Analysis of Low loss InP-based membrane waveguide for optical interconnection on Si substrate

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1. Introduction

Membrane photonic integrated circuits, which consists of thin III-V layer sandwiched by SiO_2 or Air, have been proposed to overcome signal delay and large power dissipation in global wiring [1]. It consists of laser, detector and waveguides. Although we tend to pay attention to lasers and detectors, the performance of waveguides is very important to determine the total loss and size of the circuits. To achieve low loss and compactness in waveguide, structure dependence of bending and propagation loss are analyzed in this report.

2. Results

Fig. 1 shows the cross section of the membrane waveguide. Some parameters have been introduced to calculate the loss. The refractive index of the core material ($Ga_xIn_{1-x}As_yP1-_y$) is defined as n, which ranges from 3.17-3.35, and the rib etching depth is defined as *h*. The total thickness of the waveguides was fixed to be 270 nm which matches to our membrane laser thickness, and the width *w* of the waveguide was set to be the maximum width for single-mode propagation.

Fig. 2 shows the minimum bend radius of the waveguide defined as the bending loss of less than 0.1 dB. To sum up, the refractive index does not significantly affect the bending loss, but the bending loss can be alleviated by a deeper etch.

Fig. 3 shows the result of the propagation loss as a function of the refractive index and rib etching depth. Payne-Lacey model was used for the calculation of the scattering loss with an assumed roughness autocorrelation length of 25 nm and sidewall roughness (3σ value) 3.8 nm. The calculation reveals that the propagation loss increases with the increase of rib etching depth and the refractive index.

A small-sized, low-loss bent waveguide can improve the integration of integrated optics and reduce the size as well as the cost of the device. So, the refractive index of the core material should be rather small, which means that InP should be chosen as the core material (n=3.17) rather than GaInAsP (3.17<n<3.35). An InP waveguide with a rib etching depth ranging from 0.21-0.25 μm can still achieve a propagation loss approximately 1-2 dB/cm and the bend radius is smaller than 6 μm.

Acknowledgments

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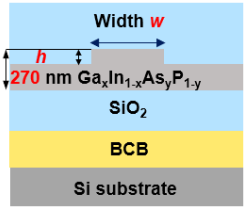

Fig. 1 Structure of InP-membrane waveguide

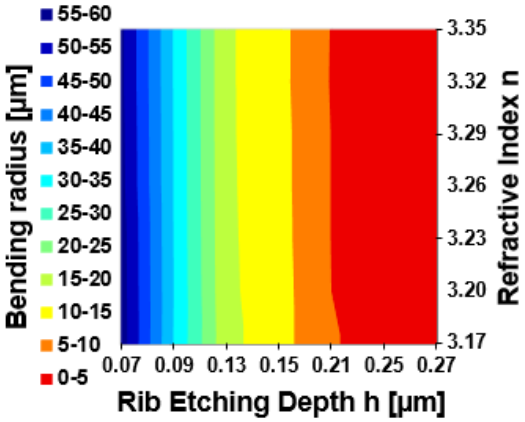

Fig.2 Bending radius @ bend loss<0.1dB as a function of refractive index and rib etching depth

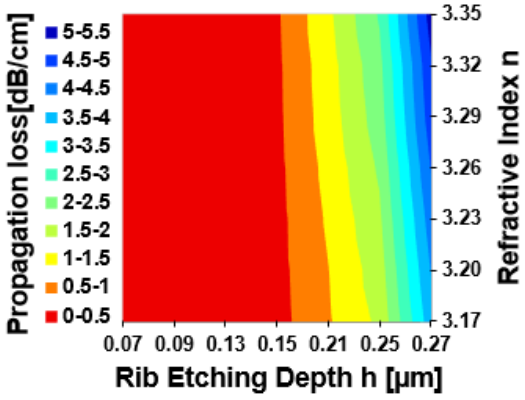

Fig. 3 Propagation loss as a function of refractive index and rib etching depth

References

[1] D. Inoue, et al. , Optics express, Vol. 23, No. 22, pp. 29024-29031, 2015.