Spectral engineering of the transmission characteristics of racetrack resonators

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We report the study of the transmission characteristics of a vertically-coupled racetrack resonator as a function of the design of its constituting waveguides. We show that the use of asymmetric couplers can lead to quasi-critical coupling over a large spectral range and thus be useful for Kerr frequency comb generation.

Introduction

Integrated whispering gallery mode resonators constitute a family of compact devices which has been shown to be attractive to perform selective filtering, low-threshold emission or nonlinear conversion functions [1]. In the latter case, and for Kerr frequency comb generation in particular, the performance is controlled by the ability to achieve critical coupling over a wide spectral range. In this paper, we study the influence of the coupler design on the spectral response of vertically-coupled racetrack resonators and draw out design rules to achieve wideband critical coupling.

Methodology and results

The spectral response of the resonators under study (see inset of Fig. 1.) is analysed using a coupled-mode theory approach. Following references [2-3], the resonator transmission characteristics consists of a set of Lorentzian-shaped dips whose lower-bound amplitude is given by

$$T_{res-} = \frac{|t|^2+\alpha^2-2\alpha|t|}{1+|t|^2\alpha^2-2\alpha|t|} = \frac{(\alpha-|t|)^2}{(1-\alpha|t|)^2} \qquad (1)$$

where $t=A_1(L_c)/A_1(0)$ is the field transmission coefficient of the coupler access waveguide and α is the single-pass loss coefficient of the resonator.
Fig. 1. illustrates that adjusting the coupler length while keeping unchanged the resonator loss spectrum significantly modifies the critical coupling (T_{res-}~0 or $|t|\sim\alpha$) bandwidth. The parametric study reveals that the widest bandwidth is obtained with an asymmetric coupler whose length is close to be the coupler half beat length ($L_\pi/2$). Physically, as it will be detailed at the meeting, this optimum arises because asymmetric couplers permit to, not only tailor the wavelength dependence of L_π, but also control the influence of the latter parameter through the adjustment of the maximum coupled power fraction, thereby enabling $|t(\lambda)|$ to mimic the weak spectral variations of the resonator loss.

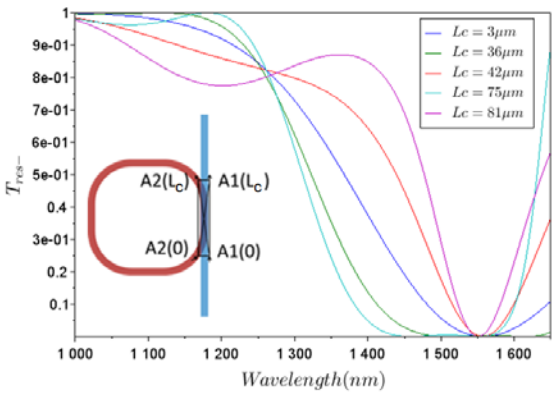

Fig 1: Calculated resonance-dip envelops inset: Studied resonator geometry

References

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