Lossless optical microstrip filters for semi-guided waves at oblique incidence

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A lossless add-drop filter can be realized by evanescently exciting optical microstrip-cavities with a semi-guided wave at oblique angles of incidence. At specific resonance angles, the incoming power is either equally split among all output ports (single cavity) or completely forward dropped to a single port (two cavities).

Single resonator cavity

We investigate optical microresonators consisting of either one or two rectangular microstrip-cavities between upper and lower slab waveguides, separated by a gap g (Fig. 1 (b)). The incoming semi-guided wave of the lower slab waveguide excites the structure at an oblique incidence angle θ (Fig. 1 (a)). Losses are fully suppressed beyond a certain incidence angle [1, 2].

First we examine a microresonator consisting of a single micro-cavity. At a specific incidence angle θ_r, at resonance, the cavity-mode is evanescently excited by the incoming slab mode. The input power is then equally split among each of the four output ports leading to 25% output power at each port (Fig. 1(c)). This resonance angle can be predicted by wavenumber matching of the incoming oblique slab mode and the cavity mode.

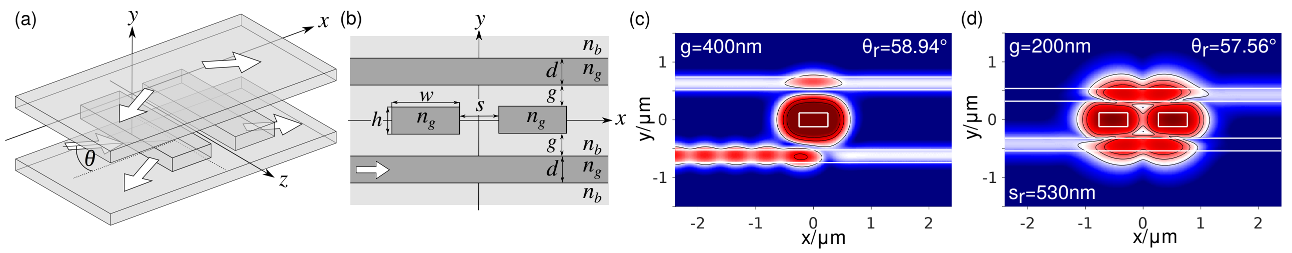

Fig. 1. Oblique excitation of a micro-cavity: 3-D sketch (a), cross section view (b) and field plots of $|E|$ at resonance for one (a) or two (b) cavities with waveguide parameters $n_g = 3.45$, $n_b = 1.45$, $d = h = 0.22\mu m$, $w = 0.5\mu m$, variable gap g and separation s.

Add-drop filter

An add-drop filter can be realized [3] by considering two identical cavities separated by a horizontal distance s (Fig. 1 (b)). For small separations s two cavity modes with even and odd symmetry exist. By exciting the structure at resonance angle θ_r and separation s_r, the modes become degenerate and are excited simultaneously. This leads to full power drop to the forward upper port due to interference in the slabs (Fig. 1 (d)). For increasing cavity distance the system becomes decoupled. Hence, the cavities must be treated as two separate systems, that do not directly influence each other. By exciting the structure under the resonance angle for a single cavity, the mode in each cavity is excited. These modes couple back into the slabs, where the fields interfere. Again, this configuration is also able to route all input power to the forward drop port for specific, large cavity distances s_r. We show that this behavior can also be understood in terms of a semi-analytical model.

References

[1] M. Hammer, L. Ebers, and J. Förstner, Opt. Express **27**, 9313 (2019)
[2] L. Ebers, M. Hammer, M. B. Berkemeier, A. Menzel, and J. Förstner, OSA Continuum **2**, 3288 (2019)
[3] C. Manolatou, M. J. Khan, S. Fan, P. R. Villeneuve, H. A. Haus and J. D. Joannopoulos, IEEE Journal of Quantum Electronics **35**, 1322 (1999)