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The Fabrication of the Double Ring Resonators Semiconductor Laser

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1. Introduction

There are reports of semiconductor ring laser operation[1-5]. Since semiconductor ring lasers do not need cleaved facets, these lasers can be easily integrated with other passive components monolithically. The ring lasers eliminate spatial hole burning due to traveling wave operation, which results in high side mode suppression ratio and reduced sensitivity to feedback. In addition, the diameter of the ring resonator can be defined by lithography thus it is possible to manipulate the central wavelength of the ring laser. We demonstrated the fabrication of the semiconductor ring laser with two ridge-waveguide circular ring cavities. The fabrication of the double circular ridge-waveguide ring laser structure is presented as well as the I-V and spectrum characteristics.

2. Device processing

The lasers were fabricated with an MOCVD grown InGaAlP multiple quantum wells laser structure. Figure 1 shows the dimension of the double ring laser with two intersected circular ridge-waveguides, one is 25 μm in diameter and the other one is 100 μm in diameter, the width of the ridge waveguide is 10 μm, and a 500 μm long Y-junction branch for laser output coupling.

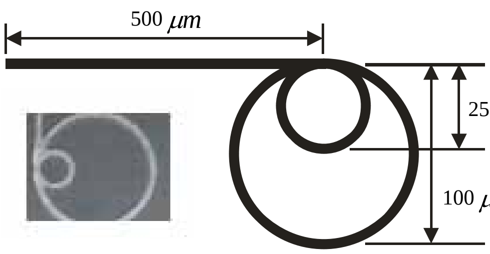

Figure 1, Dimension of the double ring laser with two intersected circular ridge-waveguides, one is 25 μm in diameter and the other one is 100 μm in diameter, the width of the ridge waveguide is 10 μm, and a 500 μm long Y-junction branch for laser output coupling.

To pattern the ring laser device, a SOG (150F, Filmtronics) layer is spun on the laser substrate, and annealed at 110 ^{O}C for 10 minutes. A second layer of conventional photoresist (AZ4903) is then spun on the top of the SOG layer. A mask aligner (Karl Suss MA45) was operating at contact mode to expose the pattern of the ring laser device. Since the developing of the SOG layer is faster than AZ4903 photoresist, by controlling the developing time, a desired undercut structure for lift-off process was reliable. Figure 2 shows the SEM pictures of the two layer photoresists process with very clear undercut structure. Au/Cr metal mask was then patterned by a subsequent lift-off process.

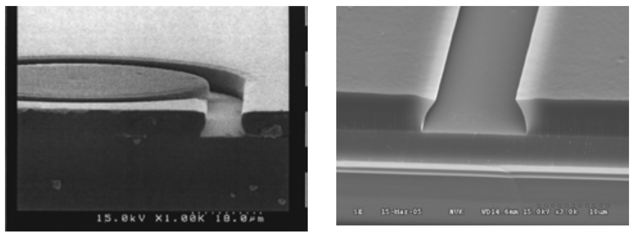

Figure 2, SEM pictures of the cross sectional profile of the two layer photoresists structure

The etching technology for the pattern definition of the ridge-waveguide structure of the circular ring laser devices is crucial to the operation of these devices since the definition and uniformity of the etched side-walls depend on the anisotropic characteristics of the etching. Reactive ion etching has been shown to give highly anisotropic etched sidewalls; however, etch damage incurred in this etching has been conjectured to lead to increased optical loss on the etched surface. we have applied the UV laser assisted cryoetching to achieve anisotropic of the circular ridge waveguide without damage to the etched side wall and optical properties for the ring laser.[9,10] Etching was done at 140 K, 10 mTorr of chlorine, and 150 mJ/cm^2 of 193nm Ar-F excimer laser operated at 10Hz repetition rate.

Confinement of the current injection area along the ring cavity is achieved by a patterned 0.2 μm silicate based spin on glass (SOG) (ACCUGLASS 204) to provide electrical isolation. A thick Au metal layer was then deposited uniformly on top of the laser device for electrode.

3. Characterizations

The double circular ring lasers were probe-tested at room temperature under constant current injection. An output power as high as 5 mW operated at 80 mA was achieved. Figure 3 shows the L-I characteristics of the double circular ring laser. The threshold current which includes the current supplied to the Y-junction branch coupler is around 62 mA which is close to the performance of a linear rig-waveguide laser fabricated with the same laser material.

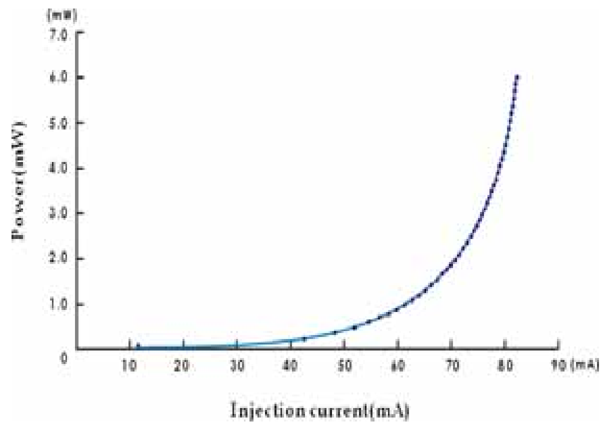

Figure 3, The L-I measurement of the double circular ring laser at constant current injection mode.

The output of the laser spectrum was measured by a Jobin Yvon SPEX 500 spectrum analyzing system with 0.01 nm resolution. Figure 4 shows the emission spectrum of the double ring laser operated at 70 mA. It clearly showed two wavelength laser operation one at 638.84 nm and the other one at 636.04nm.

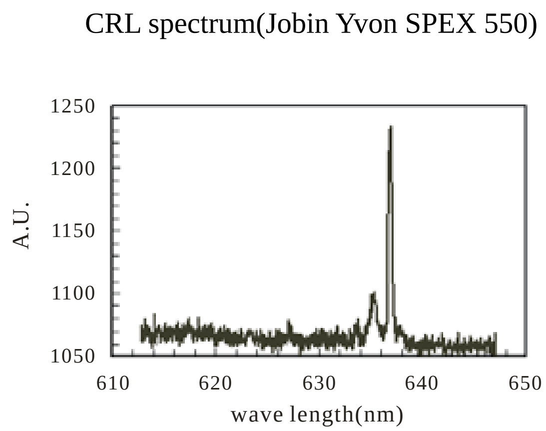

Figure 4, The output spectrum of the double ring laser operated at 70 mA.

4. Conclusions

We demonstrated the fabrication of a double circular ring laser which has two lasing wavelength. It shows the potential applications in multi-channels optical communication and signal processing. The detailed discussion of the wavelength selection by tuning the diameter of the circular ring cavity will be present in the near future.

Acknowledgements

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