Resonator chains of 2-D square dielectric optical microcavities

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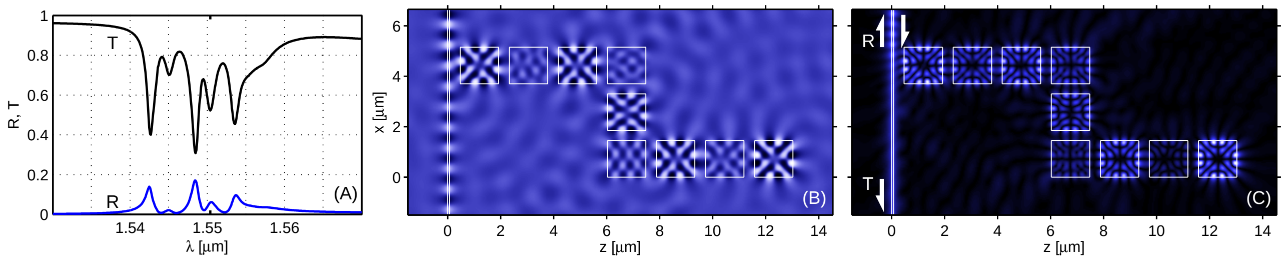
Chains of coupled square dielectric cavities are investigated. Resonant transfer of optical power can be achieved along quite arbitrary, moderately long rectangular paths, even with individual standing-wave resonators of limited quality. We introduce an ab-initio coupled mode model that helps to interprete the numerical results.

Summary

Coupled-resonator optical waveguides (CROWs) have been discussed already for some years [1] as a means to realize waveguiding along paths with small-size bends. Concepts based on series of microring resonators or sequences of defects in photonic crystal slabs [2] exist. As an alternative, in this contribution we consider chains of simple square dielectric cavities, that support a single specific standing wave resonance in the wavelength region of interest. In line with the fourfold symmetry of their resonant field pattern, the individual cavities are arranged sequentially on a discrete rectangular mesh, with guided-wave excitation at one end of the chain. The figure shows an example. Rigorous semianalytical simulations based on quadridirectional eigenmode propagation (QUEP) [3] enable convenient numerical experiments on these rectangular, piecewise constant configurations.

As some step towards an interpretation of the spectral features we look at an intuitive coupled mode theory (CMT) model for the resonator chains. The overall field in the chain is assumed to consist of bidirectional versions of the guided mode of the bus core, with variable local amplitudes, together with the identical, properly positioned resonant field patterns of the individual cavities, each multiplied by a single scalar coefficient. These latter fields can be approximated quite well by a superposition of suitable slab mode profiles, oriented along the two coordinate axes [4]. Then one proceeds along the hybrid CMT approach of Ref. [5]: By variational means one extracts a linear system of equations for the coefficients of the resonator fields, and for the amplitude functions of the bus modes, discretized in terms of finite elements, as unknowns. Note that no free parameters are introduced; the model, however, disregards any radiative losses (so far), and thus cannot be more than an approximation of the resonator chain in a kind of high-Q limit.



A chain of square microresonators, 2D-TE QUEP simulations [3] for a double bend configuration with refractive indices 1.45 *(background) and* 3.4 *(bus core, cavities), waveguide core width* $0.073\,\mu$m*, cavity width and height* $1.451\,\mu$m*, gaps* $0.4\,\mu$m*. Spectral guided-wave transmission and reflection (A); for vacuum wavelength* $\lambda = 1.5504\,\mu$m*: time snapshot of the physical principal electric field* E_y *(B), and field modulus* $|E_y|$ *(C).*

References

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