50 CHANNEL AND 50 GHZ MULTI-WAVELENGTH LASER SOURCE

N. Pleros, C. Bintjas, M. Kalyvas, G. Theophilopoulos, K. Vlachos and H. Avramopoulos

Department of Electrical and Computer Engineering, National Technical University of Athens, Zographou, GR 15773, Athens, Greece
Email: hav@cc.ece.ntua.gr

Abstract: Simultaneous oscillation of 50 wavelengths, spaced at 50 GHz, is demonstrated from a stable Fabry - Perot ring laser source that uses two semiconductor optical amplifiers. Power variation between channels is less than 1.6 dB.

Introduction

Very high capacity DWDM systems are of great practical interest. As the number of wavelength channels has continued to increase in these systems, the cost and complexity of transmitters is increasing because of the large number of individual laser diodes. To tackle these issues a number of alternative techniques for obtaining multi-wavelength operation from single laser sources has been investigated. One of these is spectrum slicing and this has been applied successfully to LED's /1/, superluminescent diodes /2/, amplified spontaneous emission from EDFAs /3/, supercontinuum generation in fiber /4/ and femtosecond pulses /5-7/. A different approach has also been investigated, in which multi-wavelength oscillation was obtained in semiconductor optical amplifier (SOA) lasers with the use of intra-cavity gratings and Fabry-Perot etalons /8-10/ and in a liquid nitrogen cooled EDF laser with a Lyot-type comb filter resulting in 24 line operation /11/.

In the present communication we present a source that uses two SOAs in combination with a fiber Fabry - Perot filter to demonstrate simultaneous, 50-line operation with nominal line spacing of 50 GHz. The maximum power variation between the 50 wavelength lines was less than 1.6 dB.

Experiment

Fig. 1 shows the experimental setup of the multiwavelength ring source.

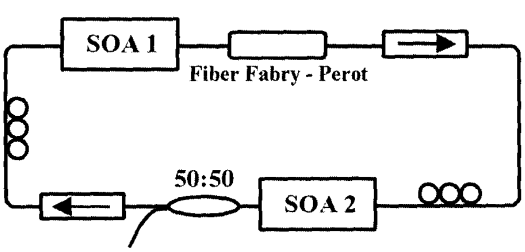

Figure 1: Experimental layout of the multi-wavelength ring laser.

It comprises of a fiber Fabry Perot filter with free spectral range (FSR) 47.75 GHz, finesse 8.1 and 12 dB loss. Gain was provided by two bulk InGaAsP/InP ridge waveguide SOAs, with facets angled at 10^0 and antireflection coated. SOA 1 was 500 μm long, provided small signal gain of 23 dB at 1522 nm, when driven with a 250 mA dc current. SOA 2 was 250 μm long, provided small signal gain of 10.5 dB at 1530 nm, when driven with a 125 mA dc current. SOA 1 and SOA 2 exhibited 1.5 dB and 2.5 dB small signal gain polarization dependence between their TE and TM axes, respectively and polarization controllers were used at their input ports. Output from the source was obtained with a 50:50 fused fiber coupler.

Simultaneous multi-wavelength operation at room temperature can be achieved with a semiconductor optical amplifier using its heterogeneously broadened structure. A laser cavity with a single SOA oscillates at slightly longer wavelengths when the signal is coupled to its high gain axis (TE) as opposed to its low gain axis. It is therefore possible to extend the oscillating bandwidth by coupling the signal to both axes. The oscillating bandwidth and average power from the source can be further increased, by introducing a second SOA with a slightly offset peak gain. Optimization of the cavity losses and adjustment of the drive currents for the two SOA's, can result in a broad, uniform oscillating spectrum. Fig. 2 displays such an oscillating spectrum with a 20 nm width from the cavity of fig. 1. The drive currents for SOA1 and SOA2 were 135 mA and 125 mA respectively.

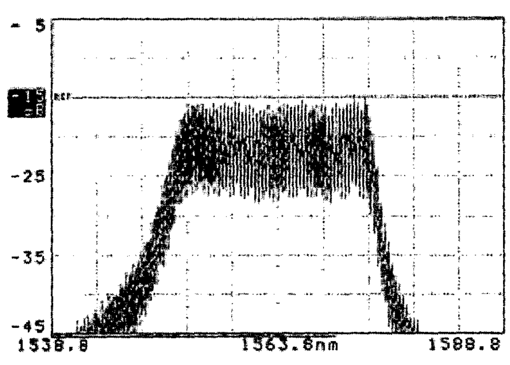

Figure 2: Optical spectrum of the multi-wavelength laser (sweep width 5 nm/div).

Fig. 3 shows the 50 central, oscillating lines which show less than 1.6 dB of power variation between them. The total output power from the source was 2 mW and the distribution in the 50 most intense lines is shown in fig.4.

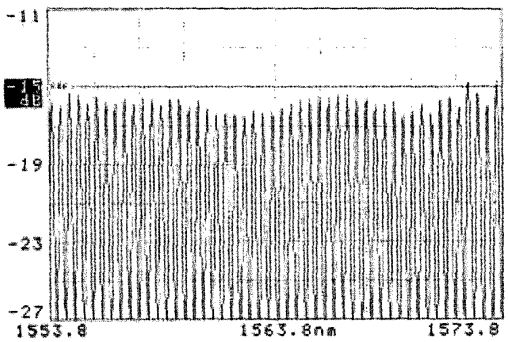

Figure 3: Optical spectrum of the multi-wavelength laser (sweep width 2 nm/div).

If a single SOA is used in the cavity of fig.1 (SOA 1), then a flat oscillating spectrum of width of 14 nm can be obtained, resulting in 35 simultaneously oscillating wavelength lines.

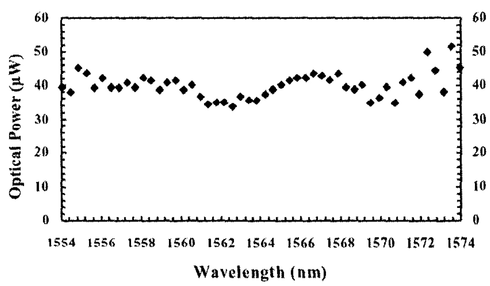

Figure 4: Power distribution for output wavelengths.

The FWHM of each oscillating wavelength was measured with an optical spectrum analyzer and was found to be 0.16 nm, which was close to the resolution of the instrument. In order to improve on the accuracy, the lines were also measured with a fiber Fabry-Perot (FFP), having 5.2 GHz bandwidth. With this technique the oscillating linewidth of each line was found to be 7 GHz, so that the decorrelated bandwidth is less than 5 GHz.

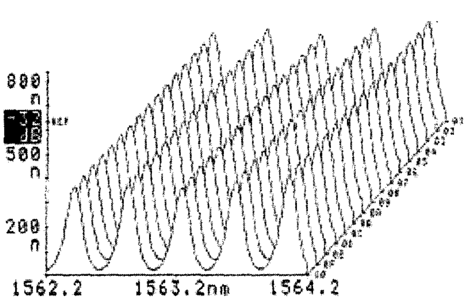

Figure 5: Output time evolution over 90 minutes.

The extinction between the lines was measured with the same technique and was found to be better than 15 dB.The oscillating lines were found to be co-polarized and nearly linearly polarized at the output of the source.

The stability of the multi-wavelength laser was also tested. Due to the relatively short cavity the output remains stable for hours in laboratory conditions. Fig. 5 shows the 3-D temporal evolution of five lines from the profile. The figure is plotted linearly, covers a 90 minutes time-span and displays the good stability characteristics of the source.

Conclusions

In summary, we have demonstrated a simple and stable in room temperature multi-wavelength source. It combines two semiconductor optical amplifiers and a fiber Fabry - Perot filter to generate simultaneously 50 co - polarized channels across 20 nm. The power variation between them is less than 1.6 dB, their extinction was greater than 15 dB and their linewidth was calculated less than 5 GHz. The source may be used with flat gain EDF amplifiers in laboratory, DWDM transmission evaluation experiments and reduce substantially the cost of the transmitter.

References

/1/ M.H. Reeve, A.R. Hunwicks, W. Zhao, S.G. Methley, L. Bickers and S. Hornung, Electron. Lett. **24**, 389, 1988.

/2/ S.S. Wagner and T.E. Chapuran, Electron. Lett. **26**, 696, 1990.

/3/ J.S. Lee, Y.C. Chung and D.J. DiGiovanni, IEEE Phot. Tech. Lett. **5**, 1458, 1993.

/4/ T. Morioka, K. Uchiyama, S. Kawanishi, S. Suzuki, M. Saruwatari, Electron. Lett. **31**, 1064, 1995.

/5/ L. Boivin, M. Wegmueller, M.C. Nuss and W.H. Knox, IEEE Phot. Tech. Lett. **22**, 446, 1999.

/6/ B.C. Collings, M.L. Mitchell, L. Boivin and W.H. Knox, ECOC 1999, paper PD1-3.

/7/ S.A.E. Lewis, M.J. Guy, J. R. Taylor, R. Kashyap, Electron. Lett. **34**, 1247, 1998.

/8/ H. Shi, G. Alphonse, J. Connolly, P. Delfyett, Electron. Lett. **34**, 179, 1998.

/9/ T. Papakyriakopoulos, A. Stavdas, E.N. Protonotarios and H. Avramopoulos, Electron. Lett. **35**, 717, 1999.

/10/K. Vlachos, K. Zoiros, T. Houbavlis and H. Avramopoulos, IEEE Phot. Tech. Lett. **12**, 25, 2000.

/11/N. Park and P. F. Wysocki, IEEE Phot. Tech. Lett. **8**, 1459, 1996.