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An 8-channel fibre-DFB laser WDM-transmitter pumped with a single 1.2W Yb-fibre laser operated at 977nm

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Abstract *A 50GHz fibre-DFB laser transmitter source is demonstrated pumped by a CW fibre laser source at 977nm. Up to 9dBm of power is achieved per fibre DFB-laser with maintenance of all key operational parameters.*

Introduction

Fibre DFB-lasers have been demonstrated as a promising alternative source in WDM-transmission on a number of occasions [1,2,3]. It has previously been demonstrated how they can be designed to meet most requirements in dense WDM transmission, due to their many inherently attractive performance parameters. Powers in excess of 20mW with low insertion-loss, single polarisation operation with a keyed axis output [4] for easy connectivity to external polarisation sensitive components and very low relative intensity noise (RIN) at telecommunication transmission frequencies to mention just a few key points, are adding to their very attractive features. If a drawback indeed has existed it has been the requirement to operate the lasers with expensive semiconductor pump-diodes that typically have had the additional requirement to be Bragg grating stabilised to provide a constant pump-wavelength.

A number of WDM-DFB fibre laser configurations supported by a single pump-unit have been demonstrated in the past, these include a serial configuration where 5 DFB lasers were simultaneously pumped at 1480nm [2], and a superstructure approach where a DFB laser had its refractive index profile modulated with a superstructure function to produce 2 identical power channels with a separation determined by the superstructure period [3]. In this paper we demonstrate for the first time the pumping of fibre DFB-lasers with another fibre-laser source in a parallel configuration where 8 fibre DFB-lasers on an ITU-grid are simultaneously pumped by a single high-power (1.2W) fibre-laser operating at 977nm. Each laser produces ~9dBm of output power with a 50GHz frequency separation and we compare the performance of the DFB-fibre lasers when pumped by either a semiconductor LD or the 977nm fibre-laser source.

Experimental setup and transmitter lay-out

Fig. 1 shows the lay-out of our WDM-transmitter. A 977nm pump-signal of up to 1.2W of optical power from a cladding-pumped (@915nm) cw Yb-fibre laser coupled and split into 8 equal outputs through 7, 3dB 980nm couplers. The coupling-loss to the splitter is measured to be ~1.8dB due to a slight modal mismatch between the fibre-laser and the 980nm coupler-fibre. Furthermore the excess-loss in the splitter is measured to be 1dB giving a total of 11.8dB insertion-loss per channel from the pump-source. When operated at 1.2W this gives a total of ~70mW of pump-light at each output port of the splitting-tree.

8 asymmetric π phase-shifted fibre DFB-lasers [3] of length 5 cm and separated in frequency by 50GHz are written into a highly doped Er/Yb fibre with a photosensitive annular ring to the core [5]. The lasers are operated in a forward pumping configuration to eliminate the need for a pump/signal WDM and exhibit an forward output power-ratio of ~50:1. An isolator is employed at the output side of the lasers to prevent back-reflections that otherwise could cause the output to become unstable. They are written using our continuous grating writing technique operated with 244nm CW UV-light and a phase-mask assembly [3].

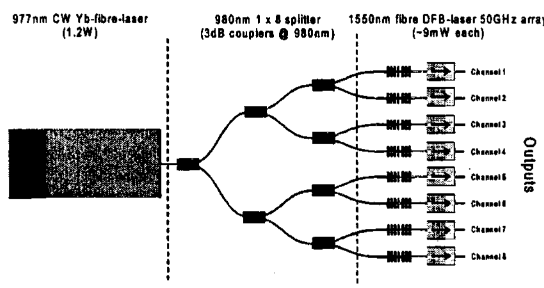

Fig. 1. Experimental set-up of the WDM-transmitter.

Experimental results and discussion

When operating the pump-fibre laser at maximum output the output comb of the array is shown in Fig.2a, this shows the 8 channels separated by 50GHz and demonstrates that an average power of 8-9mW per channel has been achieved when a total of ~800mW of power is incident in the 1x8 splitter. The slope efficiencies of the individual lasers are shown in Fig. 2b demonstrating that >10% slope-efficiency have been obtained for all the channels. When left "free-running" in time to monitor the power stability of the lasers less than 0.5dB variation was observed.

To investigate whether any performance penalties exist when operating the fibre DFB-lasers with a 977nm fibre-laser pump compared with a more traditional

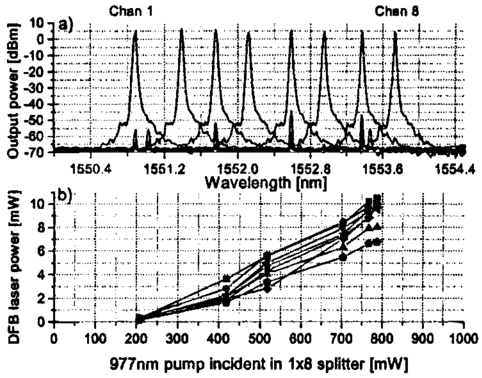

Fig. 2 Output characteristics of the fibre DFB-laser array a) channel wavelengths b) individual channel powers against total 977nm pump in the splitter.

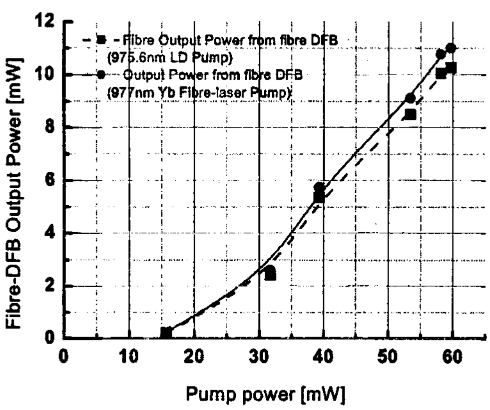

Fig. 3. Output powers against pump-power of the fibre DFB-laser when pumped by the semiconductor LD (square) and fibre-laser (circle).

semi-conductor laser-diode (LD), two comparing tests are set up. The first one is to measure the slope efficiency when pumped by either source. The most power efficient fibre DFB-laser is chosen for this exercise being channel no.5. The result of this is demonstrated in Fig. 3 and it shows that the output power performances are virtually identical in both configurations demonstrating that the power efficiencies are similar with no associated penalty. The second comparing test is related to the stability of output of the fibre DFB-laser. In this case the line-width of the fibre DFB is measured when operated in the two pump-configurations. Again the most efficient laser in terms of power is chosen for this. A delayed self-heterodyne technique is used with a resolution of 4.8kHz and a frequency-shift of 35MHz provided by an acousto-optic modulator is used. The line-width of the fibre DFB-laser when pumped with the LD is from a Lorenzian line fitting found to be ~29.3kHz where as its line-width has broadened to ~75.3kHz, additionally found from fitting a Lorenzian shape to the RF-power spectrum, when pumped with the fibre-laser (Fig. 4). This broadening we believe is due to the slightly broader pump-spectrum of the fibre-laser compared the LD together with a slight variation to the output power of this laser. Although this is quite a dramatic increase of the line-width it is not seen as an actual performance degradating factor in any way.

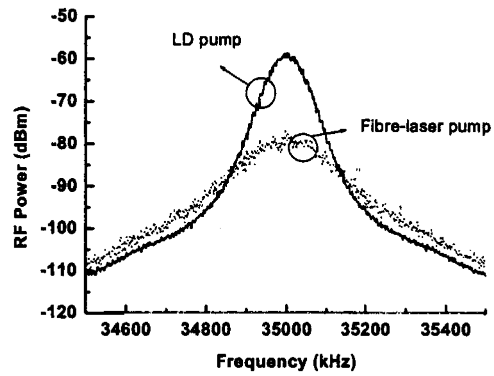

Fig. 4. Line-widths of fibre-DFB laser channel no.5 when pumped by either pump-source.

Conclusions

We have demonstrated how a recently developed 977nm high-power CW fibre-laser can provide a reliable and cheap pump-source alternative for an array-comb of 8 fibre-DFB lasers. We test the performance of the DFB-lasers when pumped with the fibre-laser source against a more standard laser diode pump-source and show that although there are some degradation to the line-width of the lasers they are by no means detrimental to their application as transmitter-sources in WDM transmission systems. We believe that this demonstration shows that an important parameter in employing fibre-DFB-lasers as transmitter sources in telecommunication-systems, namely the cost of the LD pump-sources, have been brought under control, mainly because the 977nm fibre-laser demonstrated here uses a relatively low-cost broad-stripe laser diode source at 915nm as its pump.

References

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