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Multiwavelength Hybrid Gain Fiber Laser: A systematic review

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***Abstract*-This paper is a systematic review of most of the articles which concerned with the generation of multiwavelength fiber laser based on hybrid gain. We summarize and discuss the previous studies from a scientific point of view; by explained the performance parameters of multiwavelength hybrid gain fiber laser (MHGFL). These parameters include threshold power, number of output channels, tuning range, and flatting of Stokes lines. Before that the basic concept of these types of lasers are explain based on the previous study. In addition, we described the main enhancement techniques that used in MHGFL to improve the output Stokes line.**

***Index Terms*: Fiber laser, Brillouin Scattering, Multiwavelength Brillouin Fiber Laser, Raman Fiber Laser.**

I. Introduction

There are basically two ways to increase the total capacity per fiber in Dense Wavelength Division Multiplexing (DWDM) technology. The first one is to increase the number of channels by incorporating narrower channel spacing as small as 12.5GHz, and the second technique is to increase the bit rate per channel [1]. The first approach is based on a relatively lower bit rate per channel, as compared to the second approach. Thus, leading to the relatively of used low speed electrical circuits a long with no complicated dispersion compensation technique is required [2]. In this context, many researchers and specialists were interested in Multiwavelength hybrid gain fiber laser (MHGFL) with constant channel spacing, because of potential application in optical test and measurement, optical sensor, DWDM optical communication systems and so on [3-9]. Using the side effects of the nonlinear stimulated Brillouin scattering (SBS) inside the single mode optical fiber to generate the MHGFL was demonstrated in 1996 [10]. There are two generations for this type of lasers. The first generation is the multiwavelength Brillouin-Erbium fiber laser (MBEFL) [3-9], while the second generation is the multiwavelength Brillouin-Raman fiber lasers (MBRFL) [11-14].

II. Basic Concept

In this section the basic concept of multiwavelength Brillouin fiber lasers (MBFL), MBEFL and MBRFL will be stated in briefly.

A. Multiwavelength Brillouin Fiber Laser

SBS is one of the most dominant nonlinear effects in a single mode optical fiber because it occurs at a relatively low power level [15, 16]. It causes blue shift and depleted the incident signal power if the signal power exceeded the threshold power of the SBS for certain SMF. This shift known as Stoke line propagated in opposite direction against the incident signal (backward-propagating Stokes wave) [17]. Inserting SMF inside the cavity led to generate multiple Stokes lines with equally frequency spacing approximately 10 GHz. Each Stokes signal will acts as a pump to generate the higher order Stokes signal, this configuration known as a MBFL.

However, because the Brillouin gain has a small coefficient [16], MBFL require critically-coupled resonators and cavity matching of the pump signal to achieve efficient operation. For that the use of MBFL has not been considered seriously [18]. These limitations prompted the researchers to try to find more efficient configuration using an addition gain to support the small coefficient Brillouin gain, such as using Erbium doped fiber (EDF) as an amplifier or using Raman amplifier.

B. Multiwavelength Brillouin Erbium Fiber Laser

MBEFL it is an idiom typifies the combination between two gain media to generate multiwavelength fiber laser; the nonlinear Brillouin gain and the linear EDF gain medium. The concept of MBEFL is achieved to enhance the MBFL by putting the EDF inside the laser cavity to add linear gain that compensates the losses inside the cavity and enhance the output power of the Stokes lines. The process here is to find the balancing between the two gains (nonlinear and linear). The combination of these two gains media, allow to generate a high number of Stokes lines with 10 GHz or 0.088 nm spacing at room temperature [19].

C. Multiwavelength Brillouin Raman Fiber Laser

The basic concept of MBRFL is the same of MBEFL in the aspect of combination two gain inside the cavity but the difference here comes from using nonlinear gain represented by Raman fiber amplifier (RFA) instead of using linear EDF gain. In other words the MBRFL is the combination between two nonlinear gain media, inside the SMF [20, 21].

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