

Fully suspended slot waveguide racetrack resonators

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A fully suspended slot waveguide (FSSW) racetrack resonator is experimentally demonstrated for the first time. The suspended slotted waveguide core is mechanically supported by lateral subwavelength grating (SWG) bridges. The measured loaded optical Q factor is 1650 at a resonant wavelength of 2326.20 nm, with extinction ratio of 18.1 dB.

Optical slot waveguides fabricated on the silicon-on-insulator (SOI) platform enables direct light-matter interaction [1]. Its ring resonators are promising for trace-gas sensing [2], microparticle trapping [3], and nano-optomechanical mass and displacement measurements [4]. To date, slot ring/racetrack structures on buried oxide (BOX) have been adopted in the above applications. However, their operation wavelength is limited below 4.0 μm in the mid-infrared (MIR) regime due to the strong absorption of BOX [1].

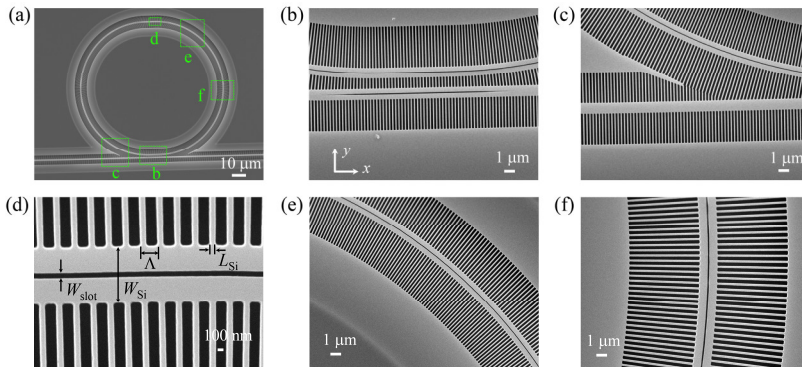


Fig. 1. Top-view SEM images of a FSSW racetrack resonator. (a) Overview of a complete racetrack resonator. (b–f) Zoomed-in areas of the waveguide coupler and bends.

In order to achieve a broad spectral range of transparency in the MIR regime, we propose and demonstrate a FSSW racetrack resonator fabricated on a 340-nm SOI wafer, where the BOX is removed finally. As shown in Fig. 1(a), a curved slotted waveguide core is mechanically supported by lateral subwavelength grating bridges. The bus waveguide is a suspended strip waveguide [5] with two strip-to-slot mode

converters and a section of slotted waveguide in the middle, as shown in Fig. 1(b). We define the bus-to-racetrack coupling length as L_c and the centre-to-centre separation of the coupling region as d . The waveguide bends shown in Fig. 1(c), (e), (f) have a same radius of R . A zoomed-in slot waveguide structure is shown in Fig. 1(d). Widths of the waveguide core and slot are W_{Si} and W_{slot} , and the period and length in the x direction of the periodic anchoring pillars in a SWG cladding are Λ and L_{Si} .

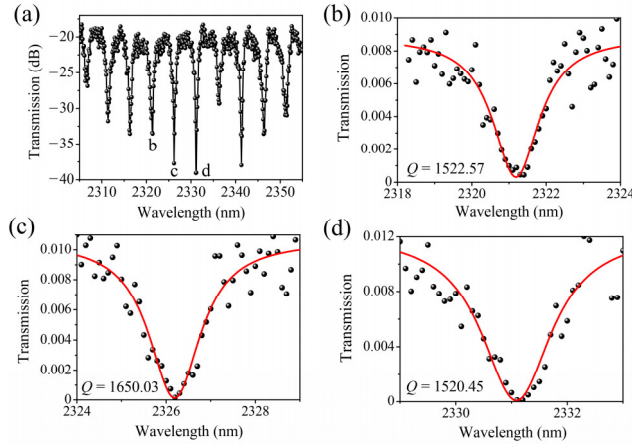


Fig. 2. (a) Transmission spectrum of a FSSW racetrack resonator. (b-d) Zoomed-in spectra of the labeled modes with fitted loaded Q factors.

Fig. 2(a) shows a measured transmission spectrum with a resolution 0.1 nm for a racetrack resonator with $(L_c, d, R) = (6.00, 1.80, 47.75) \mu\text{m}$ and $(W_{Si}, W_{slot}, \Lambda, L_{Si}) = (955.18, 87.48, 299.94, 102.07) \text{ nm}$. Regimes of under, critical, and over coupling can be seen from changes in the extinction ratios in the wavelength range from 2305 to 2355 nm with increased coupling coefficient. Three pronounced transmission dips are selected for analyzing the loaded optical Q factors. Their resonant wavelength, loaded Q factor, and extinction ratio are (2321.40 nm, 1522, 13.11 dB), (2326.20 nm, 1650, 18.14 dB), and (2331.10 nm, 1520, 19.62 dB), respectively. The loaded Q factor may be improved by optimizing L_c and d , in order to minimize the coupling loss.

In summary, we have experimentally demonstrated FSSW racetrack resonators with their loaded optical Q factors above 1500. They could be used for applications where enhancement of direct light-matter interaction is desired, such as spectroscopy, sensing, and optical tweezers.

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