A Si-based photonic syringe

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Research into trapping and manipulation of particles by propagating electromagnetic fields has been active for almost four decades and has led to a large number of applications particularly in microfluidics, biology and medicine. More recently, particle trapping and propulsion by evanescent electromagnetic fields has also been achieved.

In this work, I suggest a design of a multimode coupled slot waveguide, which supports backward (i.e., toward the source) propagating modes with substantial evanescent fields (figure 1). The core idea is to obtain non-stationary field distribution by reflecting light in different waveguide modes. Selective coupling between modes is achieved or suppressed, according to controllable selection rules in photonic structures, based on mode symmetry. These selection rules are derived by exploiting an analogy with the tight-binding method for electronic wave functions in crystals.

The direction of propagation can be flipped by changing the mode of injection. Propulsion of particles can be therefore also inverted in direction. To this goal, a mode-switching filter is proposed, which allows the switching between forward and backward direction of radiation pressure. This filter can be integrated with the back-reflecting structure in a straightforward way. I dubbed this system a "photonic syringe" [1] because it could be potentially used to push and pull particles inside empty slots, acting as "needles".

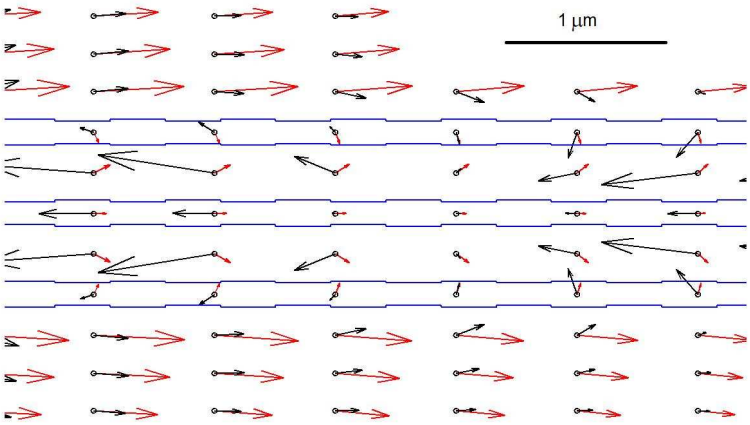

Fig. 1. 2D FDTD simulation of Poynting vector of the "photonic syringe". Light injection is from the left side. Excitation is narrowband (vacuum wavelength $\lambda_0 \approx 1.5$ μm). Map is to scale. Only a few periods are shown, in proximity of the input side. Red (black) arrows show the result without (with) corrugation. The blue lines are the outline of the structure with corrugation. While the energy in the outer side of the waveguide is always traveling forward (top and bottom of figure), in the slots (i.e. in the 2 regions between the slabs), the component along the waveguide axis is dominantly forward (backward) in absence (presence) of the corrugation.

Reference

[1] Z. Gaburro, "A design for a photonic syringe with multimode coupled slot waveguides," *Optics Express*, accepted for publication.