CMOS Compatible Directional Coupler Design and Optimization for Quantum Simulation and Communication

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Abstract

Directional Coupler is a passive optical device used to couple electromagnetic powers in a transmission line to a port enabling the signal to be used in another circuit, which is a key component widely used in chip-integrated quantum simulation and communication devices working as a quantum operation gate. The fundamental parameter for the directional coupler is the splitting ratio of the reflection and transmission signal, which is mainly decided by the operation wavelength, gap, coupling length, cross-section size and material. Here, we design the silicon direction coupler waveguide working at the wavelength of 1550 nm to meet the splitting ratio of R/T=1:1 and 1:2 by adjusting the coupling length based on FDTD method with the aid of Lumerical software. The coupler gap is 200 nm with cross-section width of 450 nm, height of 600 nm. The theoretical coupling length calculated for each ratio is 12.12 um and 14.74 um and the optimization process is to adjust this length to compensate for the effect caused by waveguide curvature at the beginning and ending of the coupling region, aiming to conclude the curvature equivalence, effective coupling length and empirical equation as an instruction for further coupler design.