Heterogeneous Lasers with Silicon Photonic External Cavity

Tomohiro Kita[1], Shotaro Takei[1], Atsushi Matsumoto[2], Naokatsu Yamamoto[2], and Hirohito Yamada[1]

[1]Graduate School of Engineering, Tohoku University
[2] National Institute of Information and Communications Technology
E-mail: tkita@ecei.tohoku.ac.jp

1. Introduction

Presently, silicon photonics is receiving considerable attention because it provides a promising platform for fabrication of highly integrated photonic devices. In addition, silicon photonic devices can be fabricated using the mature fabrication technologies of electric integrated circuits. We focused on an integrated light source and developed wavelength tunable lasers using silicon photonic technologies. The narrow spectral linewidth heterogeneous laser diode with high optical output power was realized for optical digital coherent communication systems[1]. The recent studies for expanding the availability of heterogeneous lasers will be presented.

2. Heterogeneous wavelength tunable lasers

Figure 1 shows the schematic of the heterogeneous tunable laser diode. We have fabricated the butt-jointed structure with a compound semiconductor optical amplifier (SOA) as the optical gain medium and a silicon photonic cavity as the wavelength filter. The primary advantage of a butt-jointed structure is that the SOA chip and the silicon photonic chip are individually fabricated by using the optimized fabrication processes for the materials. Moreover, the SOA is a very simple structure that provides optical gain through precise control of the lightwave, which is performed in the silicon photonic chip.

Table 1 shows the wavelength tunable lasers with various wavelength ranges that were developed by our group. Although the SOAs suitable for each wavelength ranges are different, the silicon photonic external cavities can be fabricated on the same SOI wafer. Therefore, relatively novel materials such as InAs quantum dots or GaSb quantum wells were easily available for use as SOAs and various wavelength tunable lasers covering an ultra-broad wavelength band were realized using these SOAs. The heterogeneous lasers will be effective not only for a conventional optical communication system based on a 1.55-μm-wavelength band but also for novel optical communication systems using different wavelength bands and optical sensing applications such as optical coherent tomography.

In addition, a dual-mode wavelength tunable laser diode has been demonstrated using quantum dot SOA for radio-on-fiber communication systems [6], [7]. The dual-mode tunable laser was realized by combining the unique property of a quantum dot optical amplifier and the high wavelength controllability of a silicon photonic external cavity.

3. Conclusions

The amplitude, wavelength, phase, and polarization of a lightwave can be controlled in ultra-compact silicon photonic chips. The use of heterogeneous lasers, which combine the various SOAs with unique characteristics with the silicon photonic technologies, is expected to grow in various research and application fields.

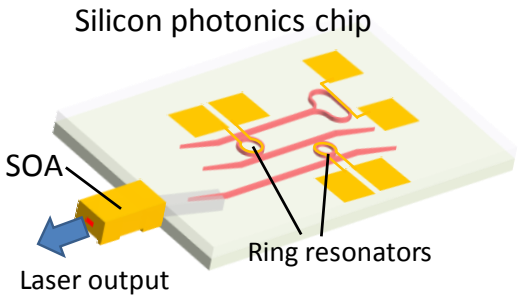

Fig. 1. Schematic of heterogeneous laser diode

Table I Developing heterogeneous tunable lasers

Wavelength tuning range(μm)	Material of active layer in SOA	Ref.
1.20–1.25	InAs quantum dot	[2], [3]
1.28–1.36	InGaAsP/InP quantum well	
1.53–1.63	InGaAsP/InP quantum well	[4]
1.68–1.78	InGaAsP/InP quantum well	[5]
2–?	GaSb quantum well	

Acknowledgements

This research was partly supported by the R&D project on carrier-conversion technology with high environmental tolerance, National Institute of Information and Communication Technology (NICT), Japan.

References

[1] T. Kita, et al., JSTQE **22** 1500612 (2016).
[2] T. Kita, et al., APEX **8**, 062701 (2015).
[3] T. Kita, et al., JJAP **55**, 04EH11 (2016).
[4] T. Kita, et al., APL **106**, 111104 (2015).
[5] S. Takei, et al., 64th JSAP Spring Meeting 2017, 16p-F204-12.
[6] T. Kita, et al., OFC2016 W1E.3.
[7] A. Matsumoto, et al., CLEO2016 SW4C.

© 2017年 応用物理学会