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Eye-diagram and Q factor evaluation of fiber ring laser in lightwave transmission

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ABSTRACT

A C-band erbium doped fiber ring laser is proposed and investigated. With the use of two sub-ring cavities and a saturable absorber, a high quality and stable fiber ring laser is obtained for high optical signal to noise ratio operation in lightwave transmission. As different fiber Bragg gratings are employed as the wavelength filter, a narrow 3 dB-bandwidth is necessary for the high quality operation. The fiber ring laser is evaluated in lightwave transmission. The Q factor and eye diagrams are also measured and discussed.

1. Introduction

Erbium doped fiber laser (EDFL) in C + L band have attracted great interest owing to their wide application, such as spectroscopy, sensing and optical coherence tomography [1–3]. EDFL also can be used in third harmonic generation (THG) green light generation, if lasing power is large enough [4,5]. Single longitudinal mode (SLM) EDFL is a potential candidate for high-speed optical fiber communication and community antenna television (CATV) systems [6]. So far fiber lasers employing erbium-doped fiber (EDF) are based on the use of either ring- or linear-cavities, wherein the gain medium is embedded. Fiber lasers employing a linear-cavity can be understood as a length of optical fiber acting as the gain medium, having been doped with rare earth elements, with two reflected mirrors on either side of the fiber ends. However, we choose the ring cavity as the main cavity structure, because the ring cavity configuration can avoid spatial hole burning (SHB) that generates the multi-longitudinal -mode operation in fiber lasers [7,8]. Furthermore, the optical signal to noise ratio (OSNR) of ring-cavity fiber lasers is generally larger than that of linear-cavity lasers. Regarding the wavelength selection devices employed in ring cavity fiber lasers, most of the previous works are based on tunable filters or acousto-optic tunable filters. In this paper, we use a fiber Bragg grating (FBG) as the wavelength selection device because of the relatively narrow 3 dB bandwidth, low insertion loss, and cost effective. In addition, the combination of a FBG and an optical circulator (OC) could filter out the unwanted noise to increase the OSNR. In the previous works [9–11], many authors report the research on achievement of single longitudinal mode operation in fiber lasers. However, few articles are focused on using the fiber lasers to transmit signals. In this paper, we demonstrate a stable EDFL with a narrow linewidth, and further employ the EDFL to transmit signals with 10 Gb/s data rates with 2^{31}-1 pseudorandom-binary-sequence (PRBS) in the nonreturn-to-zero (NRZ) format. In [12], we report the fiber mode filters with a wide operating range, which allows single longitudinal mode operation of the fiber laser in a wide range. Two sub-ring cavities and saturable absorber are inserted into the main cavity of the proposed fiber laser to ensure SLM oscillation. Also, the eye diagrams and Q factor are also verified in a communication system.

2. Experimental setup

The experimental setup of our proposed high-quality EDFL is shown in Fig. 1. The pumped laser diode (pump LD) is 1480 nm via a 1480/1550 wavelength division multiplexer (WDM) coupler. The gain medium is a 3-m EDF (Model number: Er16-8/125) with 8-μm core diameter, 9.5-μm mode field diameter (MFD) and 18 dB/m absorption at 1530 nm, respectively. An OC and a FBG, placed before the output coupler, are used to select the laser wavelength and filter out the noise to achieve the best OSNR. A

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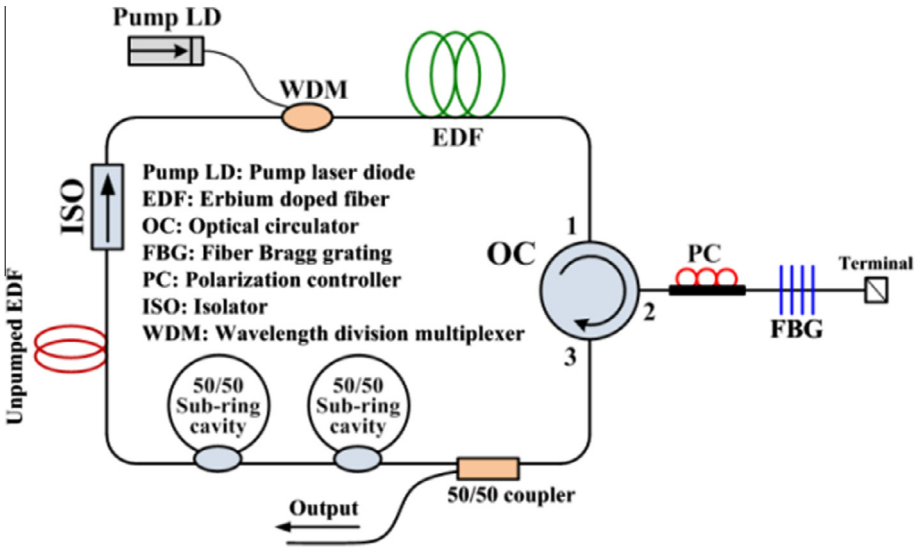

Fig. 1. Schematic of the erbium doped fiber ring laser.

polarization controller (PC) is inserted between OC and FBG to adjust the polarization state of light and stabilize the laser operation to achieve the optimal performance. Two subring cavities are inserted in the ring cavity, with each subring cavity (SRC) formed by a 2×2 fiber coupler. To verify the mode stability, an un-pumped EDF is inserted in the fiber ring cavity as a

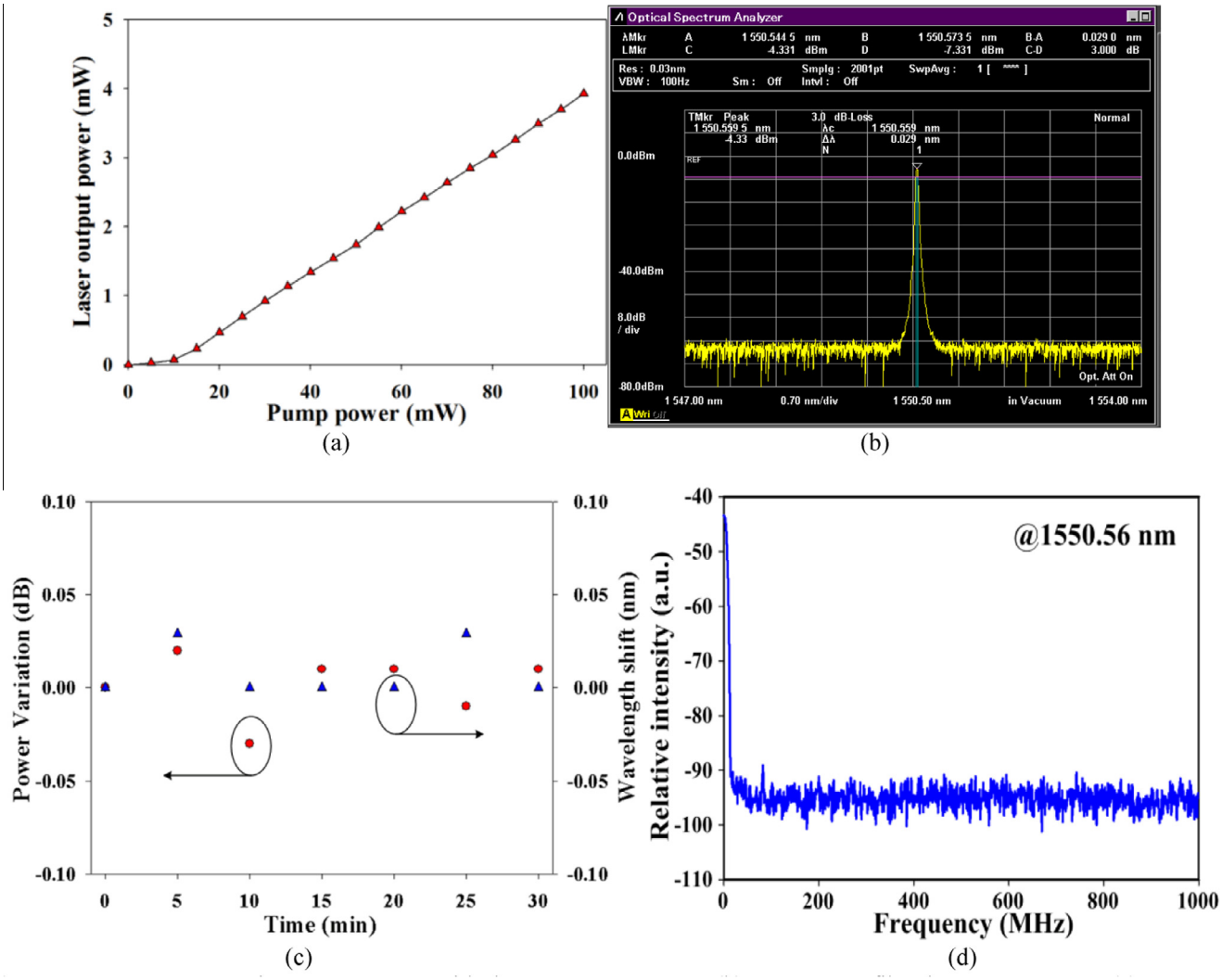

Fig. 2. (a) Laser output power against pump power with the 1550.56-nm FBG, (b) 1550.56 nm fiber laser spectrum at, (c) measurements of the power stability and wavelength shift, and (d) RF spectrum of the fiber laser.