High-Power AlGaInAs/InP DFB Lasers with Low Divergence Angle

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High-power semiconductor DFB lasers with low divergence angle fundamental transverse mode operating at wavelengths near 1.31 μm have many applications such as analog and digital fiber communication, WDM pump sources, spectroscopy, remote sensing, free-space communication, laser-based radar, and wavelength conversion in nonlinear materials [1]. These devices can potentially reduce system costs by simplifying optical alignment and package processes [2]. Devices with narrow far-field patterns (FFPs) are highly desirable for simple, high-yield optical alignment, as a low divergence angle improves the coupling efficiency and imposes less stringent tolerances in the alignment between the device and the single-mode fiber (SMF). Until now most of the high-power low divergence angle 1.31 μm DFB laser is based on InGaAsP/InP material system which has lower characteristic temperature value T_0 [3]. Here we first demonstrate the high-power fundamental transverse mode 1.31 μm AlGaInAs/InP DFB laser with low divergence angle, enabling uncooled continuous-wave (CW) operation at high ambient temperatures**.**

The MQW region contains three compressive strain InGaAIAs quantum wells and four tensile strained InGaAIAs barriers. There is a specially optimized far-field reduction layer (FRL) (1.15Q) located below the MQW active layer to pull the optical mode into the lower n-cladding layer which will increase the near field pattern size, reduce the internal loss of the waveguide and the optical confinement factor, thus to increase the saturation output power and increase the linearity of the output current-power (I-P) curve. The buried InGaAsP grating layer is positioned 160 nm above the MQW layer. The DFB laser is fabricated using a two-channel shallow etching ridge process with the ridge width of 2 μm. The device cavity length is 500 μm long with a λ/4 phase shift within the cavity. As a final step, the sample was cleaved into individual laser bars with one side facets anti-reflection (AR) coated (1%) and the other facets high-reflection (HR) coated (90%). All the measured results below are from the AR coated facet under cw operation from a single device.

Figure 1 is the I-P curve, optical spectra, horizontal and vertical FFP measured at the temperature of 25℃, 40℃, 75℃ respectively. An output power of 110 mw @320 mA at 25℃ with a slope efficiency of 0.37 mW/mA and a threshold current of 22 mA, and 60 mW @255mA at 75℃ with a slope efficiency is 0.27 mW/mA and a threshold current of 31 mA were achieved (Fig.1(a)). The center wavelength is 1312.02 nm ,1313.26nm, 1316.24 nm at 25℃, 40℃, 75℃ temperature respectively with a DFB injection current of 170 mA. The change rate of wavelength with temperature is of 0.08 nm/ ℃. In all cases, the sidemode suppression ratio (SMSR) is more than 50 dB ((Fig.1(b)). At the injection current of 170 mA, the FFP divergence angle is 14°×21°@40℃ and 15.5°× 23° @75℃ (Fig.1(c), (d)). Compared with the conventional DFB lasers, the vertical divergence is reduced more than 10° which is highly desirable when coupling with a single-mode fiber.

In conclusion, a high-power 1.31 μm AlGaInAs/InP DFB laser with a fundamental transverse mode and low divergence angle has been successfully demonstrated. The threshold current is as small as 22 mA. The highest power is more than 110 mW with a slope efficiency of 0.37 mW/mA. The FFP is 14°×21°@40℃ and 15.5°× 23°@75℃.

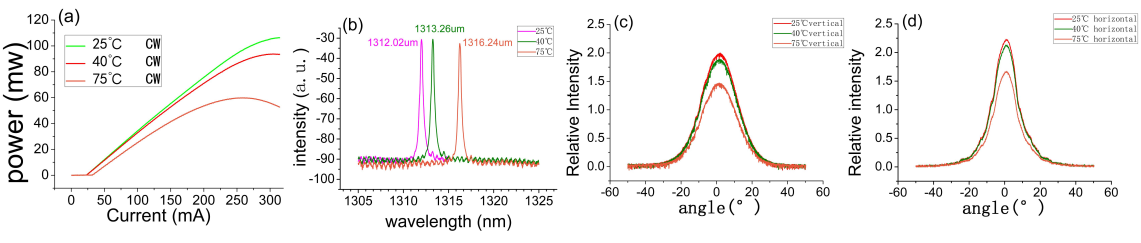

Fig. 1 (a)Measured I-P curve, (b)optical spectra, (c) vertical, and (d)horizontal FFP at 25℃, 40℃, 75℃ temperature.

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