

The backward ytterbium-doped fiber superfluorescent source

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The characteristics of backward Yb-doped double-cladding fiber superfluorescent were reported in this paper. The maximum output power of double-pass backward super-fluorescent is 2.1W with slope efficiency of 51.5% and the single-pass backward super-fluorescent is 1.1 W with slope efficiency of 29.5% with respect to absorbed pump power when the fiber length is only 2.8m. Finally, the self-oscillation of different length fiber was also discussed.

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1. Introduction

The Super-fluorescent called Amplified Spontaneous Emission (ASE) is a source between the laser and fluorescent. It can make the noise of amplifier worsen, but it is also a source that can be utilized. Now, the superfluorescent sources have applications in many fields, including rotation sensing, spectroscopy, medical imaging via optical coherence tomography and fiber-optic gyroscopes [1-2].

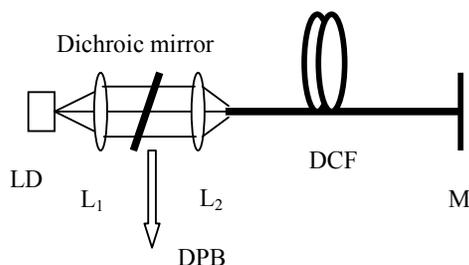


Fig. 1. Experiment configuration of Yb-doped double-cladding fiber SFS.

Relative to the Er-doped fiber sources [1-2], the Yb-doped fiber super-fluorescent sources (SFS) were lacked research. In 1997, a 30mW ytterbium-doped fiber super-fluorescent source operating around 1.06 μ m was demonstrated by Chernikov [3]. In 1998, the 485mW SFS output power with 41nm 3dB emission based on V-groove side pumping was reported [4]. In 2005, a maximum output SFS power of 2.12W and a slope efficiency of 43.2% was obtained by using a broadband dichroic mirror to compose the double-pass forward (DPF) configuration, while the output SFS power of conventional single-pass forward (SPF) is 1.46W with a slope efficiency of 23.4% and the fiber length is 25m [5]. In 2006, P.Wang demonstrated a

maximum ASE output of 63 and 47W from the two ends of the 18m fiber when the fiber was pumped by a high-power LD at 976nm, and the total output power was 110W with slope efficiency of 68% with respect to launched pump power. In order to get high power output, he used a novel fiber-end termination geometry to suppress lasing [6]. In this paper, we report the characteristics of ytterbium-doped double-cladding fiber SPB and DPB SFS pumped by a 940nm LD.

2. Experimental setup

The configuration of double-pass backward super-fluorescent source was shown in Fig. 1. If the fiber end was not placed a reflect mirror M, the configuration is called single-pass backward super-fluorescent source. The dichroic mirror has 99% reflectivity over the range 1040-1100nm and high transmission at the pump wavelength. The broadband reflection mirror has over 99% reflectivity over the range 1010-1100nm. The double-cladding Yb-doped fiber has core diameter of 30 μ m, a NA of 0.16 and 450/400 μ m D-shaped inner cladding with a NA of 0.36. The doping Yb³⁺ concentration is 6000ppm Yb₂O₃. The center wavelength of LD with a pigtail is 940nm. The diameter of pigtail is 600 μ m, and its NA is 0.22. Two lens were used to coupling the pump into the inner cladding of fiber. The L₁ is a collimate sphere lens and its focus is 50mm. L₂ is a focusing non-sphere lens and its focus is 30mm. The pump light was coupled into the inner cladding of the Yb-doped double-clad fiber at an efficiency of 30% which was measured with the truncation method. The LD was cooled by water. The temperature of water is set to 20°C. The water pressure is 0.22Mpa and the water flow is

1.44L/min.

3. Results and discussion

When the pump light was coupled into the inner clad of fiber, it was found that the Yb-doped double-clad fiber generated intensive green fluorescent. It was related to the cooperative luminescence phenomenon. In fact, this phenomenon reduced the optical to optical conversion efficiency and slope efficiency of output super-fluorescent.

In order to suppress resonant oscillation as a result of Fresnel back reflection, the output end of fiber is polished at an angle of approximately 10° . Because the forward superfluorescent output power is lower than the backward superfluorescent, the characteristics of backward super-fluorescent were focused on in this paper. The spectrometer used in experiment was made by Ocean Optic Company. The measurement range is from 580nm to 1180nm, and the resolution is 0.3nm.

The output characteristic curve of backward super-fluorescent is presented in Fig.2 When the fiber length is 2.8m, the slope efficiency of SPB superfluorescent with respect to launched pump power is 24.5%, and the slope efficiency of DPB superfluorescent with respect to launched pump power is 44.5%. If a part of pump power that is not absorbed was considered. The maximum output power of double-pass backward super-fluorescent is 2.1W with slope efficiency with respect to absorbed pump power of up to 51.5% and the single-pass backward super-fluorescent is 1.1W with slope efficiency of 29.5% with respect to absorbed pump power.

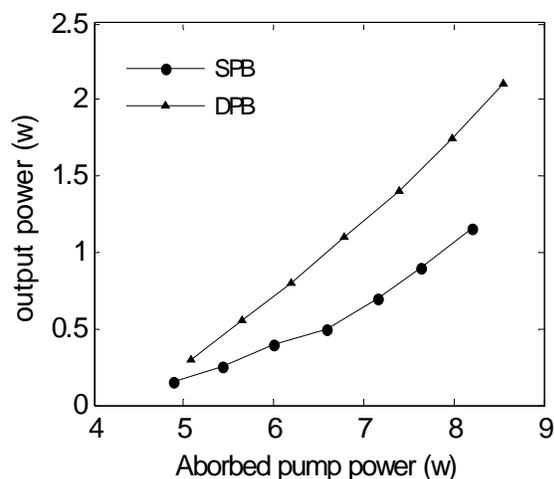


Fig. 2. Output power versus absorbed power for Yb-doped fiber SFS.

Figs. 3 and 4 show the spectrum of SPB and DPB super-fluorescent respectively. When the launched pump power is 10w. The central wavelength of SPB SFS is 1053nm and 3dB bandwidth is 30nm. The central wavelength of DPB SFS is 1065nm, and 3dB bandwidth is

about 22nm.

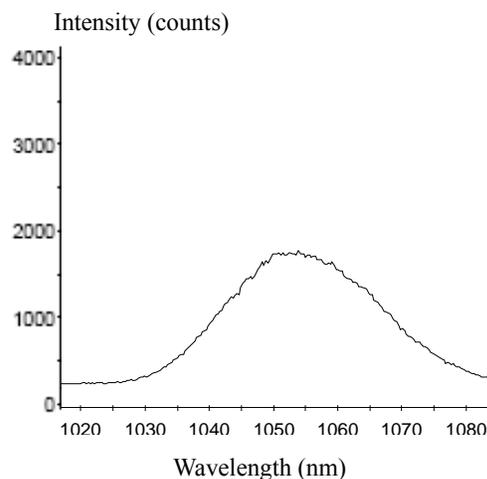


Fig. 3. Output spectrum of SFS in SPB configuration.

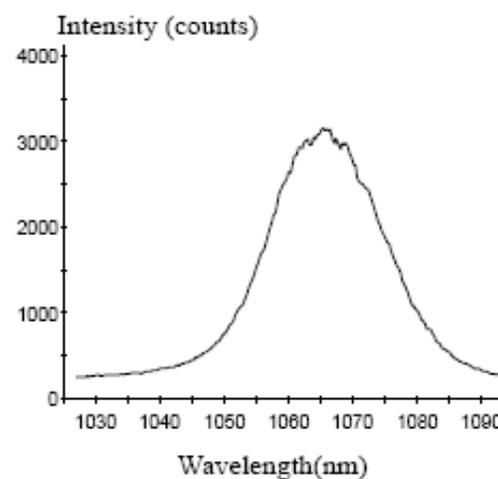


Fig. 4. Output spectrum of SFS in DPB configuration.

It is easy to generate self-oscillation if the fiber end was not processed properly. Fig. 5 shows the spectrum of self-oscillation when the fiber length is 2.8m. The experiment demonstrated that self-oscillation occurred near 1080nm when the fiber length is 9m. It was found that the wavelength of self-oscillation shifts to longer wavelengths as the fiber length increases. This can be explained by the fact that the pumping threshold for longer wavelengths is lower than for shorter wavelengths as the fiber length increases.

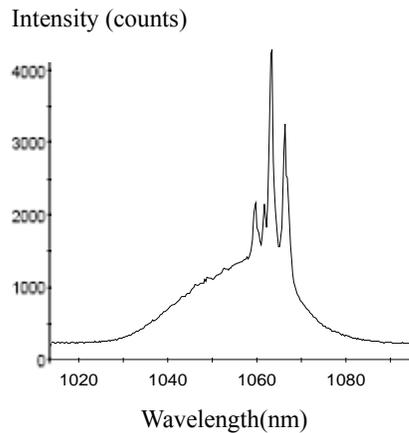


Fig. 5. Self-oscillating spectrum of 2.8m fiber.

In addition, it was observed that the 3dB spectral width of backward SFS reduced with the increase of pump power when fiber length is not change. It was attributed the width narrowing to the homogeneously broadened nature of gain medium [7].

4. Conclusions

In summary, we have demonstrated a 22nm 3dB bandwidth DPB SFS with maximum output power of 2.1w pumped by 940nm when the fiber length is only 2.8m. Its slope efficiency was 51.5% with respect to absorbed pump power and was 44.5% with respect to launched pump power. It was found that the self-oscillation wavelength changer to long wavelength when the fiber length is longer.

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