Silicon Evanescent Racetrack Laser

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Invited Paper

Abstract: We describe the utilization of hybrid silicon evanescent waveguides, consisting of III-V quantum wells bonded to silicon rib-waveguides for evanescently coupled gain, to achieve an on-chip racetrack laser integrated with photodetectors on a silicon platform.

OCIS codes: (140.5960) Semiconductor lasers; (250.5300) Photonic integrated circuits

Recently, the use of III-V quantum wells transferred to silicon waveguides for evanescently coupled gain and absorption, has been use to demonstrate electrically driven lasers [1], amplifiers [2], and photodetectors [3] on silicon. We describe here the use of this platform to achieve an on-chip laser integrated with photodetectors that can be tested on chip without dicing or facet polishing. The laser operates at 1590 nm with a threshold of 175 mA, has a maximum total output power of 29 mW, and a maximum operating temperature of 60 C [4].

Fig. 1 shows the device layout. The laser consists of a racetrack ring resonator with a directional coupler formed at one of the straight waveguide sections. The racetrack ring radius and straight waveguide sections are 200 microns and 700 microns respectively. The directional coupler length and gap are 400 microns and 0.5 microns respectively. Two 440 micron long photodetectors, having the same waveguide structure, are placed at the ends of the directional coupler output ports.

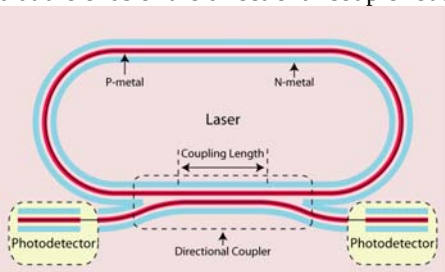

Fig. 1. The layout of the racetrack resonator and the photodetectors.

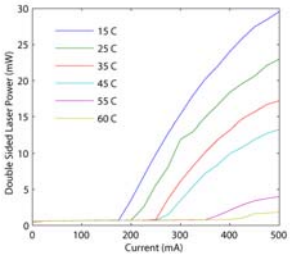

Fig. 2. The LI curve for a laser with radius

The lasers are tested on-chip by forward biasing the laser section, while applying a 5 volt reverse bias on the detector sections and collecting the reverse current. The photodetectors have an estimated responsivity of 1.25 A/W. The LI curve is shown in Figure 2. The devices lase up to 60 °C with a characteristic temperature of 55K. The device lases at 1592 nm with a maximum output power of 19 mW at 15 °C.

The integration of a racetrack laser with a photodetector on the hybrid silicon evanescent device platform demonstrates the potential to realize pratical photonic integrated circuits by taking advantage of on chip testing and characterization of lasers without the coupling losses associated with fiber coupling and eliminating the need for dicing and polishing. We have demonstrated an on chip laser with output powers up to 29 mW operating up to 60 C in the range of 1590 nm.

[1] A. W. Fang, *et al.*, "Electrically pumped hybrid AlGaInAs-silicon evanescent laser," Opt. Express **14**, 9203-9210 (2006)
[2] H. Park, *et al.*," A Hybrid AlGaInAs-Silicon Evanescent Amplifier," IEEE Photon. Tech. Lett., Vol. 19, No. 4, (2007)
[3] H. Park, *et al.*, "A hybrid AlGaInAs-silicon evanescent waveguide photodetector," Opt. Express **15**, 6044-6052 (2007)
[4] A. W. Fang, *et al.*, "Integrated AlGaInAs-silicon evanescent race track laser and photodetector," Opt. Express **15**, 2315-2322 (2007)