Noise Suppression of Spectrum-Sliced WDM-PON Light Sources Using FP-LD

Wooram Lee, Seung-Hyun Cho, Jaedong Park, Bong kyu Kim, and Byoungwhi Kim

ABSTRACT—We improved the performance of the spectrum-sliced light source for wavelength-division-multiplexed passive optical networks by employing a Fabry-Perot laser diode (FP-LD). We found that FP-LDs can suppress the intensity noise as significantly as using a gain-saturated semiconductor optical amplifier. The transmission characteristics were measured and analyzed both with and without employing an FP-LD.

Keywords—Wavelength division multiplexed-passive optical network (WDM-PON), spectrum-slicing, amplitude squeezing, semiconductor optical amplifier (SOA).

I. Introduction

There has been substantial interest in implementing a fiber-to-the-home (FTTH) network using wavelength-division-multiplexed (WDM) passive optical networks (PONs) [1]. This is because WDM-PONs can provide large transmission capacity, network security, and upgradability. However, for a practical deployment of WDM PON systems, it is important to develop a cost-effective light source operating at different wavelengths for each subscriber. The spectrum-sliced light source has been considered as an attractive candidate of WDM-PON light sources since this type can generate multi-channel light sources simultaneously [2]. However, the large intensity noise from an incoherent spectrum-sliced light source is a major limiting factor in transmitting data at a required rate and distance [3]. Recently, it has been reported that the intensity noise can be significantly reduced by passing through a gain-saturated semiconductor optical amplifier (SOA) [4]. However, the use of an SOA is an expensive solution for the performance enhancement of a WDM PON system.

In this paper, we have performed experiments with and without employing an FP-LD in the spectrum-sliced WDM-PON. We show that the intensity noise of the spectrum-sliced source can be suppressed by using a low-cost FP-LD instead of an SOA.

II. Experimental Setup

Figure 1 depicts the experimental setup to analyze the performance improvement of the spectrum-sliced light source by employing an FP-LD. The broadband light source consists of two-stage erbium doped fiber amplifiers and an optical bandpass filter (OBPF) to maximize the optical spectral density of the light reflected from the fiber Bragg grating (FBG) [5]. The light from the FBG has a full-width half maximum of about 0.7 nm and is injected into the anti-reflection (AR) coated FP-LD with a mode spacing of 1.2 nm and a threshold current of I_{th}=13 mA. The FP-LD is biased below the threshold current to be operated as a gain saturation medium [6]. The output from the FP-LD is externally modulated into the 622 Mb/s nonreturn-to-zero signal (extinction ratio : 10 dB) with an MZ-modulator. The bit error ratio (BER) was measured with a BER tester.

III. Results and Analysis

Figure 2 shows the output spectra of the light coming out from the FP-LD when the center wavelength of the spectrum-sliced light source is injected at around both a peak and a valley of the FP-LD cavity modes. Both spectra are similar in shape except for a small output power difference, which results from the low bias current and the AR-coated FP-LD [6].

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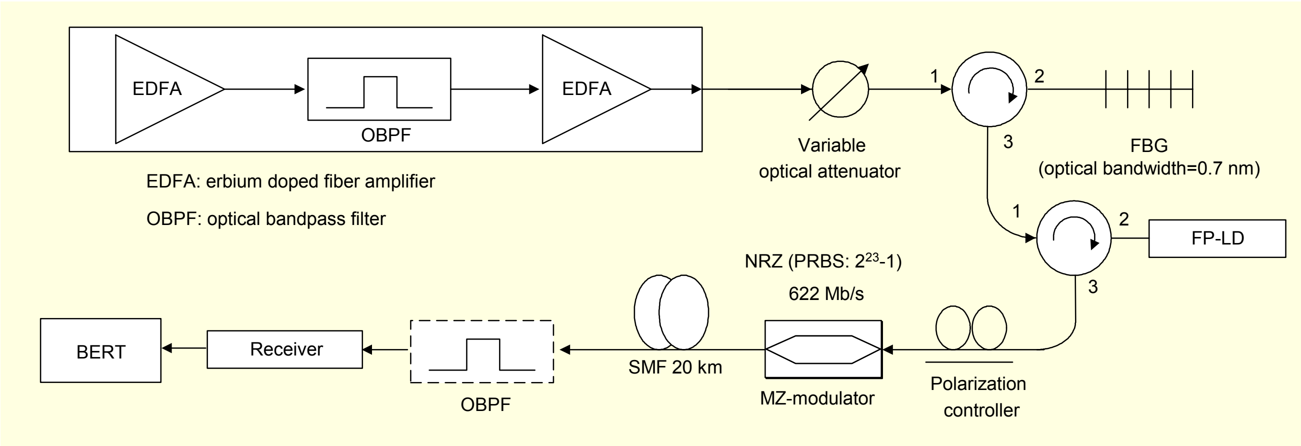

Fig. 1. Experimental setup.

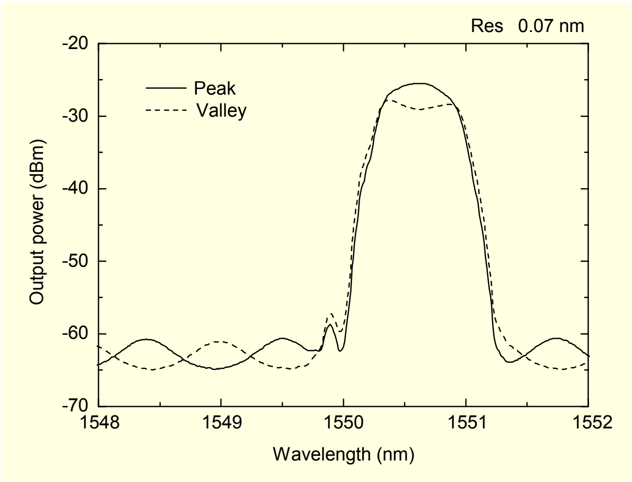

Fig. 2. Optical spectra of ASE when the center wavelength is located at the peak and valley of the FP-LD modes.

To see the gain saturation effect in the FP-LD, we measured the BER and receiver sensitivity for different injection powers at each peak and valley of the cavity modes. Figure 3 shows the measured BER values with and without the FP-LD. When the FP-LD is not used, we can observe an error-floor where the BER is above 10^{-8} because of a large intensity noise from the incoherent light source. On the other hand, when the spectrum-sliced light is reflected from the FP-LD with a bias current of 0.61 I_{th}, we can attain a BER<10^{-9} at the received power above -30 dBm. This is because the lowered gain slope of the FP-LD in the saturation region might lead to a significant decrease in the amplitude of the noise compared to that of a data signal. This result indicates that the FP-LD can be used to enhance the transmission performance of the spectrum-sliced light source. The BER performances of the light passing through a 20 km single-mode fibre (SMF) are slightly better than the back-to-back performance. This may be caused by the negative chirp of the MZ-modulator, contributing to the BER improvement.

We also measured the receiver sensitivity defined as the minimum received power to acquire a BER<10^{-9} as shown in Fig. 4. We removed the OBPF after the 20 km SMF, not considering the effect of the mode partition noise of the FP-LD output. The receiver sensitivity was degraded with increasing the power of the spectrum-sliced light injected into the FP-LD in the region below –10 dBm. This is because the intensity noise becomes more dominant than the thermal noise in the receiver as the optical power of the injected incoherent light increases, while that of the coherent light generated in the FP-LD itself is constant. On the other hand, when the injected light power exceeds –10 dBm where the FP-LD starts to show the gain saturation, the BER performance is further improved with increasing the injected light power since the amplitude squeezing effect caused by the gain saturation of the FP-LD reduces the intensity noise of the incoherent light source [7]. Even in the case where the center wavelength of the injected light is located at a valley of the FP-LD cavity modes, we could still get a BER<10^{-9} under the same injected ASE power range. This indicates that the FP-LD improves transmission characteristics of the spectrum-sliced light.

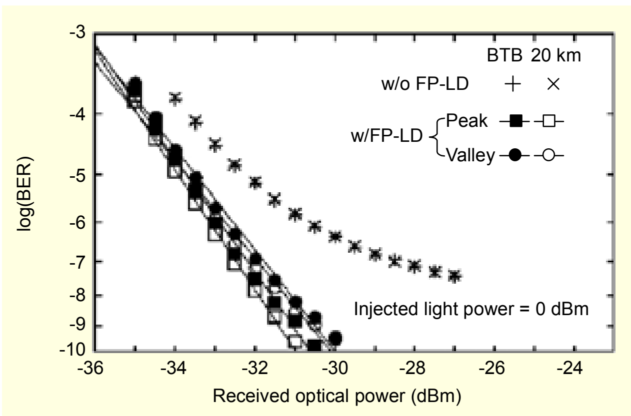

Fig. 3. Measured BER (at 622 Mb/s).

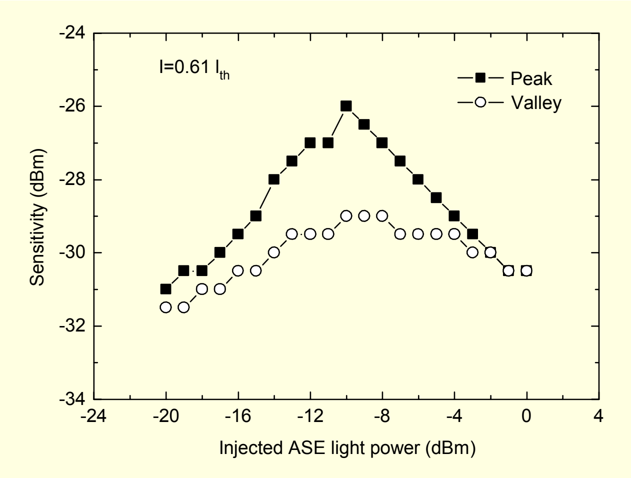

Fig. 4. Injected ASE power versus sensitivity (at 622 Mb/s and BER=10^{-9}).

IV. Conclusions

We have experimentally shown that an FP-LD can be used to overcome the transmission performance limitation of a spectrum-sliced light source caused by the intensity noise. We found that the intensity noise can be significantly suppressed by employing a low-cost FP-LD instead of an SOA. The noise reduction ratio increases as the injection power increases due to amplitude-squeezing effect of the FP-LD. It can be concluded that this scheme can be used as a cost-effective solution of WDM-PON.

References

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