5-2007

Vertically-Coupled Microring Laser Array for Dual-Wavelength Generation

Chyng Wen TEE
Singapore Management University, cwtee@smu.edu.sg

K. A. Williams

R. V. Penty

I. H. White

M. Hamacher

See next page for additional authors

DOI: https://doi.org/10.1109/CLEO.2007.4452687

Citation

TEE, Chyng Wen; Williams, K. A.; Penty, R. V.; White, I. H.; Hamacher, M.; Troppenz, U.; and Heidrich, H.. Vertically-Coupled Microring Laser Array for Dual-Wavelength Generation. (2007). *2007 Conference on Lasers and Electro-Optics CLEO: Baltimore, Maryland, May 6-11: Proceedings*. 1-2. Research Collection Lee Kong Chian School Of Business.
Available at: https://ink.library.smu.edu.sg/lkcsb_research/3356

Author

Chyng Wen TEE, K. A. Williams, R. V. Penty, I. H. White, M. Hamacher, U. Troppenz, and H. Heidrich

Vertically-coupled Microring Laser Array for Dual-Wavelength Generation

C. W. Tee(1), K. A. Williams(1,2), R. V. Penty(1), I. H. White(1),
M. Hamacher(3), U. Troppenz(3), H. Heidrich(3)
1: Cambridge University Engineering Department, 9 JJ Thompson Avenue, Cambridge, CB3 0FA, U.K.
2: Eindhoven University of Technology
3: Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institute
(email[1]: cwt23@cam.ac.uk)

Abstract: We report the first demonstration of continuous-wave operation of a tunable, compact microring laser array based on a vertical-coupling architecture, well suited to larger-scale integration. Wavelength separation tunability from 4.9 to 6.3nm is observed.

OCIS codes: (140.5960) Semiconductor lasers; (130.0250) Optoelectronics

1. Introduction

Because of their high quality factor and small feature size, ultra-compact light sources such as microring lasers are expected to play an important role in future large-scale integration of photonic integrated circuits. However, while significant advances have been made using sophisticated passive microring topologies for example for dispersion compensation and filtering, [1], the integration of multiple active components has been frustrated by the need for an integration technology which allows the close coupling of active devices with low loss bus waveguides.

Recently, vertical coupling has been explored to allow the coupling of microstructures microring and microdisk devices to separately processed bus waveguides. The possibility to define active components on one wafer face and passive structures on the opposing face has been facilitated by wafer bonding part-processed circuits to transfer wafers prior to the thinning and processing of the second wafer face. Active vertically coupled microdisk devices have been proposed for switching and routing [2], demultiplexing [3] and microresonator arrays [4]. Vertically coupled active microrings have been developed, with pulsed laser oscillation with a 13 mA threshold [5].

In this paper, we demonstrate the first CW operation of vertically coupled microring lasers and show the feasibility of an array of these devices as a compact and robust dual-wavelength light source for terahertz mode-beating applications.

2. Device Structure

When serially integrated active microring lasers with mutually offset resonance wavelengths are coupled to a single passive bus waveguide, one can obtain multiple lasing wavelengths from the same output of the bus waveguide. It is therefore possible to exploit the slight difference in wavelength-current individual laser dependnece to achieve tunability in the wavelength separation. Figure 1 shows a schematic diagram of the vertically-coupled microring laser array. The microring waveguide width and bus waveguide width are designed to be 1.8µm. The active region consists of six InGaAs quantum wells with a bandgap of Q_{ring} = 1.55µm, clad by a confinement layer waveguide width of 0.43µm. The InGaAsP bus waveguide has a bandgap of Q_{bus} = 1.44µm and a thickness of 0.35µm. Cascaded microring lasers with ring radii of 70µm and 74µm are vertically-coupled to the same bus waveguide.

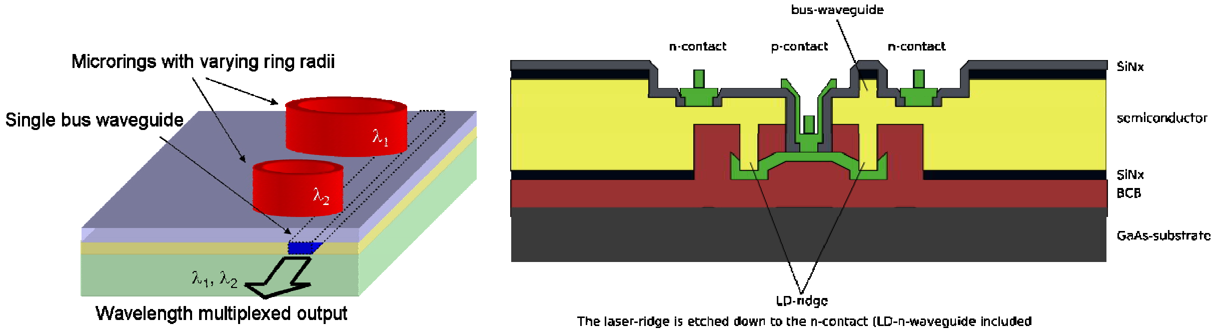

Fig. 1 Schematic of vertically-coupled microring array architecture.

3. Experiment

The threshold currents for the two cascaded lasers are 6mA. Thermal roll-over in the light-current curve occurs at 14mA. Figure 2 plots the output spectra for the clockwise propagating modes of the two lasers and combined power against wavelength under the bias current of 8mA, 10mA and 12mA. The lasing wavelength of the cascaded microring laser is centred in the 1575nm window, where a current range of 4mA gives rise to a wavelength variation from 1573.9nm to 1580nm for the 70µm-radius device and 1580.2nm to 1584.9nm for the 74µm-radius device. This corresponds to a wavelength-current sensitivity of 1.5nm/mA and 1.15nm/mA, respectively. Side-mode suppression-ratio is observed to be in excess of 20dB, demonstrating excellent single-mode operation.

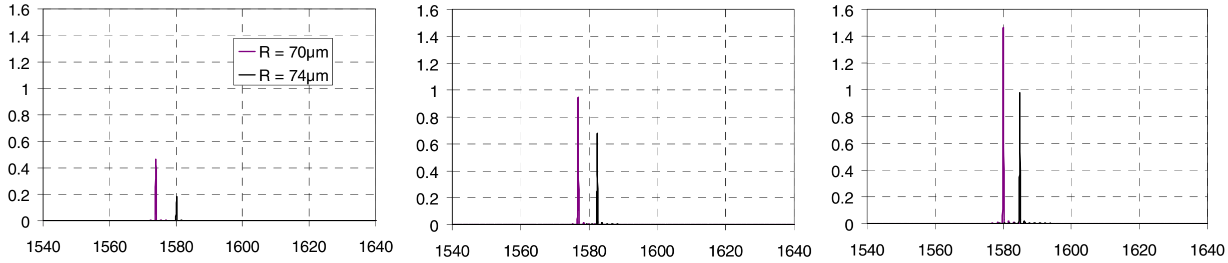

Fig. 2 Output spectra of the laser array at an injection current of 8mA(left), 10mA(middle) and 12mA(right).

Figure 3 shows the fine-tuning characteristics of the wavelength separation between the two microring lasers. The wavelength difference is observed to vary from 6.3nm at an injection current of 8mA to 4.9nm at 12mA.

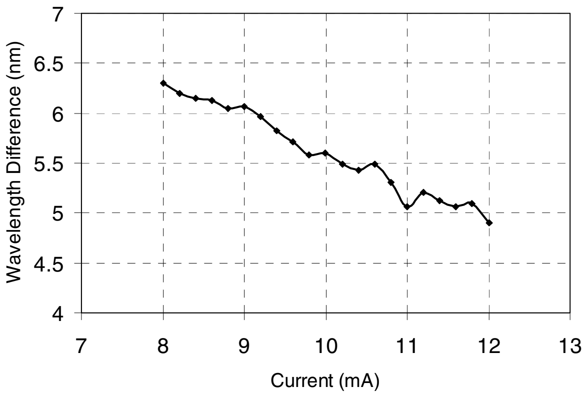

Fig. 3 Wavelength separation between the two lasing modes from the microring laser array

4. Conclusions

A novel serially-cascaded vertically-coupled microring laser array architecture based on wafer-bonding technology is proposed and demonstrated, highlighting the potential to be employed as dual-wavelength light source. CW operation of such devices is demonstrated for the first time. The cascaded devices have identical threshold current of 6mA and oscillate with side mode suppression of greater than 20dB up to 12mA. The wavelength-current sensitivity of the two lasers is measured to be 1.5nm/mA and 1.15nm/mA. This corresponds to a tunable wavelength difference of 1.4nm across a current range of 4mA, highlighting its potential as compact and robust dual-wavelength light source suitable for broadband continuous tuning.

References

[1] R. Grover, P. P. Absil, T. A. Ibrahim, P.-T. Ho, "III-V semiconductor optical micro-ring resonators," Summer School, Ettore Majorana Centre for Scientific Culture, International School of Quantum Electronics, Erice, Sicily, Italy, 18-25 October, 2003.

[2] K. Djordjev, S. J. Choi, S. J. Choi, P. D. Dapkus, "Vertically coupled InP microdisk switching devices with electroabsorptive active regions", IEEE Photon. Technol. Lett., vol. 14, pp. 1115-1117, 2002.

[3] S. J. Choi, Z. Peng, Q. Yang, S. J. Choi, P. D. Dapkus, "An eight-channel demultiplexing switch array using vertically coupled active semiconductor microdisk resonators", IEEE Photon. Technol. Lett., vol. 16, pp. 2517-2519, 2004.

[4] S.J. Choi, Z. Peng, Q. Yang, S.J. Choi and P. Dapkus, "Eight-channel microdisk CW laser arrays vertically coupled to common output bus waveguides", IEEE Photon. Technol. Lett., vol. 16, pp. 356-358, 2004

[5] K. Amarnath, R. Grover, S. Kanakaraju, P. T. Ho, "Electrically pumped InGaAsP-InP microring optical amplifiers and lasers with surface passivation", IEEE Photon. Technol. Lett., vol. 17, pp. 2280-2282, 2005.