Progress towards efficient Bi fiber lasers and amplifiers

J. K. Sahu, N. K. Thipparapu, A. A. Umnikov, P. Barua
Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, U.K.
**Corresponding author e-mail address: jks@orc.soton.ac.uk*

Introduction

Bismuth (Bi) as an active dopant in fibers has shown promising results to develop lasers and amplifiers in the wavelength range 1150-1800nm thanks to its broad luminescence characteristics. The strong influence of co-dopant on Bi emission paved the way to select an appropriate glass matrix depending on the desired wavelength of operation. Bi-doped aluminosilicate (BASF), phosphosilicate (BPSF) and germanosilicate fibers (BGSF) exhibit luminescence around 1150nm, 1300nm and 1450nm, respectively. Recent results have demonstrated the possibility to extend the Bi luminescence window beyond 1600nm by using highly germania doped Bi fibers. Among all of these, BGSFs have reached laser efficiencies higher than 50%. On the other hand, the achieved laser efficiencies of BASFs and BPSFs are comparatively low. In particular, there is a necessity to develop efficient BASFs and BPSFs because of their capacity to generate visible light by frequency doubling, and lasers and amplifiers in the second telecommunication window, respectively [1]. Here, we review our recent results in BASFs and BPSFs. The Bi-doped fiber preforms were fabricated using conventional MCVD-solution doping technique [2, 3]. The BASF and BPSF have the core diameter of 8 and 13μm, respectively, with a cladding diameter of 100μm. The refractive index difference (Δn) of BASF and BPSF was found to be 0.008 and 0.004, respectively. These fibers were characterised for absorption and unsaturable loss (UL). The obtained results were used to select appropriate pump wavelength for laser and amplifier development.

Experimental Results

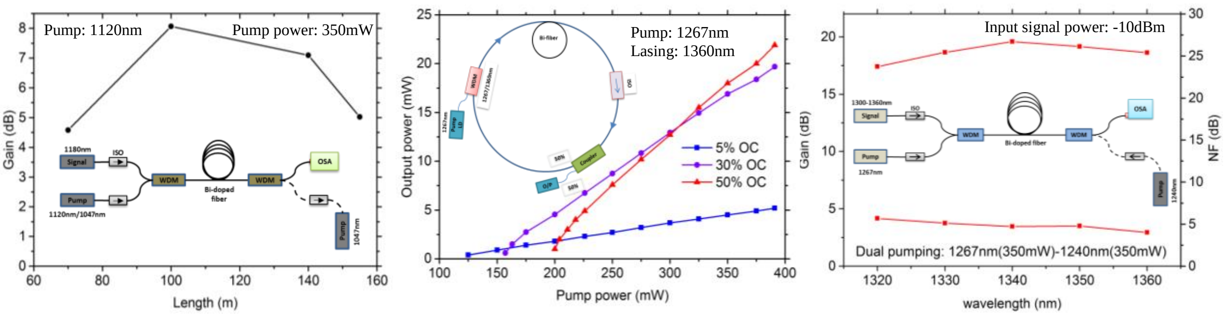

Fig. 1a) Gain variation with fiber length at 1180nm in BASF amplifier for a signal power of -4dBm, b) laser output power vs launched pump power with different output coupling (OC) for 46m BPSF, and c) gain characteristics in BPSF amplifier with dual pumping (1267nm and 1240nm) for 130m long fiber.

The absorption in BASF at 1120 and 1047nm pump wavelengths was 0.35 and 0.7dB/m, respectively. UL was found to be 35% at 1120nm and 65% at 1047nm pump wavelengths. The experimental set up and the corresponding gain characteristics of the BASF amplifier are shown in Fig.1a. A commercially available 1120nm laser diode (LD) with a pump power of 350mW has been used as a pump. The amplifier has a maximum gain of about 8dB at 1180nm with an input signal power of -4dBm for a fiber length of 100m. The performance of the amplifier for 1120nm pump was compared with the conventional pumping wavelength around 1047nm. Gain enhancement of 70% was achieved with the 1120nm pump as compared to the 1047nm pump. A further 3.5dB gain was obtained on simultaneous pumping at 1120 and 1047nm. Low gain enhancement with dual pumping has been explained by the increase in UL measured by simultaneously pumping the fiber at 1120 and 1047nm wavelengths [2]. In case of BPSF, a 1267nm LD pumped all-fiber laser in a ring cavity has been demonstrated with an output power of 22mW and operating at 1360nm as shown in Fig.1b. The laser efficiency was 11% for an optimum output coupling ratio of 50/50 with a fiber length less than 50m. The absorption at 1267nm pump wavelength was found to be 1dB/m. The UL was around 7.2% (13.5%) at pump wavelength 1267nm (1210nm) in BPSF. The 1267nm pumping wavelength was chosen due to lower UL in BPSF among the available pump LDs [3]. Moreover a maximum gain of around 20dB and NF of 5 dB has been achieved at 1340nm from the same BPSF for an input signal of -10dBm as shown in Fig.3c. In this case the fiber was pumped bi-directionally using 1267 and 1240nm LDs. The output power of each LD was 350mW. A gain of 18.5±1dB has been obtained from 1320-1360nm (40nm) with a NF below 6dB using 130m long fiber.

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References

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