Monolithic Optical Injection Locking DFB Lasers Based on Four Phase-Shifts Sampling Sections

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Optical injection locking has shown many advantages such as reducing the noise of a slave laser, reducing the laser linewidth, improving the bandwidth and suppressing the frequency chirp [1, 2]. Achieving a locked state often requires a tunable external cavity laser or a well-matched DFB laser since the operating wavelength and polarization of the master laser and the slave laser must be matched. In this paper, we demonstrate a monolithic optical injection locking (MOIL) DFB laser based on four phase-shifts (4PS) sampling sections. Based on the 4PS structure, the lasing wavelength can be precisely controlled by designing the sampling period, meanwhile, the effective grating coupling coefficient κ of the +1st channel is significantly enhanced, equal to 0.9 times that of a uniform seed grating [3]. The device is based on a sidewall grating structure, requiring only one metalorganic vapor-phase epitaxy (MOVPE) step and one III-V material etching step to complete the fabrication process.

As shown in Fig. 1(a), the MOIL DFB laser consists of two back-to-back DFB laser sections (L_{master}=580 µm, L_{slave}=400 µm) with an isolation groove (20-µm-long) defined between them. Both master and slave lasers have the same seed grating period (257 nm) and the same sampling period (4.418 µm). The grating in each sampling period is evenly divided into four sections, with each adjacent grating section subjected to a π/2 phase shift. Two π phase shift are respectively inserted into the middle of two laser cavities to ensure each section operates in a single longitudinal mode. Fig. 1(b) is a microscope image of the fabricated device, and the front and rear facets of the devices were straight cleaved without coatings.

After fabrication, the devices were mounted epilayer-up on a copper heat sink with a Peltier cooler. The heat sink temperature was set at 20 °C and the devices were tested under CW conditions, with all results measured from the slave laser side. Fig. 2(a) shows an optical spectrum map of the device, with the injection current of the slave laser (I_{slave}) held at 35 mA and I_{master} scanned from 0 mA to 100 mA. In Fig. 2(b), when I_{master}=0 mA, I_{slave}=35 mA, the lasing wavelength of the slave laser shows a 3.3 nm blue shift compared to the master laser due to the carrier-induced change of the refractive index. When I_{master} is in the range 35-72 mA, the device operates in a nonlinear regime. As shown in Fig. 2(c), a increasing I_{master} makes the lasing wavelength difference between slave mode and master mode smaller, and both modes reach the threshold intensity level that allows four wavelength mixing to occur, the F-P modes can also be observed due to the facet reflection. With 73 mA ≤ I_{master} ≤100 mA, the injection from the master laser to the slave laser is sufficient to force the slave into the optical injection locking condition (Fig. 2(d)). The dynamic characteristics of the device will be reported in the near future.

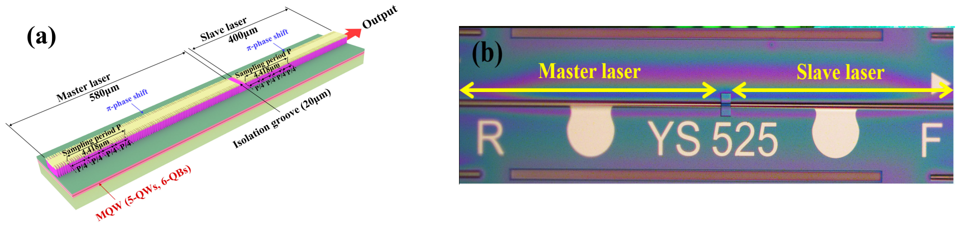

Fig. 1 (a) Schematic of the MOIL DFB laser. (b) Microscope image of the MOIL DFB laser.

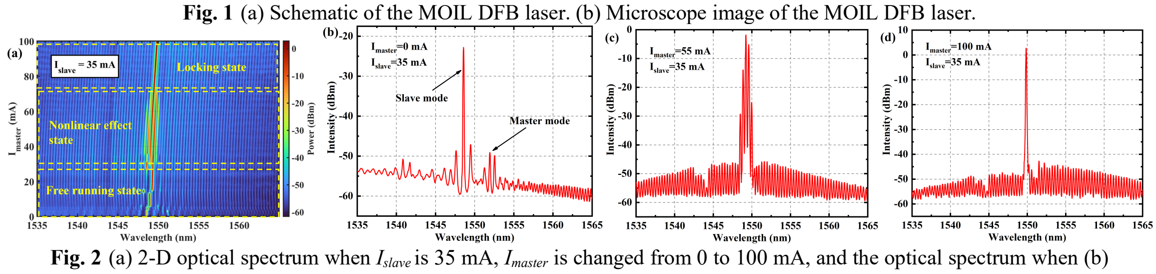

Fig. 2 (a) 2-D optical spectrum when I_{slave} is 35 mA, I_{master} is changed from 0 to 100 mA, and the optical spectrum when (b) I_{master}=0 mA, (c) I_{master}=55 mA, (d) I_{master}=100 mA.

References

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