipulation of light, along with increased possibilities for multiplexing [2].

To achieve both high Q-factors and external E-field enhancement, our structure employs the use of quasi-bound states in the continuum (q-BIC). These sharp resonances can be manufactured in all-dielectric metasurfaces by introducing a small degree of asymmetry to the nanogeometry [3].

Based on initial designs in air [4], our novel design for an all-dielectric nanoresonator with q-BIC resonances has been adapted to use Si_3N_4 and transferred onto a fused silica substrate, creating a metasurface with high transmission in the visible and near-IR spectra. Water was used as an appropriate bulk sensing medium. This results in a practical design which produces high Q-factor and E-field enhancement external to the structure. With a slot width of 45 nm, simulations provide a Q-factor of up to 1.4×10^5, bulk sensitivity of 135 nm/RIU, and figure-of-merit (FOM) of >20,000. The design has been found to have very good tunability while maintaining the qBIC resonance trough a range of wavelengths in the visible/near-IR. The fabrication and characterization of this design in Si3N4 has been carried out and the experimental results and comparisons with simulations are presented.

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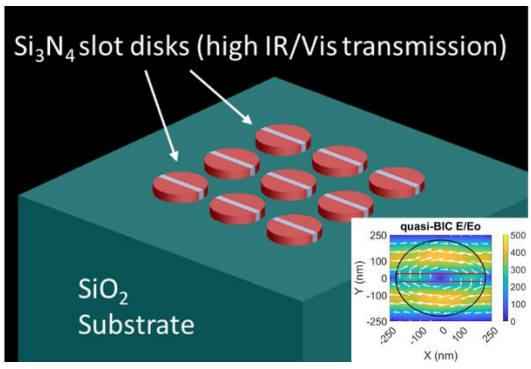

Figure 1. Metasurface materials and slotted nanodisk array design, with E-field enhancement mode, E/E_0 of up to 450, shown relative to the resonator (inset).

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