

2D photonic nanojet via Bloch surface wave: limitations and beyond

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Microstructures, e.g., microspheres, can generate a highly confined beam propagating over several wavelengths while maintaining a sub- λ beam size. It is a well-known nonresonant phenomenon that appears for a wide range of diameters of microspheres, from approximately 2λ to 40λ . Chen *et al.* first reported this phenomenon and named it *photonic nanojet* (PNJ) in 2004 [1]. Recently, the PNJ generation has been demonstrated using non-circular geometries in 3D like micro-pyramids and rectangular pillars, and it has been also applied to 2D surface waves *via* surface plasmon polariton (SPP) [2]. In this study, we propose a new host of PNJs in 2D surface wave implementation. Bloch surface wave (BSW) is a dielectric analogue of SPPs, which is an electromagnetic surface wave excited at the interface between a truncated periodic dielectric multilayer and a surrounding medium. Dielectric materials assures low optical loss and longer propagation of BSWs, reported, but not limited, up to 2.5 mm [3]. In addition, design flexibility of the 2D system allows arbitrary shapes of optical elements, which is advantageous compared to the constraints in 3D micro-fabrication.

The schematic of the BSW platform with elements under study is shown in Fig 1(a). The operation wavelength is $1.55 \mu\text{m}$. By chemical vapor deposition, six periods of Si_3N_4 ($n_1 = 1.79$) and SiO_2 ($n_2 = 1.45$) are alternately deposited on a glass substrate. For the top layer, an additional 50-nm-thick layer of Si_3N_4 is deposited. On the top of the platform, 60-nm-thick TiO_2 ($n_s = 2.23$) is additionally patterned for the element structures, the fabrication details are reported elsewhere [3]. Numerical studies are carried out using a commercial FDTD tool (CST microwave studio). We employ scanning near-field optical microscopy (SNOM) for experimental verifications. When the BSW illuminates a TiO_2 microdisk, as the scenario shown in Fig. 1(b), the expected PNJ does not arise. The reason is that the effective refractive index contrast is too low, i.e., $\Delta n = 0.15$ [3]. The goal of our study is to surmount this limitation by shape changes, and to obtain a tightly confined beam like PNJs. Avoiding too complex structures, we vary the element shape, e.g., ellipse, rhombus, and triangle. Among them, the isosceles triangle of base = $10 \mu\text{m}$ and altitude = $14 \mu\text{m}$, shown in Fig. 1(d), leads to the smallest spot, whose FWHM size reaches 0.62λ . In the conference, we will present beam properties depending on shape changes and corresponding experimental results measured by SNOM.

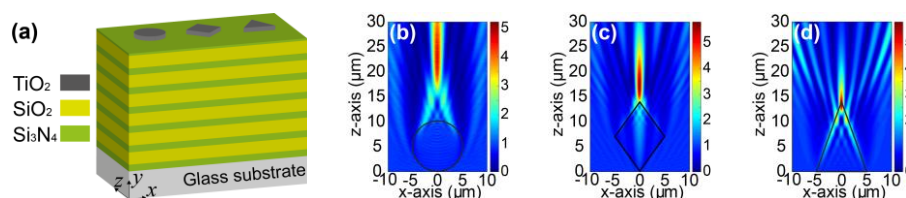


Fig. 1: (a) Schematic of BSW platform with investigated TiO_2 elements. FDTD simulation results for the intensity distributions: (b) a microdisk of diameter = $10 \mu\text{m}$, (c) a rhombus of diagonals of $10 \mu\text{m}$ and $14 \mu\text{m}$, and (d) an isosceles triangle of base = $10 \mu\text{m}$ and altitude = $14 \mu\text{m}$.

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