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PLC-Type Hybrid External Cavity Laser Integrated with a Front-Monitor PD on a Si Platform

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1.Introduction

External cavity lasers [1] composed of a UV written waveguide grating and an LD are promising light sources for WDM systems because their oscillation wavelength is stabilized to the Bragg wavelength of the grating and is less dependent on temperature than that of conventional DFB LDs [2]. We have fabricated integrated external cavity lasers in which an LD chip is integrated with a grating written in a silica waveguide [2-4], using silica based planar lightwave circuit (PLC) technologies [5]. We have also suppressed temperature dependent mode hopping by employing silicone between the LD and the grating [6]. For practical applications, it is important to control the optical power of these external cavity lasers to ensure their power is constant. PLC devices are advantageous in that they can be integrated with a monitor PD on a Si platform [5].

In this letter, we propose a hybrid external cavity laser integrated with a monitor PD on Si and we examine the possibility of auto power control (APC) by changing the temperature of the external cavity laser.

2. Design and fabrication

Figure 1 shows our proposed configuration for a hybrid external cavity laser integrated with a monitor PD. A spot-size converter integrated LD (SS-LD) [7] and a monitor PD (MPD) are mounted on Si terraces [5] which are formed on a Si substrate. In this SS-LD, the front facet was coated with anti-reflection film and the rear facet was coated with high-reflection film. We formed a 4 mm grating on the silica waveguide by irradiating the silica waveguide with an ArF excimer laser through a phasemask. The reflectivity of the grating was 45%. The relative index difference of the silica waveguide was 0.75% and its core was 7x7 μm. The grooves were filled with silicone and their total length was 290 μm. The external cavity laser oscillated in the cavity from the center of the grating to the rear facet of the SS-LD. The coupling ratio of the directional coupler was about 7% with which the lasing power was detected by the MPD. The device size of our proposed external cavity laser is 2.7 mm x 20 mm.

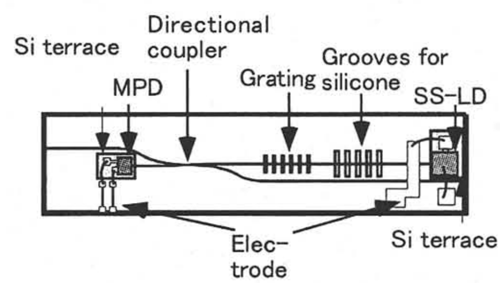

Fig. 1 Configuration of proposed external cavity laser

3. Measurement results

Figure 2 shows the output power against current.

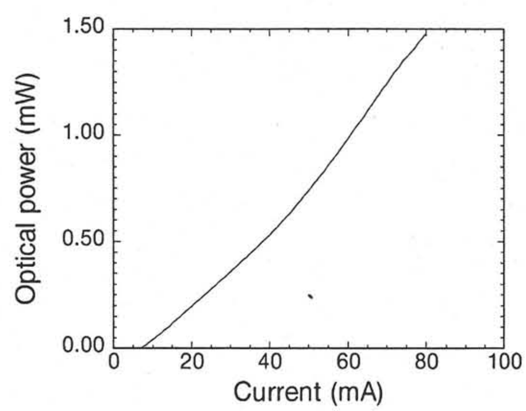

Fig. 2 Optical power against current at 25℃

The threshold current was 9 mA and the optical power was 0.98 mW at an injection current of 60 mA.

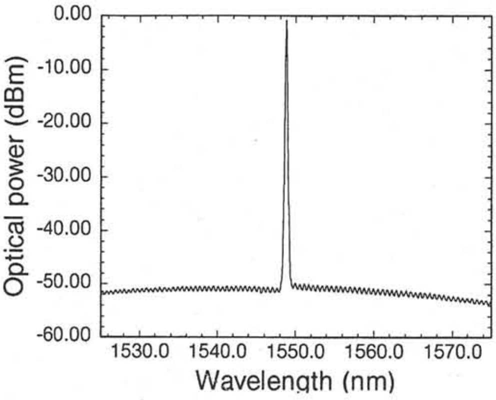

Fig. 3 Oscillation spectrum at 25℃, 60 mA

Figure 3 shows the output spectrum of the external cavity laser. It confirms the realization of single-mode oscillation with a side mode suppression ratio of 50 dB. We confirmed there were no side modes using a Michelson interferometer type spectrum analyzer with a 0.007 nm resolution.

Next, we investigated the temperature dependence of the external cavity laser integrated with an MPD. Figure 4 shows the optical power against temperature when we controlled the external cavity laser by APC. The optical power was from 0.49 to 0.60 mW at temperatures from 18℃ to 58℃. This confirms that our use of APC enabled us to control the optical power variation within 10 %.

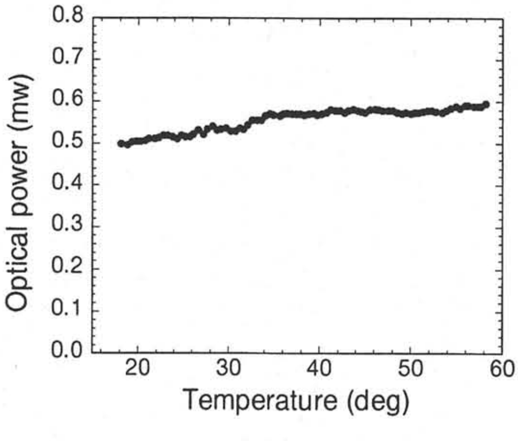

Fig. 4 Optical power against temperature with APC

Figure 5 shows the oscillation wavelength against temperature when we controlled the external cavity laser with APC. It confirms that the oscillation wavelength changed continuously with changes in temperature from 18 ℃ to 52℃ where there was no mode hopping. At 52℃ the oscillation wavelength jumped 0.06 nm and this is mode hopping. We controlled the output power variation within 10% and simultaneously suppressed the mode hopping between 18 ℃ and 52 ℃.

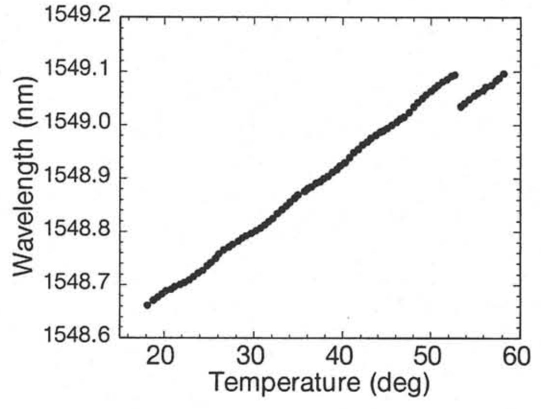

Fig. 5 Oscillation wavelength against temperature with APC

4.Conclusion

We fabricated a hybrid external cavity laser integrated with an MPD on Si and we used APC to control the output power variation to less than 10% with changes in temperature. We simultaneously suppressed the temperature dependent mode hopping between 18℃ and 52℃.

References

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