Investigation of Si Sidewall Bragg Grating for Hybrid III-V/SOI DFB Lasers

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1. Introduction

LiDAR (Light Detection and Ranging) is extending its role in many applications such as autonomous cars and drones. We are developing a one-chip FMCW LiDAR system on Silicon photonics platform using slow-light grating couplers and hybrid lasers [1]. In this system, a tunable 1.55-μm DFB laser with <1-nm tuning range, ~100-kHz scanning speed, while maintaining high power (>100 mW) and narrow linewidth (~few hundred kHz), is required. Distributed feedback via sidewall Bragg grating structure patterned on the sidewalls of the Si waveguide is concerned in this study rather than the conventional top-etched one so as to reduce process complexity and avoid possible thermal issues. In this report, 2-μm-width Si waveguide sidewall Bragg grating was fabricated to check the deviation between design and measurement in terms of the mode coupling coefficient (κ) and scattering loss (α_s) as a step towards such DFB lasers.

2. Discussion

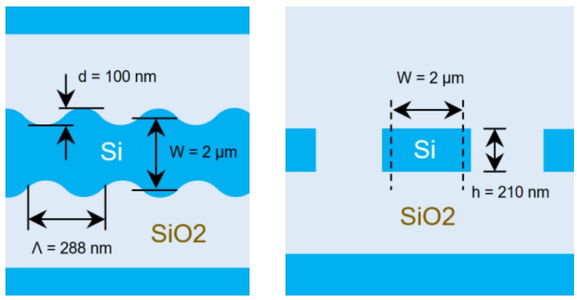
Figure 1 shows the design of the grating fabricated in this report. For the hybrid DFB laser, coupling coefficient (κ) and cavity length (L) are important design parameters. To reduce self-heating in high power lasers, relatively long cavities (usually > 1mm) are used. In this case, lower coupling coefficients are required to achieve the same κL product. In this study, the hybrid laser is designed with a coupling coefficient of 10 cm^{-1} to achieve a κL = 2 at 2 mm cavity length. The required depth of the sidewall grating is 100 nm at 2 μm width × 210 nm height Si waveguide assuming sinusoidal sidewall perturbation due to lithography rounding effect asshown in Fig. 2. If Si waveguide Bragg grating is covered with SiO_2 rather than the III-V mesa, the coupling coefficient value will increase to 54 cm^{-1}.

The Si waveguide Bragg grating was fabricated and cladded with SiO_2. The grating depth shrank to 90 nm after fabrication. Figure 3 shows the transmission spectra of the fabricated SOI wire waveguide with lengths of (a) 450 μm and (b) 600 μm. The coupling coefficient value is extracted from the ratio between stopband minima of the different grating structure lengths using coupled mode theory. The extracted value of the coupling coefficient is 45 cm^{-1} compared to the design value of 54 cm^{-1}. Such lower value is in good consistency with the shrinkage in the grating depth.

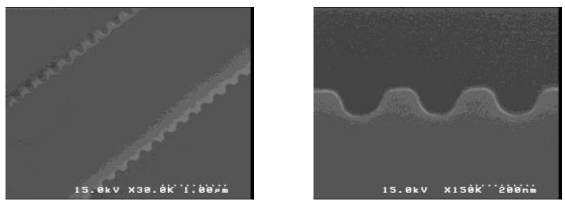
In addition, the scattering loss (α_s) is extracted from fitting using transmission value of the pass band, assuming a constant value near the center wavelength. Low scattering loss value of 1.8 cm^{-1} was obtained. This value is expected to be even lower in the hybrid DFB laser and can be easily neglected compared to absorption losses in the III-V active region.

References

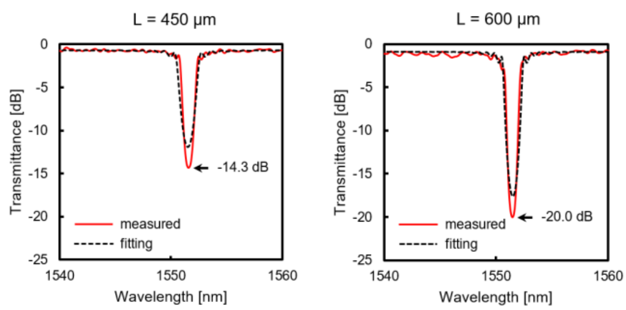
[1] T. Baba, *et al.*, SSDM *2017*, H-8-04 (2017).
[2] Y. Hayashi, *et al.*, *JJAP* **55**, 082701 (2016).



(a) (b)
Fig. 1 Schematics of the (a) top and (b) cross sectional views of the designed SOI Bragg grating.



(a) (b)
Fig. 2 SEM images of (a) the 2 μm × 210 nm Si waveguide with (b) 90 nm sidewall Bragg grating depth.



(a) (b)
Fig. 3 Transmission spectra of the fabricated SOI Bragg grating with lengths of (a) 450 μm and (b) 600 μm.