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S-band multiwavelength Brillouin-Raman fiber laser utilizing an optical reflector

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ABSTRACT

This paper reports on the performance of multi-wavelength Brillouin-Raman fiber laser exploiting an optical reflector. The ring-cavity multi-wavelength Brillouin-Raman fiber laser is based on hybrid Brillouin-Raman gain supported by SBS and SRS. The multiwavelength Brillouin-Raman fiber laser is systematically analyzed at different values of Raman pump powers, Brillouin pump powers, and categorically based on single mode fiber length, and Raman fiber length which operated from 1460 nm to 1430 nm of BP wavelengths. The optical reflector at 90% of reflectivity acts as an optical mirror is used in this structure. There are 5 channels at 1500 nm, and 1510 nm of BP wavelengths observed at Raman pump power of 30 dBm, 8 km of Raman fiber and 4 km of single mode fiber. In addition, the Raman pump power of 30 dBm is able to produce high gain value and subsequently generate a large number of channels across S-band region.

1. Introduction

The fiber optic communication system is well known to be capable of transmitting signal information from one place to another location by propagating light through an optical fiber with a range of frequencies. Multiple wavelengths or frequencies have much-attracted attention vis-à-vis single-wavelength fiber, thus an attractive candidate for the dense wavelength division multiplexing (DWDM) systems [1].

The multi-wavelength Brillouin-Raman fiber laser (MBRFL) is generated by a seed signal [2,3]. Brillouin and Raman gains are combined for generating multi-wavelength output. In MBRFL, the stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS) are third order nonlinear effects that can cooperate together to produce some channels. SRS is a nonlinear phenomenon arising from inelastic Raman scattering [4]. Raman scattering is triggered by the collision between the light vibrational modes of the molecule in the lattice crystal [5]. Meanwhile, stimulated Brillouin scattering (SBS) is a nonlinear effect that exists in the optical fiber through the generation of backward propagating optical waves [6,7]. SBS can generate multiple channels output spectrums with a narrow linewidth and consistent channels spacing.

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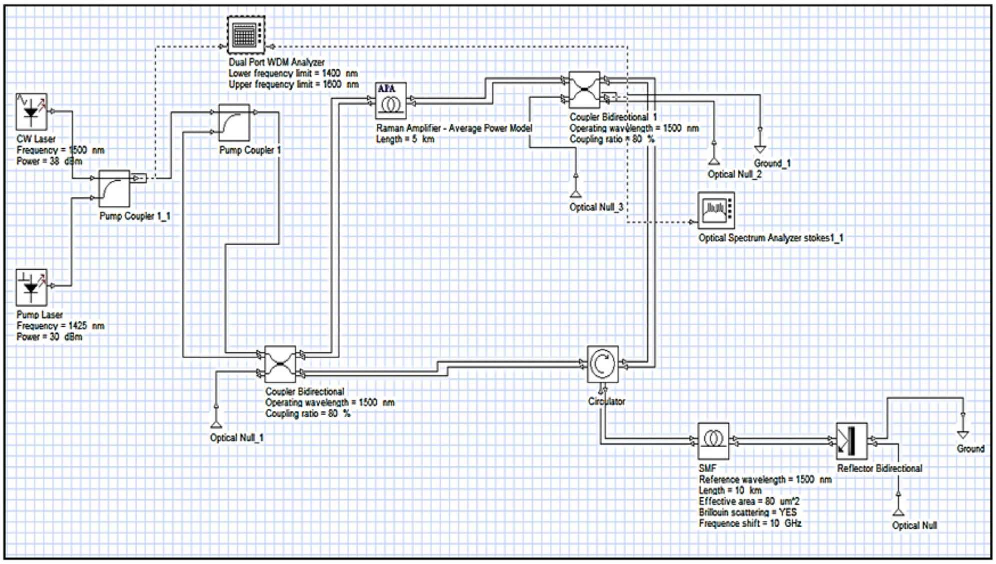

Fig. 1. Simulation Layout of the ring-cavity MBRFL.

Critical traffic of data transmission in communication technology has a high requirement for wider bandwidth with an efficient optical amplifier to solve the problem for transmitting the information at fastest speed [8]. L-band and C-band region are most likely to be deployed in the transmission system and unfortunately became exhausted. Therefore, the capabilities of data transmission can be ultimately improved by changing into new transmission window, which is proposed in this paper to be the S-band region. Moreover, the MWBRFL complements the critical optical communication which needed in widening spectral region with the ability of ultra-broad bandwidth [9] and stable room temperature operation [10]. Exploitation of S-band region in optical communication is the most likely band after C-band and L-band region. S-band region has the potential of increasing the bandwidth in transmitting signal in the communication windows. Attenuation in the S-band region is better to compare to the attenuation of L-band region [11]. Furthermore, less sensitivity to micro-bending and macro-bending loss [11].

Several of MBFFL have been previously reported in [12–14]. The characteristic of MBRFL operated in S-band region is reported in [12]. A Dispersion Compensating Fiber (DCF) with the length of 7.7 km and Raman pump amplifier (RFA) at the power of 380 mW. This MBRFL can generate 32 St line at flat peak output power of −18 dBm. However, this laser structure focuses on linear-cavity structure by placing optical circulators that acting as mirrors at each end of the cavity. The impact of multi-wavelength generation in the MBRFL operated in S-band region has been investigated in [13]. This laser structure is successfully produced up to 6 BS signal by employing fiber Bragg grating (FBG) as a reflector. Meanwhile, the MWBEFL that has the capability to produced ∼0.16 nm and tuning range between 1490 nm–1530 nm is has been reported in [14]. However, all of these MBRFL focused on linear-cavity structure.

This work dedicated to the performance study of the ring-cavity MBRFL employing optical reflector in the S-band operation region. A narrow bandwidth Brillouin gain is combined with a broad bandwidth Raman gain to create multiple channels. It has been reported that there are 5 channels at 1500 nm and 1510 nm of BP wavelengths using 8 km Raman fiber. The RP power of 30 dBm can produce a high gain value across S-band region. Meanwhile, 5 channels are generated at 4 km of SMF when 1500 nm and 1510 nm of BP wavelengths are launched into the ring-cavity MBRFL structure.

2. Simulation and illustration structure

The simulation layout and the schematic diagram of the ring-cavity MBRFL structure utilizing optical reflector for the production of multiple channels at S-band region are depicted in Figs. 1 and 2, respectively. The structure of the ring-cavity MBRFL consists of Raman pump (RP), a laser source, two optical bidirectional couplers, optical pump coupler, an optical circulator, bi-directional Raman amplifier-average power model, single mode fiber (SMF) and optical reflector at 90% of reflectivity which acts as an optical mirror. Optical spectrum analyzer (OSA) is used to monitor and verify all outputs. The RP power is provided by utilizing external RP at 1425 nm of wavelength. The RP is used as a primary light source for bidirectional Raman amplifier-average power model. Moreover, bi-directional Raman amplifier-average power model is used to provide Raman amplification for BP signal and BS signal. Meanwhile, an external laser source supports the BP signal with a linewidth of approximately 20 MHz and able to generate BS signal. The injected BP wavelength into the ring-cavity MBRFL is varied from 1460 nm to 1530 nm. The RP and BP signals are injected and combined via the bi-directional optical coupler and optical