Hybrid DFB Lasers Consisting of GaInAsP Gain Region and Si Vertical Grating Fabricated by Room-temperature Surface-activated Bonding

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Introduction

In recent years, the hybrid integration of III-V lasers on Silicon by wafer bonding has gained attention as on-chip light sources in Silicon photonics. The hybrid DFB laser is a promising candidate for coherent detection applications such as coherent optical communications and FMCW LiDAR systems due to its high single-mode wavelength stability. In this work, the lasing operation of a λ/4-shifted hybrid GaInAsP/SOI DFB laser fabricated by room-temperature surface-activated bonding is reported for the first time.

Results

Figure 1 shows a schematic cross-sectional view of the GaInAsP/SOI hybrid DFB laser. The Si waveguide with λ/4-shifted vertical Bragg grating was patterned by electron beam lithography (EBL). Figure 2 shows a SEM image of the grating structure. The waveguide width (W_{Si}), width perturbation (ΔW_{Si}), grating pitch (Λ), and grating section length (L_{DFB}) were 2.0 μm, 0.3 μm, 283 nm, 930 μm, respectively. Surface-activated bonding was utilized by activating the GaInAsP/InP and SOI wafer surfaces prior to bonding by Xe and Ar fast atom beam (FAB) irradiation, respectively [1]. Ridge and taper structures were defined by lithography and etching processes, with ridge width (W_{InP}) and taper length (L_{taper}) of 3 μm and 110 μm, respectively. Finally, metallization, cleavage, and anti-reflection (AR) coating were applied.

The lasing wavelength was ~1.52 μm at 20 °C, which is far shorter than gain peak (~1.55 μm), with side-mode suppression ratio (SMSR) > 30 dB. Figure 3 shows the light output characteristics with continuous-wave (CW) operation. Threshold currents of 68 and 92 mA and slope efficiency of 2.4 and 1.4 mW/A were obtained at the stage temperatures of 10 °C and 20 °C, respectively. Since the performance is limited mainly by Bragg wavelength detuning, we believe that relatively large difference of the threshold current and slope efficiency was caused between stage temperatures. Thus, grating pitch adjustment corresponding to 1.55 μm can realize better performance in near future.

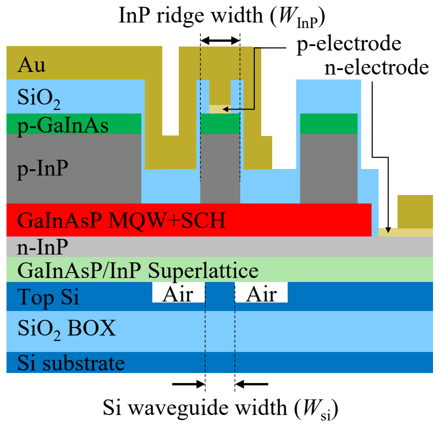

Fig. 1 Schematic cross-sectional view of the hybrid GaInAsP/SOI DFB laser with ridge structure

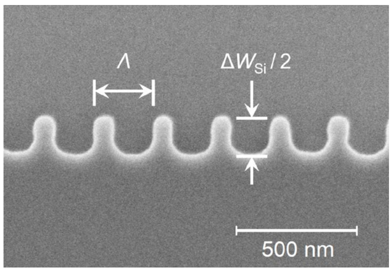

Fig. 2 SEM image of the Si waveguide Bragg grating structure (top view)

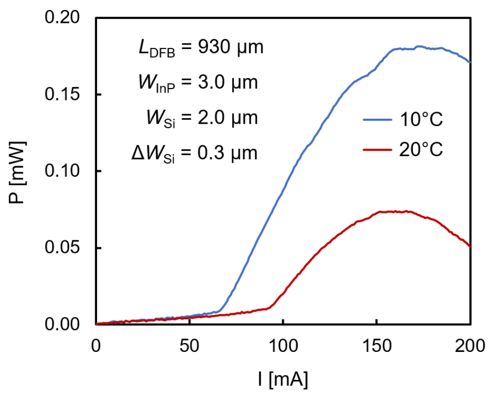

Fig. 3 Light output characteristics with CW operation at stage temperatures of 10°C and 20°C

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References

[1] Y. Wang *et al.*, JJAP 59, 052004 (2020).