Broadband Tunability of External-Cavity Semiconductor Lasers for Optical Communication

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Recent technology makes optical fibers have the loss less than 0.5dB/km for wavelength from 1300 nm to 1600nm. [1] Er-doped fiber amplifiers and lasers however only cover from C-band (1525nm to 1565nm) to L-Band (1570nm to 1610nm), so significant useful bandwidth is still not exploited. Semiconductor lasers/amplifiers using multiple-quantum-well (MQW) engineering [2], [3], [4] thus provide alternatives other than Er-doped fiber for the broadband purpose. However, the use of multiple-quantum-well (MQW) engineer for broadband purpose is not straightforward. [5] This work reports the significant influence of the layout of nonidentical MQWs on the broadband tunability of external-cavity semiconductor lasers. Study shows that, using properly designed MQWs as the laser gain material, the external-cavity semiconductor laser exhibits an extremely broadband tuning range, covering from 1300nm to 1540nm. On the other hand, if opposite sequential layout of MQWs is used, tunability covers only from 1290nm to 1450nm.

The designed quantum-well structure with broadband tunability has two $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ QWs near the n-cladding layer and three $\text{In}_{0.67}\text{Ga}_{0.33}\text{As}_{0.72}\text{P}_{0.28}$ QWs near the p-cladding layer. The quantum wells are separated by wide $\text{In}_{0.86}\text{Ga}_{0.14}\text{As}_{0.3}\text{P}_{0.7}$ barriers. Another quantum-well structure with an opposite well sequence is also experimented. The layer structures are shown in Fig. 1

Fig. 1 (a) layer structure for broadband tunability (b) opposite QW sequence exhibiting much narrower tunability

Bent-stripe ridge-waveguide semiconductor optical amplifiers (SOAs) were fabricated on those substrates. [5] The device length is about 500 μm . The SOAs are used in the external cavity. Broadband tunability is obtained for the layer structure shown in Fig. 1(a). The tuning spectra are shown in Fig. 2.

Fig.2 The tuning spectra at different wavelengths for the layer structure shown in Fig. 1(a).

In comparison, the tuning range for using SOAs with the layer structure shown in Fig. 1(b) is much narrower. Its threshold vs. tuning wavelength is shown in Fig. 3. The increase of threshold after 1450 nm limits the tunability. The reason for the limitation is attributed to the carrier distribution and different capture ability of those QWs. The details will be discussed in the presentation.

Fig.3 Threshold current vs. tuning wavelength for the layer structure shown in Fig. 1(b).

References:

- [1] Stern, T. E. and Bala, K.: 'Multiewavelength Optical Networks', Chap. 4, pp. 193-199, Addison-Wesley, MA, 1999.
- [2] Ching-Fuh Lin, Bor-Lin Lee, and Po-Chien Lin, *IEEE Photon. Technol. Lett.* 8, 1456 (1996).
- [3] X. Zhu, D. T. Cassidy, M. J. Hamp, D. A. Thompson, B. J. Robinson, Q. C. Zhao, and M. Davies, *IEEE Photon. Technol. Lett.* 9, 1202 (1997).
- [4] H. S. Gingrich, D. R. Chumney, S.-Z. Sun, S. D. Hersee, L. F. Lester, and S. R. Brueck, *IEEE Photon. Technol. Lett.*, vol. 9, pp. 155-157, 1997.
- [5] Ching-Fuh Lin, Bing-Ruey Wu, Lih-Wen Lai, and Tien-Tsorng Shih, *Opt. Lett.* July, 2001.