

7. Discussion

The described fabrication process can be improved to reduce the roughness and the tilt of the mirror. Evaporation of metal at an angle can be done to reduce the tilt and to increase the conformity of the mirror to the waveguide. PMMA can be replaced with other resists that offer higher sidewall smoothness. Adding post-fabrication processing, such as rapid thermal annealing, can smooth the mirrors' rough surface. Also other fabrication techniques can be investigated.

High mirror reflectivity R is critical to obtain high finesse, narrow resonance line width, and high extinction ratio, desirable in many applications. Our design was constrained by the height of the Si waveguide (250 nm), set by the availability of SOI wafers. In practice, the guide cross section can be optimized to achieve reflectivity of 0.95, as suggested by Fig. 3b. Even higher reflectivity (up to 0.975) can be obtained on the expense of mode confinement by significantly decreasing the cross section of the waveguide, and pushing the mode out into the cladding, as suggested by the same figure. Nevertheless, the inherent material loss limits the reflectivity to ~97.5%, corresponding to the maximum finesse of ~120. Such losses do not exist in DBRs, whose reflectivity approaches unity for a sufficiently large number of periods.

The reflectivity of metallic mirrors cannot compete with the conventional DBRs. Nor can the resonator achieve the Q-factors of the state-of-the-art resonators with small mode volumes [3,32–35]. The major strength of metallic mirrors, however, rests with their ability to provide reasonably high reflectivity over a broad band of wavelengths and low polarization sensitivity. In addition, the optical skin depth in metal is on the order of 10 nm, so that a very thin layer of metal is sufficient to achieve the desired reflectivity. Hence the proposed metallic mirrors can attain extremely small footprints, by an order of magnitude smaller than those of a typical DBR. DBR's smallest feature size is in the deep sub-micron regime and requires a high degree of fabrication accuracy. Metallic mirrors, in contrast, impose no such constraints and exhibit low sensitivity to fabrication imperfections.

8. Summary

To summarize, we demonstrated a micro-resonator based on silicon waveguide terminated with metallic mirrors. The mirrors are compact and highly reflective. The geometry was optimized to achieve an unloaded Q-factor of 2100 for a resonator 13.4 μm long. Its measured transmission spectrum was in good agreement with the developed analytical model. The device may be used to construct high-order inline filters, spectrum shapers, true-time delays, modulators, channel add-drop multiplexers, and biochemical sensors.

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