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SOA AND RSOA BASED FULL-DUPLEX DWDM TRANSMISSION SYSTEM

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ABSTRACT

Due to rapid increases of the on-demand services a bidirectional DWDM transport system employing SOA and RSOA is proposed and demonstrated. Brilliant performances of BER were achieved for both down/up-link transmissions over a 100-km SMF.

KEYWORDS: DWDM, RSOA, SOA

1. INTRODUCTION

Due to rapid increases of on demand services like video conferencing on demand game, movie etc. Dense-wavelength-division-multiplexing (DWDM) transport systems can fully employ very high bandwidth in a bidirectional single mode fiber by taking advantage of advanced optical technology that is able to launch and multiplex multiple wavelengths in one fiber [1-3]. A DWDM transport system is envisioned to have a multiple number of distributed feedback laser diodes (DFB LDs) which are wavelength-selected for each channel and controlled to operate at a specific wavelength; but this process is complex and not economy. For a successful implementation of DWDM transport systems, it is necessary to develop feasible and low complexity light source. To design economy system using SOA based broad band ASE light source, and optical band pass filters are feasible technique in which narrow wavelength is picked up from a broadband light source and externally modulated by the Mach-Zehnder modulator (MZM) to transmit resultant modulated wave as a optical signals. It is smart because it avoids the need of multiple DFB LDs with well-defined wavelengths. In recent studies, reflective semiconductor optical amplifier (RSOA) is widely used in the light wave transport systems due to its wavelength reuse and remodulation characteristics [4-6]. RSOA, which has broad and flat amplified spontaneous emission (ASE) spectrum, is expected to replace multiple DFB LDs in DWDM systems by spectral sliced technique using optical band pass filter. In this paper, architecture of bidirectional DWDM transport systems based on SOA and RSOA is proposed and demonstrated. SOA is used as a broadband light source, in which the bandwidth of the SOA-ASE spectrum is as wide as 80 nm. And the RSOA is used to reuse a multiple number of wavelengths and remodulate the upstream data signal with data rate is 1.5Gbps. Impressive performances of bit error rate (BER) and clear eye diagram were obtained over a 100-km bidirectional single-mode fiber (BSMF) down-link and up-link transmissions

2. EXPERIMENTAL SETUP

Figure 1 shows the experimental configuration of our proposed bidirectional DWDM transport systems based on SOA and RSOA. The broadband SOA based -ASE light source is amplified by erbium-doped fiber amplifier (EDFA-1), externally modulated with 2.5 Gbps data signal, efficiently split into two optical channels by a 1×2 optical splitter and passes through two optical band-pass filters (OBPFs), and multiplexed back into the EDFA-2 by a 2×1 optical combiner. The 2.5 Gbps data signal has a pseudorandom binary sequence (PRBS) length of 2^{11}-1. All EDFAs have similar optical characteristics, with an output power of 17 dBm and a noise figure of 4.5 dB, at an input power of 0 dBm. The spectral sliced two wavelengths of λ_1 and λ_2 are externally modulated with 2.5 Gbps downstream data signal by MZM modulator. An optical circulator (OC1) was placed after the EDFA-2, to

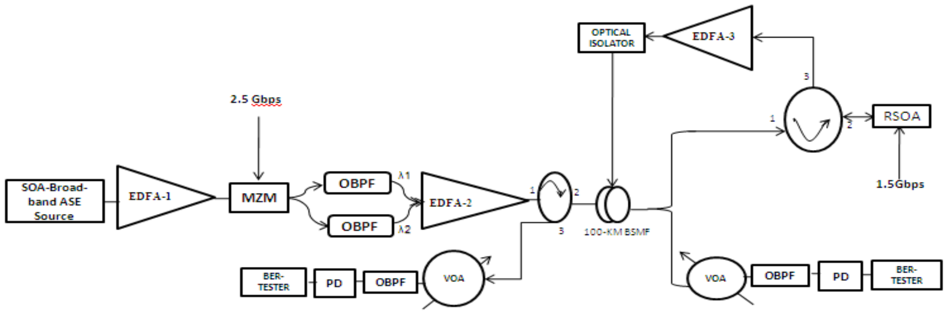

Figure 1: Experimental Setup for Bidirectional DWDM Proposed System

Divide both downstream and upstream data signals. Over a 100-km BSMF transmission, the downstream optical signals were split by a 1×2 optical splitter. One half of the signals pass through a variable optical attenuator (VOA), wavelength picked up by an optical BPF (OBPF), and detected by an Avalanche photodiode (APD). The other half of the signals were circulated and reused by the OC2 and RSOA. For up-link transmission, the downstream optical signals are directly modulated through the RSOA by 1.5 Gbps upstream data signal, with a PRBS length of 2^{11}-1. The optical signals are circulated and amplified by the OC2 and the EDFA-3 before coupled into the same 100 km BSMF link. Since both of the downstream and upstream signals are transmitted at the same BSMF, an optical isolator is placed after the EDFA-3 to avoid the downstream data signals. BER values were measured and analyzed at both sites by BER tester and the eye diagrams were observed by Eye-Analyzers.

3. RESULT

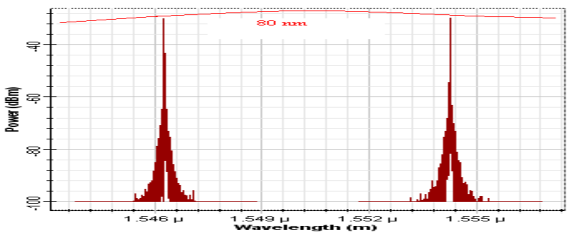

Figure 2: Shows that the Optical Spectrum of SOA-ASE Source

The optical spectrum for the SOA-ASE and two selected wavelengths is present in Figure. 2. The bandwidth of the SOA-ASE spectrum is as wide as 80 nm (1505-1585 nm), with a flatness of 3 dB. We select the wavelengths of λ_1 (1546.26 nm) and λ_2 (1554.26 nm) using spectrum-sliced technique with large channel spacing of 8 nm to avoid the crosstalk that arises from the incomplete isolation of the adjacent channels. When an ASE is used as the light source of DWDM systems, the signal-to-noise ratio (SNR) of systems is given by [7]:

$$SNR = B_{opc}/B_{elec} \qquad (1)$$

Where B_{opc} is the optical bandwidth and B_{elec} is the electrical bandwidth. The SNR is proportional to the optical bandwidth, and inverse proportional to the electrical bandwidth. They are small electrical bandwidths compared to the optical bandwidth. Thereby, the SNR value is improved in which causing systems with better performances. The gain model of RSOA which explains the gain saturation phenomenon can be stated as [8]:

$$G_s = P_{sat,\ out} / P_{sat\ ,\ in} \tag{2}$$

Where $P_{sat,\ out}$ is the output saturation power, $P_{sat\ ,\ in}$ is the input saturation power, and G_s is the saturation gain at, $P_{sat,\ out}$. The input saturation power $P_{sat\ ,\ in}$ is defined as the optical power injected into the RSOA where optical gain decreases by 3 dB. It is obvious that $P_{sat\ ,out}$ and G_s depend on the $P_{sat\ ,\ in}$; higher $P_{sat\ ,\ in}$ leads to higher $P_{sat\ ,\ out}$ and lower G_s . Due to long haul transmission over a BSMF using the same wavelengths in both directions; it may happen that Rayleigh backscattering noise limits the systems seriously. The Rayleigh backscattering noise is generated due to both the back-reflection of downstream signal and that of remodulated upstream signal in a RSOA. To reduce the Rayleigh backscattering noise caused by the remodulation, the RSOA is operated in the saturation region. Figure. 3 shows the measured BER values for up-link transmission by varying the RSOA injection power level -10 and -20 dBm; in other words, from the linear region to the saturation one. The eye diagrams corresponding to the RSOA injection power levels of -10 and -20 dBm are demonstrated in Figure. 4(a) and (b), respectively. Amplitude and jitter fluctuations in the signal are clearly observed in Figure. 4(a). Originally, the downstream data signals should be erased by the RSOA. With the elimination of the downstream data signals, the upstream data signal is remodulated by the RSOA. Nevertheless, the downstream data signals are not sufficiently suppressed since the RSOA is operated in the linear region, leading to fluctuations for eye diagram. However in Figure. 4(b), amplitude and jitter fluctuations in the signal are clearly reduced due to the sufficient suppression of the downstream data signals. The measured down/up-link BER curves for 100 Km BSMF and B-t-B as RSOA with -10 dBm injection power as a function of the received optical power level are plotted in the Figure. 5. For down-link transmission and at a BER of 10^{-9}, the received optical power level is -24.1 dBm. For up-link transmission and at a BER of $10^{-9,}$ the received optical power level is -26.6 dBm. Good BER performances are achieved over a 100-km BSMF transport for both down/up-link transmissions. At a BER of 10^{-9}; there exist large power penalties of 8.7 dB (down-link) and 7.3 dB (up-link) between the BTB and over 100-km BSMF transmission. These large power penalties are owing to fiber dispersion-induced penalties. BER performances might be affected by the crosstalk from the adjacent channels (linear crosstalk) and the stimulated Raman scattering (SRS)-induced crosstalk (nonlinear crosstalk). However, linear crosstalk can be avoided if selected wavelengths with large channel spacing and SRS-induced crosstalk can be reduced if channel powers are made so equal that SRS-induced amplification is negligible. All EDFAs used in systems have flat amplifier gain (with a flat gain within 3 dB over entire C-band); flat amplifier gain in a wavelength range of a few tens of nanometers can be very useful in reducing the Raman-induced crosstalk. No effect of crosstalk is observed between optical channels because of large channel spacing and equal channel powers; i.e., BER performances are not degraded by the crosstalk.

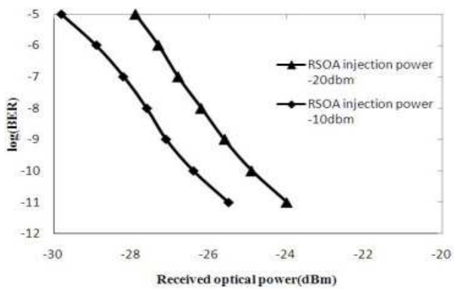

Figure 3: The Measured BER Values for Up-Link Transmission by Varying the RSOA Injection Power Level of -20dBm and -10dBm

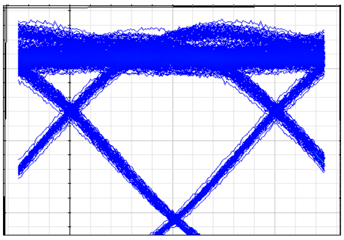

Figure 4(a): The Eye Diagram Corresponding to the RSOA Injection Power Level -20dbm

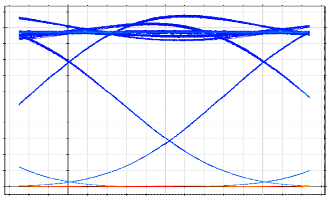

Figure 4(b): The Eye Diagram Corresponding to the RSOA Injection Power Level -10dBm

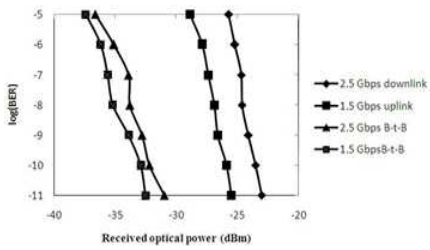

Figure 5: The Measured Down/Uplink BER Graph as RSOA Injection Power Level of -10dBm with Received Optical Power

4. CONCLUSIONS

This study presents a two-wavelength bidirectional DWDM transport system based on SOA and RSOA. The SOA are taken on the role is used as a broadband light source, and the RSOA is used to reuse the multiple downstream wavelengths and remodulate the upstream data signal. Since our proposed systems do not use multiple DFB LDs with well-defined wavelengths, it reveals a prominent one with simpler and more economic advantages than that of the traditional bidirectional DWDM transport systems**.**

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REFERENCES

1. Sang-Mook Lee, Ki-Man Choi, Sil-Gu Mun, Jung-Hyung Moon, and Chang-Hee Lee, *Member*, *IEEE*, “Dense WDM-PON Based on Wavelength-Locked Fabry–Pérot Laser Diodes,”*IEEE PHOTONICS TECHNOLOGY LETTERS,*” VOL. 17, NO. 7, JULY 2005.

2. R. D. Feldman, E. E. Harstead, S. Jiang, T. H. Wood, and M. Zirngibl, “An evaluation of architectures incorporating wavelength division multiplexing for broad-band fiber access,” *J. Lightw. Technol.*, vol. 16, no. 9,

pp. 1546–1559, Sep. 1998.

3. Anindya Sundar Das, Ardhendu Sekhar Patra, “Simultaneous Signal Transmission of different data-rates in a DWDM System employing external injection locking technique”, *Journal of Optics and Laser Technology*, 64, 2014, pp. 23-27.

4. Elaine Wong, Ka Lun Lee, and Trevor B. Anderson, “Directly Modulated Self-Seeding Reflective Semiconductor Optical Amplifiers as Colorless Transmitters in Wavelength Division Multiplexed Passive Optical Networks,” JOURNAL OF LIGHTWAVE TECHNOLOGY, VOL. 25, NO. 1, JANUARY 2007.

5. N. Deng, C. K. Chan, L. K. Chen, and F. Tong, " Data re-modulation on downstream OFSK signal for upstream transmission in WDM passive optical network,” *Electron. Lett.*, vol. 39, no. 24, pp. 1741–1743,Nov. 2003.

A. S. Das, and A. S. Patra, Bidirectional transmission of 10 Gbps using RSOA based WDM-PON and optical carrier suppression scheme, Journal of Optical Communications. Volume 35, Issue 3, Pages 239–243, ISSN (Print) 0173-4911, DOI: 10.1515/joc-2013-0166, 2014.

6. Chowdhury, H. C. Chien, and G. K. Chang, " Centralized, colorless, wavelength reusable 25 GHz spaced DWDM-PON with 10 Gb/s DPSK downstream and re-modulated 10 Gb/s duobinary upstream for next generation local access system," presented at the ECOC 2008, Paper We.3.F.4.

7. W. Chow” Wavelength remodulation using DPSK down-and-upstream with high extinction ratio for 10-Gb/s DWDM-passive optical networks,” *IEEE Photon. Technol. Lett.*, vol. 20, no. 1, pp. 12–14, Jan. 1, 2008.