Raman Amplification Effects on Stimulated Brillouin Scattering Threshold in Multiwavelength Brillouin-Raman Fiber Laser

A. K. Abass [1], M. H. Al-Mansoori [2], M. Z. Jamaludin [1], F. Abdullah [1], T. F. Al-Mashhadani [1]
[1] *Center for Photonic Technologies, Electronics and Communication Engineering Department, College of Engineering,*
Universiti Tenaga Nasional, 43000 Kajang, Selangor, Malaysia
[2] *Faculty of Engineering, Sohar University, PO Box 44, Sohar, PCI 311, Oman*

Abstract- **We report experimental results demonstrating the stimulated Brillouin scattering threshold (SBS$_{\text{TH}}$) features in multiwavelength Brillouin-Raman fiber laser against Raman pump power (RPP) variation. The reduction of SBS$_{\text{TH}}$ is attributed to the Raman amplification on each of oscillated Brillouin pump power (OBP) and generated Stokes signals. The saturation in SBS$_{\text{TH}}$ is owing to the RPP depletion, this saturation is coincides with the appearance of Raman peak gain. In addition, the red shift effect became significant at RPP beyond 650mW and led to degradation of the Raman amplification. This degradation appeared as an increase in SBS$_{\text{TH}}$ after the saturation region. Moreover, the Brillouin Stokes comb can be generated only at the saturation region of the Raman amplification between 350 to 600 mW of Raman pump.**

I. INTRODUCTION

Multiwavelength Brillouin-Raman fiber laser (MBRFL) is the second generation of multiwavelength hybrid gain fiber laser, and it can be defined as combination between two nonlinear gains, Brillouin gain (narrow bandwidth gain) and Raman gain (wide bandwidth gain) inside fiber cavity [1–3].

In this hybrid system, the optical fiber utilized as gain medium for both Brillouin and Raman gain simultaneously. Therefore, it is more complex and difficult to understand the behavior of this system than it is in conventional multiwavelength Brillouin fiber laser (MBFL) [4], [5]. In this context, the Raman pump changes the generating mechanism of the Brillouin channels, in which the generated Stokes will acts as a secondary pump source to generate the high order Brillouin Stokes line [5–7].

On the other hand, the Raman amplification affects the MBRFL performance parameters in terms of Brillouin Stokes lines intensity, power level fluctuation between neighboring channels, optical signal-to- noise ratio (OSNR) and flat-amplitude bandwidth [5–8]. In addition, the effects of Raman pumping schemes on these parameters was explained previously[9], [10].

Furthermore, the stimulated Brillouin scattering threshold (SBS$_{\text{TH}}$) reduction under the condition of Raman amplification have been investigated theoretically and experimentally in Raman fiber amplifier[11–13] and in MBRFL [9]. However, all these studies relatively work with low Raman pump power and show a linear relationship in SBS$_{\text{TH}}$ reduction according to the Raman pump effects.

In this paper, SBS$_{\text{TH}}$ behavior in MBRFL according to high Raman pump power variations is investigated for the first time to the best our knowledge. The experimental findings at first show high reduction in the SBS$_{\text{TH}}$ due to the effect of Raman amplification on oscillated Brillouin pump power (OBP) and generated Stokes lines. After that, SBS$_{\text{TH}}$ tend to be saturated simultaneously, with the appearance of the Raman peak gain (RPG). In addition, the red shift effect plays an important role in the increasing of SBS$_{\text{TH}}$ by shifting the Raman peak gain to the longer wavelengths. Moreover, the Raman pump power (RPP) is classified according to the SBS$_{\text{TH}}$ variations into three regions; low, moderate, and high Raman pump power.

II. EXPERIMENTAL SETUP

The configuration of the MBRFL based on linear cavity is illustrated in Fig.1. The linear cavity of the laser is created by placing high-reflectivity mirror at each ends. A 25km standard single mode fiber (SMF) is used as gain media for both Brillouin and Raman nonlinear gain. The Brillouin pump (Bp) is injected from a tunable laser source (TLS) with maximum output power of 10 dBm ranging from 1530 nm to 1630 nm and a linewidth of about 200 kHz. The Raman amplification is obtained when the SMF is forward pumped by a Raman pump laser with maximum output power of 2W at 1480nm wavelength.

In this laser structure, Bp is injected via port 1 of optical circulator and 3-dB optical coupler (OC) and combined with Raman pump (RPU) by a wavelength selective coupler (WSC) into the SMF. The output spectrum is measured at port 3 of the circulator by using an optical spectrum analyzer (OSA).

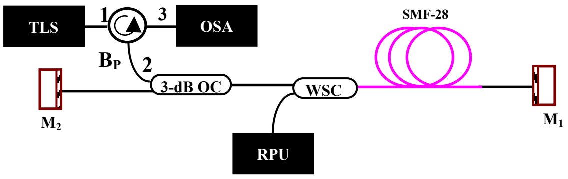

Fig.1. Schematic setup of linear cavity MBRFL co-propagating configuration

978-1-4673-1463-3/12/$31.00 ©2012 IEEE