1607 nm DFB Fibre Laser for Optical Communication in the L-band

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Abstract: A DFB fibre laser operating at 1607 nm having 75.4 dB signal to ASE ratio and RIN below -150 dB/Hz is introduced. An external cavity laser is used for comparison in a 10 Gbit/s transmission experiment over 72 km of standard single mode fibre with no observable difference.

Introduction

Recent development in broadband optical amplifiers has expanded the gain bandwidth of erbium doped fibre amplifiers above the 1600 nm limit [1]. Optical transmission in the L-band (1570 nm - 1610 nm) increases the bandwidth available for WDM transmission in the low loss region of standard fibres, thereby increasing the network capacity and flexibility [2]. Further, it enables WDM transmission on installed dispersion shifted fibres, where a sufficient amount of dispersion suppresses channel crosstalk generated by four-wave mixing [2]. DFB fibre lasers use the same gain medium as the optical amplifiers and are thus a promising candidate to provide high quality laser sources for L-band transmission.

We report device characteristics and system performance results for a new DFB fibre laser operating at 1607 nm. The system results obtained using an external cavity semiconductor laser are included for comparison.

Device Characteristics

Bragg grating based DFB fibre lasers with grating and phase-shift induced by UV-irradiation were introduced in 1995 [3] and have since then been proven to be attractive sources for WDM telecommunication [4] and spectroscopy. These lasers have excellent temperature stability and can be positioned at a specific wavelength with a precision of 0.05 nm. In this work a 1607 nm laser was fabricated using a very strong Bragg grating in a high-gain erbium doped fibre. Single-frequency and single-polarisation lasing were obtained using a UV-induced, polarisation dependent phase-shift in the centre of the Bragg grating [5]. Fig. 1a shows the laser spectrum when pumped by 80 mW 980 nm light. The laser output power versus the available pump power is shown in Fig. 1b. The lasing threshold is around 20 mW pump power.

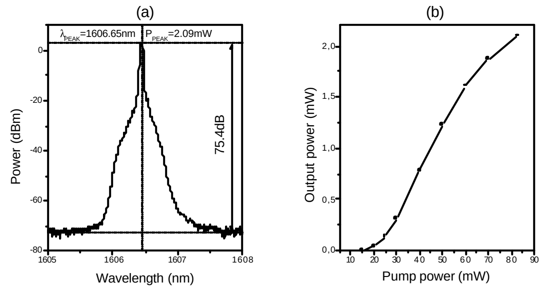

Fig. 1 (a) Laser spectrum measured by optical spectrum analyzer with 0.05 nm resolution, (b) Output power from DFB fibre laser versus available pump power.

The laser spectrum and output power were measured by an optical spectrum analyzer with 0.05 nm resolution. At 80 mW pump power the laser output is 2.1 mW and the ASE noise floor is suppressed by 75 dB. The good noise performance is also seen in the relative intensity noise (RIN) measurement (Fig. 2). The RIN measurement was done using an HP Lightwave Analyzer, and the laser RIN is below -150 dB/Hz for frequencies above 10 MHz.

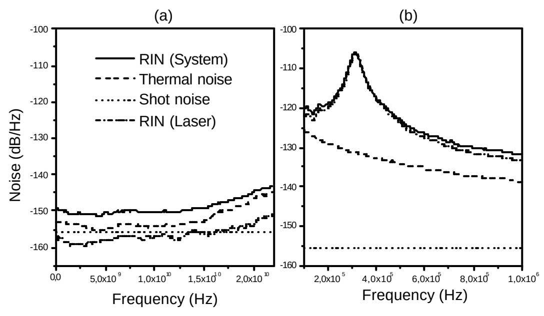

Fig. 2 Measurement of the laser noise spectrum. (a) Full range of the Lightwave Analyzer, (b)

Zoom around the relaxation frequency of the laser (313kHz)

Transmission experiment

To assess the lasers performance as a source for L-band optical communication systems, a transmission experiment was performed. The influence of the fibre lasers narrow linewidth in the region of 1 KHz is estimated by comparing the transmission performance to that of an external cavity laser (ECL) with a linewidth of several hundred kilohertz. The experimental setup is shown in Fig. 3.

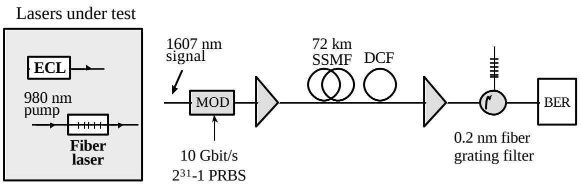

Fig. 3 Experimental setup.

Each laser under test, emitting a signal power of 5 dBm at 1607 nm, is NRZ-modulated externally at 10 Gbit/s with a PRBS length of 2^{31}-1. An L-band amplifier boosts the signal after modulation to ~6 dBm, which is launched directly into 72 km standard single mode fibre followed by dispersion compensating fibre (DCF). The receiver consists of a high gain L-band amplifier, a fibre based Bragg grating bandpass filter and a pin-diode followed by electrical amplification and a BER test-set. The optical band-pass filter has a 3 dB bandwidth of 0.2 nm. The obtained eye diagrams after transmission for the two lasers are shown in Fig. 4.

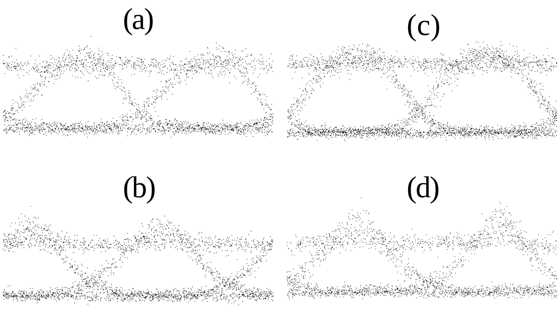

Fig. 4. Eye diagrams before and after transmission. (a) Fibre laser back-to-back. (b) Fibre laser after transmission. (c) ECL back-to-back. (d) ECL after transmission.

No visible difference in the eye diagrams for the fibre laser and the external cavity laser is observed before (back-to-back) or after transmission. It is noted that pulse shaping occurs during transmission. This is ascribed to both imperfect dispersion compensation and the narrow optical filtering of the Bragg grating filter. The equal transmission performance is also observed from the BER characteristics seen from Fig. 5. A small negative penalty of 0.5 dB@10^{-9} is seen for the fibre laser before transmission, which is mainly ascribed to reflections from the Bragg grating filter due to reduced isolation of the circulator in the long wavelength regime. This is further emphasised by the lack of difference in the BER characteristics for the external cavity laser before and after transmission.

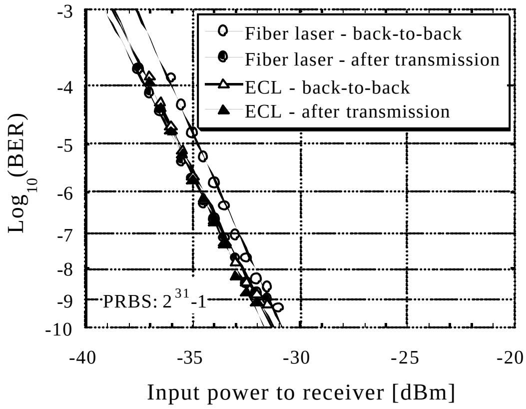

Fig. 5 BER characteristics for lasers under comparison

Nevertheless, no difference between the fibre laser and the external cavity laser after transmission is observed, despite the very narrow linewidth of the fibre laser.

Conclusion

In conclusion, the fibre lasers based on UV-written Bragg gratings have proven to be a very stable, high quality laser source in the long wavelength region. They have a very low noise emission and have shown transmission capabilities indistinguishable from that of an external cavity laser. Furthermore, with their narrow linewidth and excellent stability they are an obvious possibility in DWDM systems covering an 80 nm wavelength range from 1530 nm to 1610 nm.

Acknowledgements

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