4.2~5.2 dB. We used these relatively small extinction ratios to avoid the modulation-induced mode-hopping. The overshoot in the resulting eye diagram was attributed to the reduced damping in the ECL. The red and blue lines indicate the BER curves measured in the back-to-back condition and after the transmission over 20-km long SMF, respectively, at three different wavelengths. The power penalties measured after the 20-km long transmission were <2.8 dB (@ BER = 10^{-10}). In this experiment, we set the effective LEF to be 1. For this purpose, we moved the lasing mode to be 0.17 nm longer than the wavelength of the peak PBR reflectivity. However, this wavelength is beyond the stable region of lasing mode since the free-spectral-range of this ECL is 0.24 nm (thus, its stable region is within ± 0.12 nm from the peak PBR reflectivity). This discrepancy can be explained by the mode-coupling phenomenon and its effect on the change of mode stability region [14, 15]. This mode-coupling induces larger gain suppression for neighboring modes of the lasing mode (symmetric part) and gain enhancement for longer wavelength mode (asymmetric part). The combined effect is that the stability region of a lasing mode becomes wider and its center moves to the longer wavelength as the power increases. As a result, two lasing modes were possible under the same condition as shown in Fig. 5 and the longer wavelength mode of the PBR could lase at this wavelength of higher mirror loss. The wavelengths where the modulation bandwidth and BER were obtained were the detuning limits where severe mode-hopping does not happen.

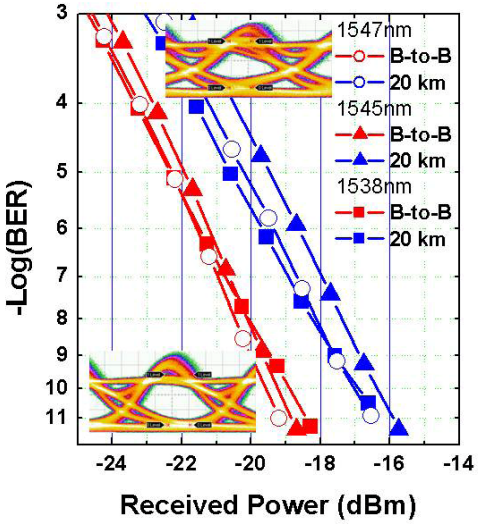

Fig. 7. Measured BER curves and eye diagrams of the 10-Gb/s signal (obtained from a directly modulated ECL) in back-to-back condition and after 20 km of SMF transmission.

5. Summary

We have developed a tunable ECL capable of operating at 10 Gb/s. This ECL was composed of a high-speed SLD and an optimally designed PBR. The total cavity length was reduced to 5 mm (equivalent free-space length) to maximize the modulation bandwidth. The tuning range, output power, and 3-dB modulation bandwidth of this ECL were measured to be >11.2 nm, >3 dBm, and >8 GHz, respectively. We directly modulated this ECL at 10 Gb/s (pattern length: 2^{31}-1) and transmitted the modulated signal over a 20-km long SMF. This was possible by detuning the operating wavelength of this ECL to the longer wavelength detuning of the ECL wavelength by ~0.17 nm from the peak PBR reflectivity. The power penalty was measured to be <2.8 dB (@ BER = 10^{-10}) after the 20-km long SMF transmission. We expect that the transmission performances of this ECL can be further improved by increasing the coupling efficiency between the high-speed SLD and PBR. In addition, we believe that this

ECL has a potential to be low cost and can be used as colorless light source in 10-Gb/s WDM-PON systems.

Acknowledgments

This work is supported by the IT R&D Program of MK/IIT (10039164), Rep. of Korea.

#171590 - $15.00 USD Received 28 Jun 2012; revised 3 Aug 2012; accepted 16 Aug 2012; published 21 Aug 2012