Vertical Field Enhancement of Spot Size Converter by Using Nano-Pixel Waveguide and Window Structure

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1. Introduction

Spot size converter (SSC) is one of the essential building blocks in integrated photonic circuits. It enhances the optical coupling efficiency by spot-size expansion from the device side toward optical fiber. Up to now, there have been quite a few demonstrations of mode-size conversion device with nano-pixel waveguide [1-3]. The above-mentioned structures; however; are not able to effectively enhance the spot size especially in the vertical direction. Moreover, these structures did not realize the good ratio of vertical and horizontal optical field profiles of output mode, which not efficiently increase the coupling efficiency between SSC and fiber.

2. Concept of vertical field enhancement of spot size converter by using nano-pixel density

The designed SSC is consisting of the nano-pixel waveguide and SiO_2 window structure (12×10×4.5 μm^3), as shown in Fig. 1. The nano-pixel waveguide is chosen to be 1×2 μm^2 which is discretized into 5×10 nano-pixels. Here, 30 nano-pixels is chosen in the inset of Fig. 1. The radii of the nano-pixels are 150 nm (bigger one) and 100 nm (small one), respectively. The device is designed on a high-mesa waveguide with 100 nm core silicon layer and 2 μm buried oxide top coating layer. When the light was injected from input high-mesa waveguide to the nano-pixel waveguide, the effective index in the vertical direction becomes smaller due to the introduction of nano-pixel. Then, the vertical field will be enhanced by increasing the nano-pixel density, due to the decrease of the effective refractive index. On the other hand, the horizontal field enhancement is achieved by arranging the layout of nano-pixel, not the density. As this result, the vertical field profile will be controlled via the nano-pixel density, to realize a good ratio of vertical and horizontal optical field profile for high coupling efficiency.

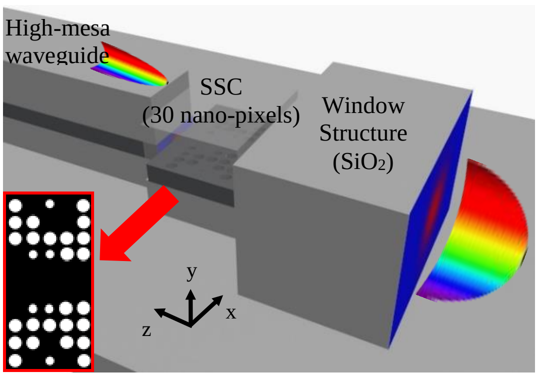

Fig. 1 The designed SSC of 30 nano-pixels (1×2 μm^2) with SiO_2 window structure (12×10×4.5 μm^3).

3. Results and discussions

FDTD simulations are firstly performed for the designed SSC. Figure 2 are shown the optical near field profile and electric field intensity distribution $|E|^2$ of the output mode in fiber side when light injects the optical fiber from the high-mesa waveguide via the designed SSC with 30 nano-pixels and SiO_2 window structure (12×10×4.5 μm^3). The initially injected mode is the fundamental TE mode inside the high-mesa waveguide at the operating wavelength of 1.572 μm in the whole simulated calculation. As seen in Fig. 2 (a) and (b), the FWHM value of confined the horizontal and vertical mode profile is enhanced to 4.8 μm, 4.9 μm, respectively. It features a good ratio of vertical and horizontal optical field profile of output mode. The theoretical calculation shows a coupling efficiency of -0.4 dB by combining the designed SSC of 30 nano-pixels waveguide and window structure. Note that the “window facet” is easily realized relatively with less loss by using dry-etching or others which offers precise length control of the window region in case of SiO_2, not like laser diode facet.

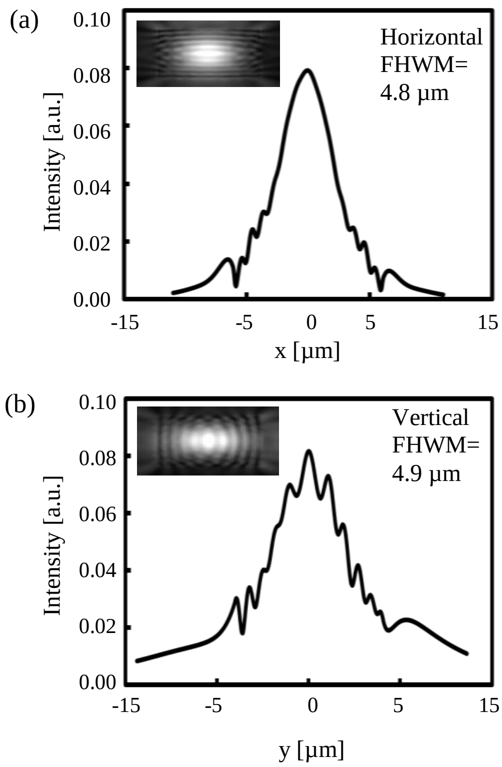

Fig. 2 The optical near field performance for the designed SSC with SiO_2 window structure. Horizontal (a) and vertical (b) optical field profile of the output mode when light injects the window structure from the high-mesa waveguide via the designed SSC of 30 nano-pixels (1×2 μm^2).

4. Conclusion

One has proposed a spot size converter which enables spot size expansion especially in the vertical, not only lateral, direction by using a nano-pixel density control. The theoretical calculation shows a coupling efficiency of -0.4 dB at λ_0=1.572 μm.

Acknowledgement

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Reference

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