Broadly Tunable External-Cavity Semiconductor Lasers in Optical-Communication Band Using Fabry-Perot Laser Diodes without Anti-Reflection Coating

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Abstract: Using proper quantum-well structure, carriers distribute over a broad bandwidth, suppressing self-oscillation of uncoated Fabry-Perot laser diodes, but still providing gain for external-cavity configuration. Then broadband tuning range of 200nm is achieved.

OCIS Codes: (140.3600) Lasers, tunable; (250.5980) Semiconductor optical amplifiers

1. Introduction

The mass transfer of data stimulates the broadband requirements in optical communication. Many efforts are thus devoted to expanding bandwidth. With optical fibers covering nearly from 1200nm to 1600nm with the loss less than 0.5dB/km, [1] components and systems for optical-fiber communication are therefore demanded to have similar broadband characteristics. However, the bandwidth of Er-doped fiber amplifiers/lasers is much less than the available bandwidth of optical fibers. Semiconductor lasers/amplifiers using multiple-quantum-well (MQW) engineering [2], [3], [4] thus provide alternative choices. Recently, 240 nm tuning range in the external-cavity semiconductor laser using nonidentical MQWs had been reported. [5] However, the threshold current is very high. This work reports broadband tuning of 200 nm with much less threshold current, achieved using uncoated Fabry-Perot (FP) laser diodes (LDs). As the gain bandwidth is broad, carriers distribute over a broad spectrum. Then under a certain pumping level, the FP-LDs do not oscillate due to the large mirror loss of the cleaved facets, while the devices still have the gain. As external feedback is provided at a certain wavelength, this device can oscillate. Theoretical analysis and experiments show that the broadband characteristics make the uncoated LDs suitable for broadband tuning.

2. Broadband tuning using uncoated LDs

With some algebraic derivations, we obtain three operation situations of uncoated FP-LDs: (i) lasing situation; (ii) round-trip amplification; (iii) single-pass amplification. Fig. 1 schematically shows the gain spectrum and pumping levels required for the above three cases. When the pumping level is between I_2 and I_3, the device provides sufficient gain for round-trip amplification, but insufficient gain for lasing without additional feedback. Therefore, when the uncoated FP-LD is set up in an external cavity, tuning can be achieved for the pumping level approximately between I_2 and I_3. The tuning range is approximately between λ_1 and λ_2.

Nonidentical MQWs were used for the broadband purpose. The broadband characteristics mean that more carriers are required to fill in the energy states spreading over the broad spectrum. Thus the threshold current for the uncoated LDs is larger than the LDs with conventional MQWs. The increased threshold then gives a large range of pumping level between I_2 and I_3 for operation in this work. Also, the gain spectrum is significantly broadened when the pumping level increases from I_2 to I_3.

FP-LDs with 3-μm-wide ridge-waveguide were fabricated. The threshold current is around 140 mA. Fig. 2 shows the broad spectra of the LDs before lasing. The LD is set up in an external cavity consisting of a grating for wavelength tuning. Fig. 3 shows the threshold current vs. the tuning wavelength. For the injection current below 140 mA, the wavelength is tunable from 1340 nm to 1540 nm without the concern of self-oscillation in the FP-LD. The output power could be more than 15 mW for a large tuning range. Details will be reported in the presentation.

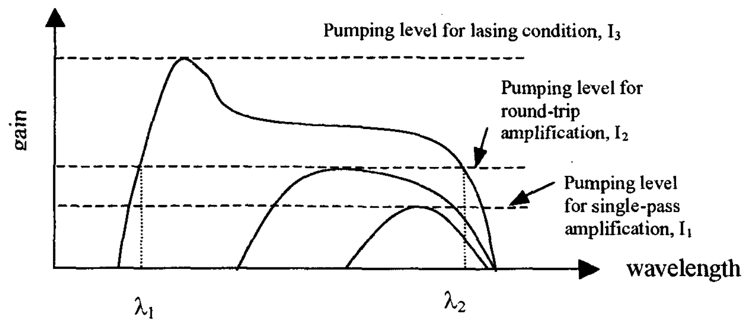

Fig. 1 The schematic of gain spectrum and pumping levels required for the three conditions.

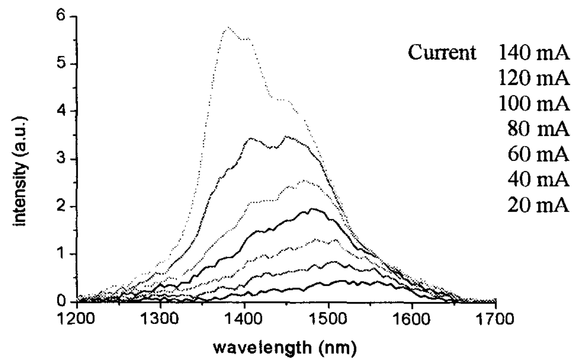

Fig. 2 The emission spectra of 300-μm LDs at different injection currents before lasing.

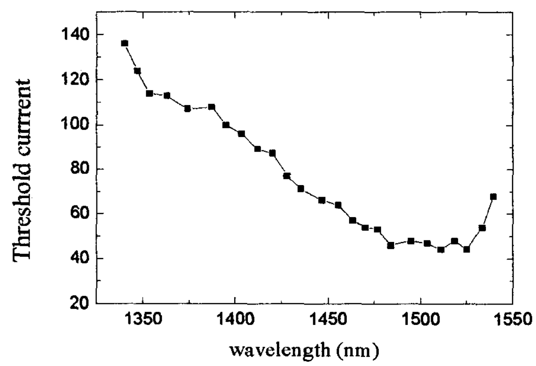

Fig. 3 Tuning threshold vs. wavelength.

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