Yb-doped superfluorescent fiber source with cascaded broad fiber Bragg gratings

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Received September 17, 2002

In this paper, the Yb-doped superfluorescent fiber source (SFS) with cascaded broad fiber Bragg gratings (FBGs) are reported. The spectral properties of this SFS with cascaded broad FBGs are described and compared with that without cascaded broad FBGs. The experimental results have shown that cascaded broad FBGs can increase the output of some special wave bands.

OCIS codes: 060.0060, 140.6630, 170.6280, 140.0140.

Broadband sources have diverse applications such as interferometry, sensors, spectroscopy and optical coherence technology (OCT) imaging. Rare-earth doped superfluorescent fiber sources(SFS)[1] have emerged as an excellent candidate for broadband sources. Pumped around 980 nm, Ytterbium in germano-silicate glass fiber possesses a very broad emission spectrum, extending almost from 1010 to 1150 nm, which makes it attractive for broad spectrum generation[2]. More recently, a high-power Yb-doped SFS have been reported based on a double-clad Yb-doped fiber[3].

A variety of SFS configurations, such as forward configuration, backward configuration, single pass and double pass, have been reported, depending on the presence of reflectors and the propagation direction of the pumping light relative to the propagation direction of the source output. Each configuration has its own characteristics, merits, and disadvantages[4]. In the double-pass configuration, the reflector with high reflectivity is important, and now mirrors with high reflectivity and fiber ring reflectors have been used[5].

In this letter, a novel high reflector, cascaded broad FBGs, is presented, which can increase considerably and smoothly the output in some special useful bands.

Figure 1 shows the SFS setup with cascaded broad FBGs. The pump power source is a laser diode with the output wavelength at 975 nm. The fiber used in this experiment has a doping level of 700 ppm of Yb^{3+}. The length of the fiber is 21 m. Pump power is coupled into the Yb-doped fiber by a wavelength multiplexed coupler which separates and muitlplexes the pump (975 nm) and emission (1053 nm) wavelengths. An isolator (ISO) is used in the setup to avoid a spectrally featureless superfluorescent output, since laser oscillation will occur via reflection from 4% fresnel reflection with corresponding longitudinal mode frequencies. The cascaded broad FBGs, which are made of FBG1 and FBG2, are used in the configuration. As shown in Figs. 2 and 3, the reflected band of FBG1 is from 1052.5 to 1053.56 nm with the width of 1.06 nm and the reflectivity of 29.2 dB, and that of FBG2 is from 1053.56 to 1055.5 nm with the width of 1.94 nm and the reflectivity of 34.2 dB. In Fig. 3, the left part, approximately from 1048 to 1053 nm, will not reflect the light but cause loss. The output power (dBm)

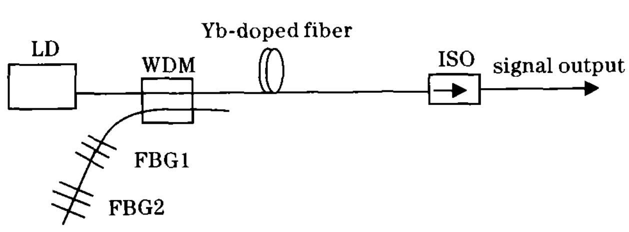

Fig. 1. Configuration of the Yb-doped superfluorescent fiber source with cascaded broad FBGs.

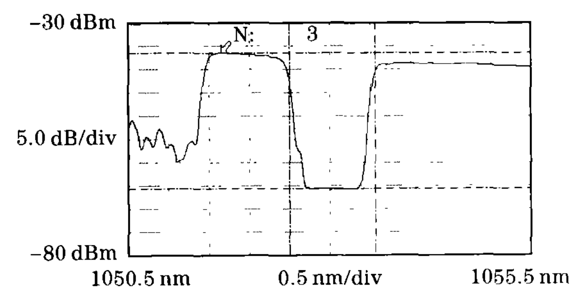

Fig. 2. Transmission spectrum of FBG1.

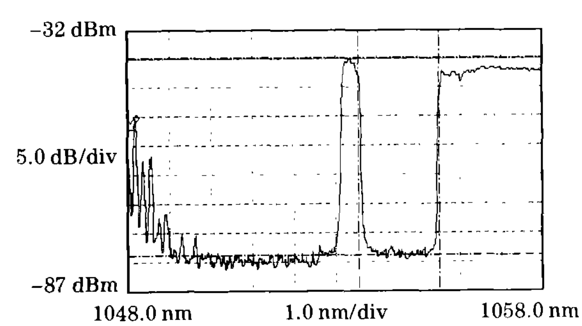

Fig. 3. Transmission spectrum of FBG2.

and the spectral characteristics are measured by an optical spectrum analyzer (OSA).

Figure 4 shows the output power (dBm) as a function of the pump power. The output power in Fig. 4 is clearly different for the cases of the configurations with and without cascaded broad FBGs. With the pump power increasing, the output powers of the SFSs, at the band around 1053 nm with and without cascaded broad FBGs, increase, but the former increases more quickly. Figure 5 shows the spectrum of the Yb^{3+}-doped superfluorescent fiber source with cascaded broad FBGs (span=5 nm set in optical spectrum analyzer). From Fig. 5 we can see that the 3nm broad superfluorescence from 1052.5 to 1055.5 nm has increased by about 10 dB (the left part is 12.18 dB and the right 9.18 dB). We are interested in this wave band because it is useful in the making of various FBGs around 1053 nm. The result has demonstrated that cascaded broad FBGs are able to increase the output power at some special wave bands.

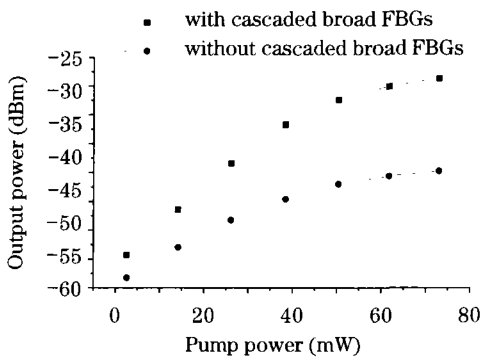

Fig. 4. The output power (dBm) around 1053 nm as a function of pump power (mW).

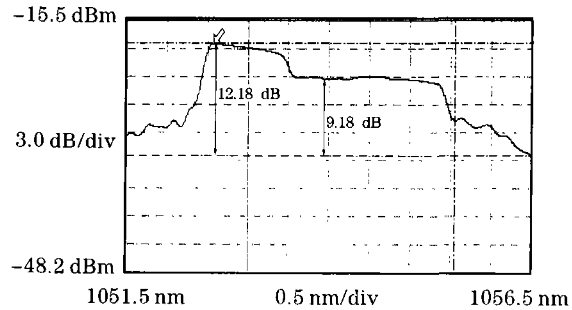

Fig. 5. The spectrum of the Yb^{3+}-doped superfluorescent fiber source with cascaded broad FBGs (span=5 nm).

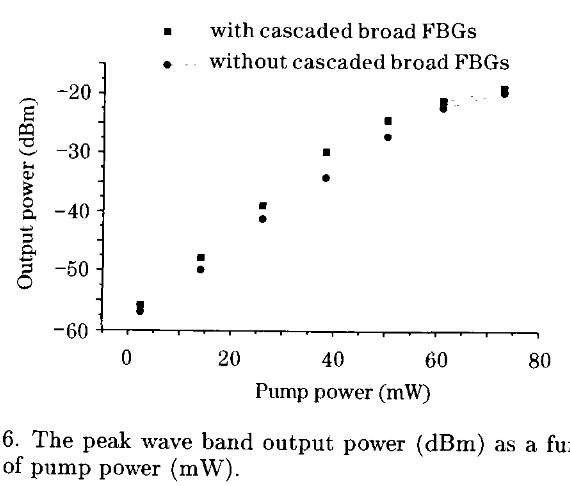

Fig. 6. The peak wave band output power (dBm) as a function of pump power (mW).

In Fig. 5, the output power (dBm) in 1053.56–1055.5 nm wave band (caused by FBG1) is lower than that of 1052.5 – 1053.56 nm (caused by FBG2) although FBG2 has a higher reflectivity. For this, there are two reasons. First, the emission cross section of the 1052.5–1053.56 nm wave band is larger than that of the 1053.56 – 1055.5 nm because the latter wavelength is longer. Secondly, the FBG2 is spiced to FBG1, leading to one more spice point.

Figure 6 depicts the output power at the peak band in the configurations with and without cascaded broad FBGs, respectively. The two curves are close to each other and the difference between them is very little. In the Yb-doped SFS, the superfluorescence peak appears at 1030 nm wave band, which is not included in the reflecting band caused by cascaded broad FBGs. So the cascaded broad FBGs can not reflect the output at the peak band. And the inserting loss of cascaded broad FBGs does not apparently influence the output power in the peak wave bands. In the experiment, we also investigate the output power at some other bands which are not involved in the reflecting band, and have gained the same results. The cascaded broad FBGs can only raise the output power at certain wave bands, causing little effect at other wave bands.

By using the cascaded broad FBGs with certain reflectivity in special wave bands, we have investigated the output power (dBm) and the optical spectral characteristics of the raised SFS wave bands. We successfully increased the power by 12.18 dB at 1052.5 – 1053.56 nm wave band and that by 9.18 dB at 1053.56 – 1055.5 nm wave band in the cascaded broad FBGs configuration.

This work was supported by the National Hi-Tech 863-804 Foundation of China. Q. Qiao's e-mail address is qqqiao@etang.com.

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