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Multiple-mode Four-wave Mixing in a 4H-silicon-carbide Microring Resonator

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***Abstract*— We demonstrate a 4H-silicon carbide-on-insulator integrated microring resonator with three polarization and spatial mode resonances, and show experimentally that four-wave mixing is achievable among all modes in the single device.**

Keywords—silicon carbide; microring resonator; four-wave mixing.

I. Introduction

Silicon carbide (SiC) exhibits excellent optical properties, such as a wide wavelength window of transparency, high refractive index, and strong third-order nonlinearity, making it a promising material for integrated photonics [1]. Four-wave mixing (FWM), a third-order nonlinear process, makes possible all-optical signal processing and facilitates wavelength conversion, which is an important implementation for wavelength-division multiplexing (WDM). As WDM has been greatly explored, polarization-division multiplexing (PDM) and space-division multiplexing (SDM) become emerging strategies, in order to further substantially expanding the information transmission capacity in fiber optics [2]. These technologies are also able to increase the throughput of the on-chip optical interconnections [3]. Here, we report a 4H-SiC multimode microring resonator, enabling FWM in different polarization and spatial mode resonances, which holds a great potential for combining WDM with PDM and SDM on the 4H-SiC-on-insulator (SiCOI) integrated platform.

II. Experiments and Results

We designed and fabricated a multimode microring resonator, enabling resonance of TE_{00}, TE_{10}, and TM_{00} modes simultaneously, on the 4H-SiCOI integrated platform. Figure 1 shows the scanning electron microscope image of the fabricated device. The microring resonator has a diameter of 66μm, and a cross section of 400 nm in height and 1200 nm in width. The transmittance of the microring resonator is shown in Figure 2(a). The quality factor of TE_{00}, TE_{10}, and TM_{00} resonance in the microring resonator, which is extracted from each resonate transmittance, is about 46000, 21000, and 19000, respectively.

To generate FWM, two CW lasers, connected with polarization controllers to acquire quasi-TE or quasi-TM modes, are amplified by EDFAs, and are launched into the device with the same on-chip power of 17 mW. By fixing one pump and sweeping the wavelength of the other one, the two incident pump can be tuned into the desired resonances. With two pumps on resonance simultaneously, new frequencies are generated based on FWM. As shown in Figure 2(b), FWM generated in TE_{00}, TE_{10}, and TM_{00} resonances is achieved, with a conversion efficiency of -51dB, -45dB, and -43dB, respectively. The conversion efficiency can be further improved by optimizing the fabrication process to have a higher quality factor for every mode.

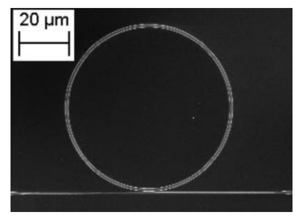
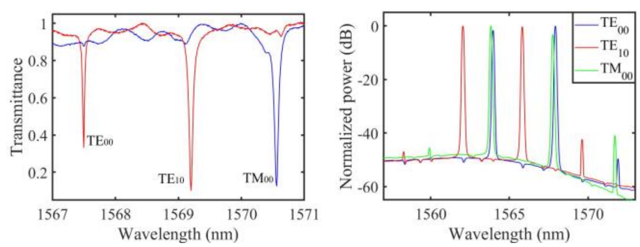


Figure 1: Scanning electron microscope image of the 4H-SiC multimode microring resonator.



(a) (b)

Figure 2: (a) Transmittance of the TE_{00}, TE_{10}, and TM_{00} modes in the 4H-SiC multimode microring resonator. (b) FWM spectra of TE_{00}, TE_{10}, and TM_{00} modes.

The experimental results indicate that, besides the wavelength, it is also possible to utilize either the polarization or the spatial modes as an additional degree of freedom to increase the transmission capacity of optical communication on the 4H-SiCOI integrated platforms.

III. Reference

(1) Guidry, M. A., Yang, K. Y., Lukin, D. M., Markosyan, A., Yang, J., Fejer, M. M., and Vučković, J. Optica 7.9 (2020): 1139-1142.
(2) Richardson, D. J., Fini, J. M., and Nelson, L. E. Nature photonics 7.5 (2013): 354-362.
(3) Dai, D., Wang, J., and He, S. Progress In Electromagnetics Research 143 (2013): 773-819.

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