

Continues-wave Brillouin-Raman fiber ring laser using 7.7 km long dispersion compensating fiber at 1563 nm wavelength

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Abstract. We demonstrate the generation of continues-wave (CW) laser based on Brillouin-Raman fiber laser (BRFL) by incorporating a 7.7 km long dispersion compensating fiber (DCF) as a nonlinear gain medium. The 1455 nm Raman pump (RP) was launched into the DCF via a wavelength division multiplexing (WDM). At 645 mW pump power, stable CW laser presence at 1563.5 nm (1st stokes), 1563.4 (2nd stokes) nm and 1563.3 nm (3rd stokes). Those peak wavelengths have produced most identical output power. This finding proves our ring laser cavity has the capability to generate stable CW BRFL. Thus, it potentially to generate pulse laser operation in the future work.

1. Introduction

Brillouin-Raman fiber laser (BRFL) scattering effects have provided high attention in several significant types of research recently. It offers high benefits and remarkable potentials with wide applications. Brillouin stokes lines have been achieved based on the mixed effect of Rayleigh scattering, Raman amplification and Brillouin shift in a linear laser cavity and single-pass Raman amplification configuration. However, the stability of this wavelength lasing outputs was still inefficient and inaccurate that can clearly observe from the given spectra in their experiments. So, it needs to be improved before those reported BRFL sources are practically used. Also, the stability of the lasing oscillations in their configuration was not analyzed [1].

Moreover, in the previous studies have described vital findings and importance role in this hybrid BRFL. For example, in [1], a Stable room-temperature multi-wavelength lasing oscillations in a Brillouin-Raman fiber ring laser has been demonstrated. In [2] investigate 20 GHz spacing multi-wavelength generation of a Brillouin-Raman fiber laser in a hybrid linear cavity 150-km-range distributed temperature sensor based on coherent detection of spontaneous Brillouin backscatter and in-line Raman amplification. A study of multiwavelength Brillouin-Raman ring-cavity fiber laser with 22-GHz Spacing was also be measured [3]. The research of contribution of Rayleigh scattering on Brillouin comb line generation in Raman fiber laser was reported in [4]. The 17-channels S-band multi-wavelength Brillouin/erbium fiber laser co-pump with Raman source characteristics was also



being studied [5]. Distributed Brillouin fiber sensor assisted by first-order Raman amplification features is explained in [6]. In [7] describe S-band multi-wavelength Brillouin-Raman fiber laser. Brillouin optical time-domain analysis assisted by second-order Raman amplification. For [8], Brillouin optical time-domain analysis assisted by second-order Raman amplification was obtained. The study of dynamics of cascaded Brillouin-Rayleigh scattering in a distributed fiber Raman amplifier was also determined [9]. The analysis of Brillouin-Raman comb fiber laser with cooperative Rayleigh scattering in a linear cavity was shown in [10].

In this paper, it indicates the generation of continues-wave (CW) laser with BRFL by using a 7.7 km long dispersion compensating fiber (DCF) as a nonlinear gain medium. The 1455 nm Raman pump (RP) was provided into the DCF through a wavelength division multiplexing (WDM). At 645 pump power, stable CW laser presence at 1563.5 nm (1st stokes), 1563.4 (2nd stokes) nm and 1563.3 nm (3rd stokes). The peak wavelengths have produced most identical output power. This finding proves that the ring laser cavity can generate stable CW BRFL.

2. Methodology

The ring cavity configuration for BRFL is shown in **Figure 1**. The proposed BRFL consists of a 1455-nm Raman pump (RP), wavelength division multiplexer (WDM), 7.7 km long DCF, 10-dB coupler, Brillouin pump (BP), and circulator. The RP has core pumped a nonlinear gain medium of 7.7 km long DCF through WDM. Via a circulator, the narrow linewidth Tunable Light Source (TLS) is integrated into the laser cavity to provide the BP source. This BP signal will generate the CW laser in the 7.7 km DCF, which is also injected with a 1455 nm RP signal at 645 mW and 892 mW. The RP provides Raman amplification to the BP, thus reducing the BP loss and provides higher powered Stokes wavelengths. This will help to generate more subsequent Stokes. The amplification of the generated Stokes wavelengths is accomplished by the use of the DCF based amplifier.

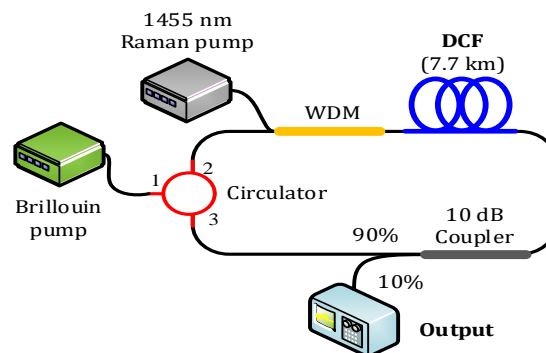


Figure 1. Experimental setup for the proposed DCF based BRFL.

3. Results and discussion

The spectrum generated by the proposed setup is shown in **Figure 2**. The output spectra of Raman fiber laser is obtained at 645 mW and 892 mW. This is for comparison purpose to show its significant results of output power (dBm) versus wavelength. The tuning range of the proposed BRFL is approximately 20 nm from 1550 to 1570 nm respectively. This output spectra will be used to determine whether Stokes wavelengths can be produced.

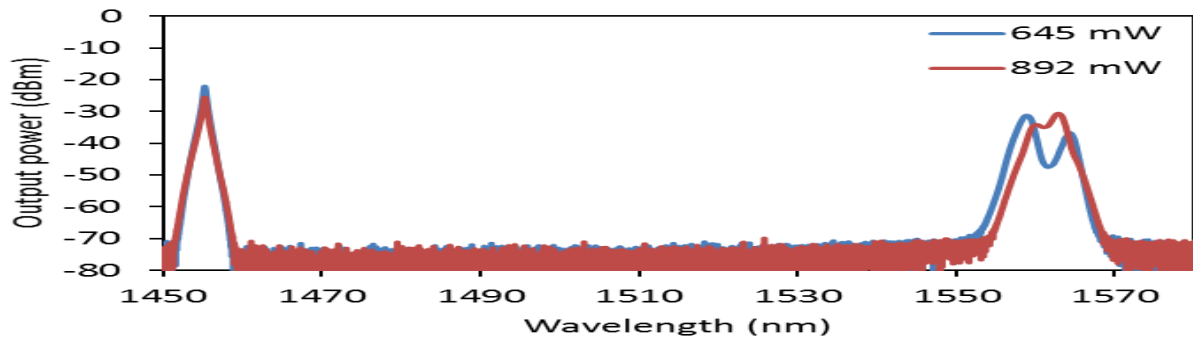


Figure 2. Output spectrum of Raman fiber laser at 645 mW and 892 mW.

In Figure 3, it shows the output spectrum at 892 mW for Brillouin fiber laser and Raman pump. This vital finding indicates the pattern characteristics of the spectrum between both Brillouin and Raman pumps. This is important to lead in studying the relationship of it.

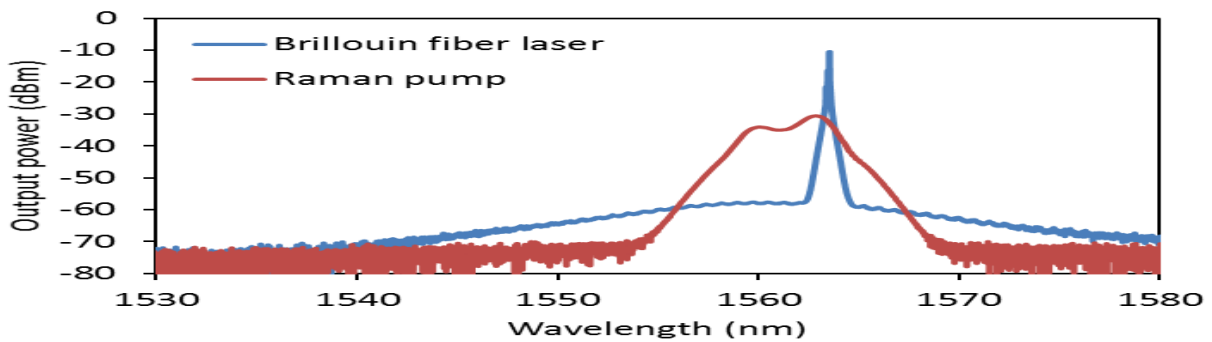


Figure 3. Output spectrum at 892 mW.

To obtain the range for generating the number of Stokes wavelengths and also to determine the tuning range of the proposed BRFL, BP signals at different wavelengths are injected into the BRFL cavity. Figure 4 shows the output spectrum of the Brillouin fiber laser at 892 mW pump power. This comparison of both spectrums offers better understanding in producing results of Stokes wavelengths. A stable CW laser presence at 1563.5 nm (1st Stokes), 1563.4 (2nd Stokes) nm and 1563.3 nm (3rd Stokes) with a spacing of ~ 0.08 nm.

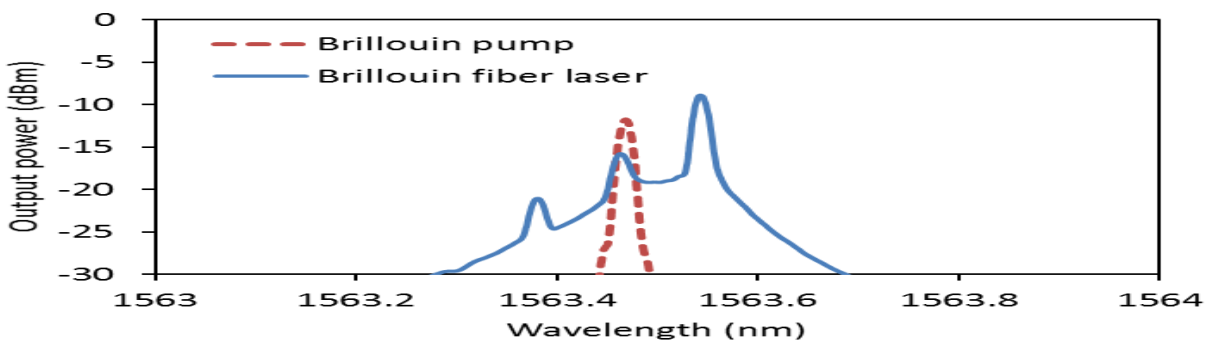


Figure 4. Output spectrum of the Brillouin fiber laser at 892 mW pump power.

Additionally, the output power of Brillouin pump and Raman pump at 1563 nm are compared to Figure 5 and Figure 6. The measured of Stokes power in both pumps indicate good results to show its correlation with the power of Brillouin and Raman pumps.

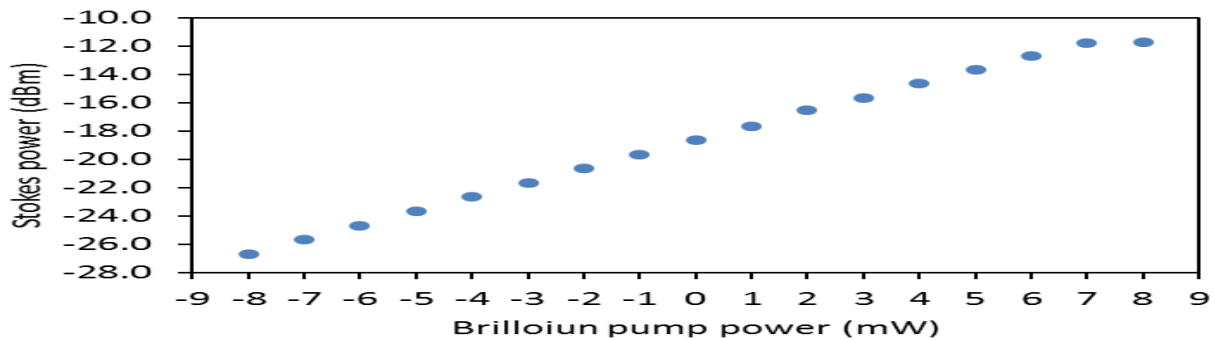


Figure 5. The output power of Brillouin pump at 1563 nm.

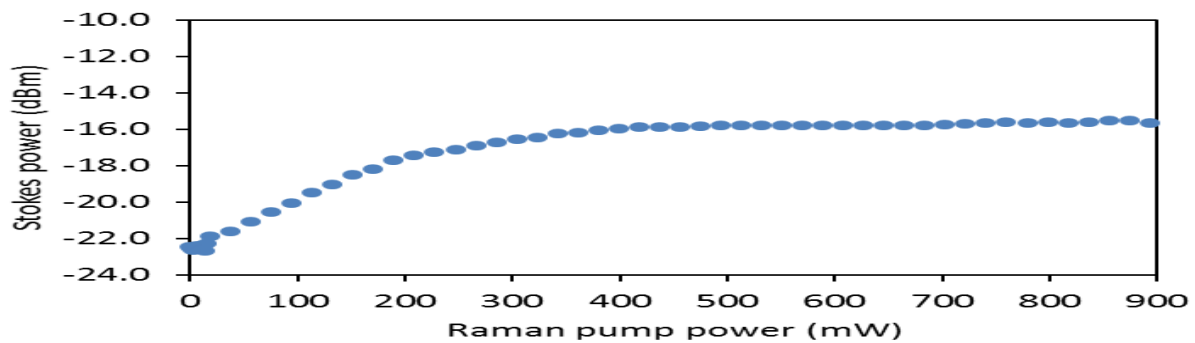


Figure 6. The output power of Raman pump at 1563 nm.

As shown in Figure 7, the injected BP only generates three Stokes wavelengths. It indicates the output power at 1563.5 nm (1st), 1563.4 (2nd) nm and 1563.3 nm (3rd) via a power meter. All these three Stokes show the same pattern of uniform and stable power curve.

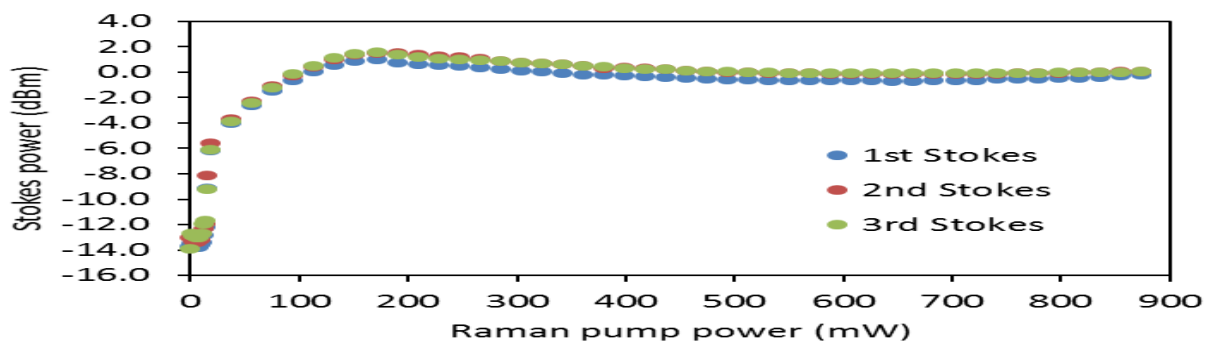


Figure 7. Output power at 1563.5 nm (1st), 1563.4 (2nd) nm and 1563.3 nm (3rd) via a power meter.

4. Conclusion

This paper has successfully demonstrated a CW laser via BRFL through 7.7 km long DCF as a nonlinear gain medium. The 1455 nm RP was injected into the DCF via a WDM. At 645 mW pump power, stable CW laser presence at 1563.5 nm (1st Stokes), 1563.4 (2nd Stokes) nm and 1563.3 nm (3rd Stokes). The peak wavelengths have produced most uniform output power. This result shows that this ring laser cavity capable of generating stable CW BRFL. Thus, it has high potential to produce pulse laser operation in the next extended research of future work.

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