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Ultra-Broadband Tunable External Cavity Laser with Chirped Multiple InAs/InP Quantum Dot Active Layers

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Abstract

We report an ultra-broadband tunable InAs/InP quantum dot external cavity laser with chirped multiple quantum dot layers as the active region. An ultra-broad wavelength tuning range of 221 nm from 1445 nm to 1666 nm covering S-C-L-U bands is achieved under an injection current of 0.5A. Furthermore, a maximum wavelength tuning range of 239 nm from 1429 nm to 1668 nm can be obtained under different currents.

1. Introduction

External cavity (EC) lasers based on quantum dot (QD) broad gain medium are greatly attractive for a variety of applications including spectroscopic analysis [1], biomedical treatments [2] and environmental monitoring [3]. In particular, InAs/InP QD-EC lasers emitting around 1550 nm are of great interest for fiber-optic data communication based on dense wavelength division multiplexing technology [4] and coherent optical communication systems [5]. There are two common technical paths to realize broadband tunable QD-EC lasers. One is to widen the modal gain spectrum of the QD assembles, such as by optimizing the growth conditions of the QDs or by adopting chirped multiple QD layers emitting at different center wavelengths [6]. Another is to eliminate Fabry-Perot (FP) resonance by applying antireflection/high-reflection (AR/HR) facet coating or bent waveguide geometry laser diode [7]. So far, there have been only a few reports about InAs/InP QD-EC lasers. For example, Ortner et al. demonstrated a broadly tunable QD-EC laser with a tuning range of 166 nm under different bias currents [8]. In contrast, a tunable range over 200 nm has been achieved for InAs/GaAs QD-EC lasers emitting around 1310 nm [6]. The wavelength tuning range for InAs/InP QD-EC lasers obviously falls behind that based on InAs/GaAs QDs and needs to be further improved.

In this work, we demonstrate an ultra-broadband tunable InAs/InP QD-EC laser by applying chirped multiple quantum dot layers as the active region and AR/HR facet coating. An ultra-broad wavelength tuning range of 221 nm encompassing S-C-L-U bands is achieved under a relatively low pulsed injection current of 0.5 A. Furthermore, a maximum wavelength tuning range of 239 nm can be obtained under different currents.

2. Experiments

The QD lasers used in the study were grown on InP substrates by metal-organic chemical vapor deposition. The active region of the lasers consisted of seven chirped stacked InAs/InGaAsP/InP QD layers with gradually changed height of QDs emitting at different wavelengths, as schematically shown in Fig.1. Ridge waveguide lasers with 6 μm width were fabricated by using standard photolithography and wet etching techniques. The laser chips were cleaved to form FP lasers with a cavity length of 1.5 mm. The rear facet of the FP lasers was coated with an anti-reflective reflectivity of about 0.1%, whereas the front facet had a high reflective reflectivity of 99%.

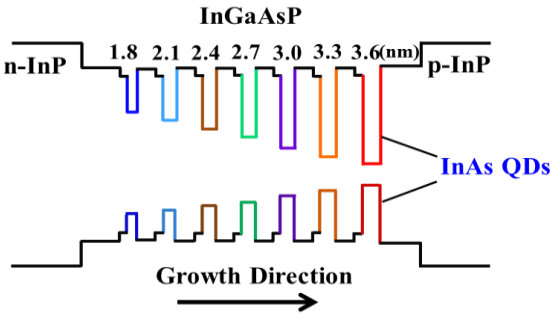

Fig. 1 Schematic energy diagram of the epitaxial layer structure for the chirped QD laser.

The QD lasers were investigated under a grating-coupled EC arrangement in the Littrow configuration, as illustrated in Fig. 2. The laser chip was mounted on the heat sink with the p-side down; a TEC chip was employed to continue maintaining laser operation at 16 ℃. The output light from the AR-coated facet was collimated through an AR-coated aspherical lens, and then coupled with a grating blazing at

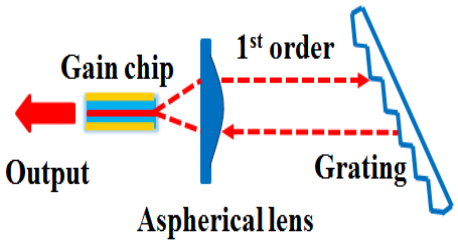

Fig. 2 Sketch of external cavity laser in Littrow configuration.

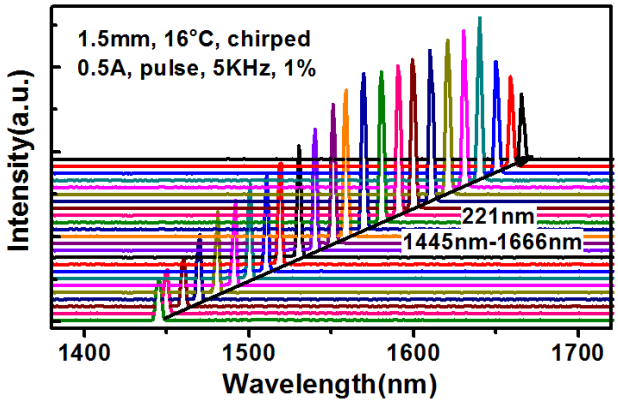

Fig. 3 Tuning spectra of the QD-EC laser, obtained under a pulsed injection current of 0.5A.

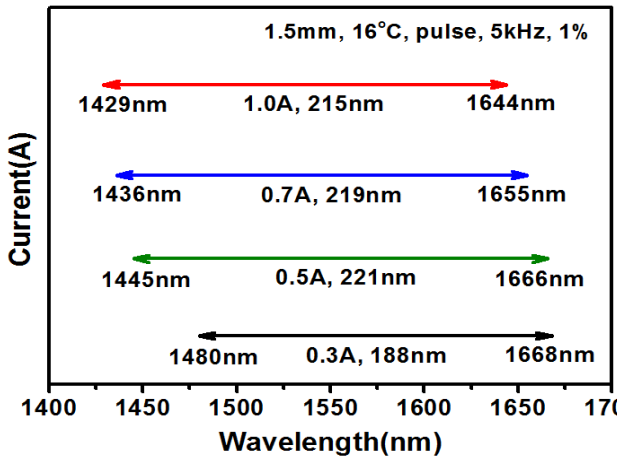

Fig. 4 Tuning range limits of the QD-EC laser, obtained under different injection currents.

1.6 μm (600 grooves/mm) to provide external feedback for the laser diode. A multiple fiber was placed in front of the HR facet to collect the emission light and acquire optical spectrum measurements.

3. Results and discussion

Figure 3 shows the tuning spectra of the QD-EC laser under a pulsed injection current of 0.5A. From the figure, an ultra-broad wavelength tuning range of 221 nm from 1445 nm to 1666 nm is achieved, which almost covers the S-C-L-U bands. Figure 4 summarizes the tuning range limits of the QD-EC laser under different injection currents. The whole tunable range can be further extended to 239 nm from 1429 nm to 1668 nm at the different injection currents.

4. Conclusions

We have demonstrated an ultra-broadband tunable InAs/InP QD-EC laser by adopting an active region with chirped multiple QD layers and AR/HR facet coating. An ultra-broad wavelength tuning range of 221 nm from 1445 nm to 1666 nm covering S-C-L-U bands was achieved under a relatively low pulsed injection current of 0.5 A. Furthermore, the wavelength tuning range could be further incresed to 239 nm from 1429 nm to 1668 nm under different injection currents.

Acknowledgements

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