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Silica High-Mesa Waveguide for Infrared Sensing

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1. Introduction

High-mesa waveguide is attractive as a certain potion of propagation light profiles out of the waveguide, which can be used for infrared absorption. One of the issues for high-mesa waveguide is its high propagation loss, since high propagation loss consumes light power, which restricts sensing limitation. We tried to fabricate Silica high-mesa waveguide for its low propagation loss possibility. The implemented waveguide showed the propagation loss of 0.65dB/cm (@ λ=1550nm, w=2.3μm), which was higher than expected value of lower than 0.1dB/cm. We investigated the reason of high propagation loss and found that the radiation loss takes a large part of propagation loss. For further improvement, we propose lower cladding layer of more than 5μm to suppress the radiation loss.

2. Propagation Loss Analysis

Figure 1 shows the waveguide cross-section of the Silica high-mesa waveguide. The evaluated propagation loss as a function of waveguide width is shown in Fig. 2. The propagation loss shows 0.65dB/cm when w=2.3μm, which is higher than expected value of lower than 0.1dB/cm, while it is below 0.1dB/cm in case of wider width of more than 3.2μm. Because the refractive index difference between core and cladding is only 2.5%, we suspected that maybe the radiation toward substrate takes a large part of the propagation loss. Figure 3 shows the radiation loss as a function of wavelength (red line: experiment, blue line: calculation) in case of w=2.3μm. The radiation loss is theoretically evaluated through function (1). It is well known that, according to Maxwell equation, the amount of radiation mode can be evaluated by the imaginary part of effective index through the equation below [1]:

$$\alpha_{RL} = \frac{20}{\ln(10)} \frac{2\pi}{\lambda} \mathrm{Im}(n_{eff}) \qquad (1)$$

Here, α_{RL} is the amount of radiation loss, **λ** is wavelength, $\mathrm{Im}(n_{eff})$ is the imaginary part of effective refractive index, defined as $n_{eff}=\beta/k_0$, where β is propagation constant and k_0 is the free-space wavenumber. The imaginary part of effective refractive index can be deduced by finite element method (FEM) and perfectly matched layer (PML) boundary condition [2]. From Fig. 3, we know that the both results show that the radiation loss is approximately 0.45dB/cm (@1550nm, @w=2.3μm), which means the radiation loss takes almost 70% of the propagation loss.

3. Scheme to suppress the radiation loss

Use the method mentioned above, we give the relation between radiation loss and lower cladding layer height which is shown in Fig. 4. From Fig. 4, the radiation loss will be decreased as the lower cladding layer increased and when lower cladding layer is higher than 5μm, the radiation loss should be lower than 0.03dB/cm.

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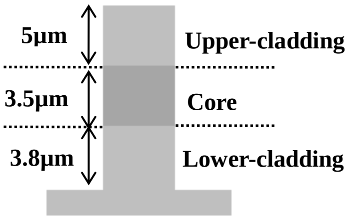

Fig. 1. Schematic of Silica high-mesa waveguide cross section.

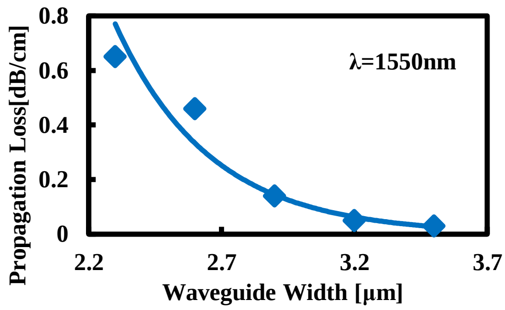

Fig. 2. Propagation loss as a function of waeguide width.

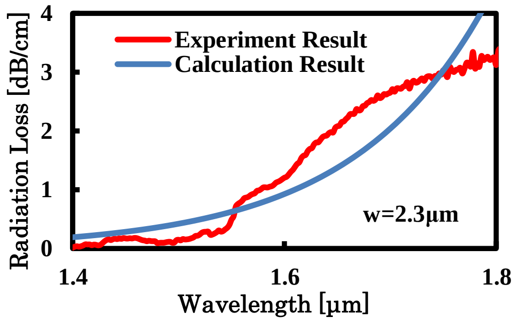

Fig. 3. Radiation loss as a function of wavelength.

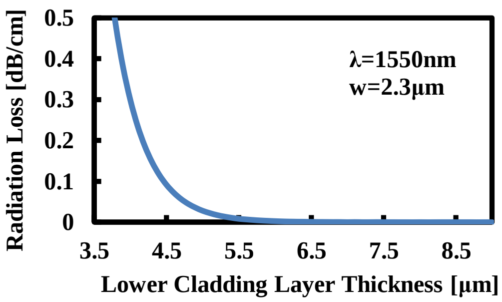

Fig. 4. Radiation loss as a function of lower cladding layer thickness.

Reference

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[2] J. P. Berenger, J. Computational Phys., 114(1994)185.