

All-fiber Bi-doped laser continuously tunable from 1317-1375nm

Naresh Kumar Thipparapu, Siyi Wang, Andrey A Umnikov, Pranabesh Barua and Jayanta K. Sahu

Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, U.K.

Exploring the new wavelength bands is of great importance for many different applications such as medicine, astronomy, material processing, defence and optical fiber communication. Ytterbium (Yb), Erbium (Er), and Thulium (Tm) or Holmium (Ho)-doped fibers covers the wavelength bands around 1, 1.5 and 2 μ m, respectively. However, the band between Yb and Er is mostly not covered by the rare earth (RE)-doped silica fibers. Recent years, there is a growing interest to use Bi-doped fibers with different host materials such as aluminosilicate, phosphosilicate and germanosilicate to explore the wavelength band from 1150-1500nm. Also, Bi-doped germanosilicate fibers with a high concentration of germanium (up to 50mol%) were used to cover the band from 1600-1800nm. Many optoelectronic devices including amplifiers, lasers, amplified spontaneous emission (ASE) sources and pulsed lasers were reported using Bi-doped fibers [1-3]. However, less work is being done to develop tunable Bi-doped fiber lasers. Using a Bi-doped germanosilicate fiber a tunable laser operating from 1360 to 1510nm was reported. The cavity was formed by a loop reflector and an external plane diffraction grating [4].

In this paper, we demonstrate a tunable laser operating in 1317 to 1375nm band using Bi-doped phosphosilicate fiber fabricated in-house using modified chemical vapour deposition (MCVD)-solution doping technique. The fiber has a core and clad diameter of 9 μ m and 125 μ m, respectively. The index difference (Δn) between the core and clad was around 0.004. The absorption at 1270nm pump wavelength was 0.57dB/m.

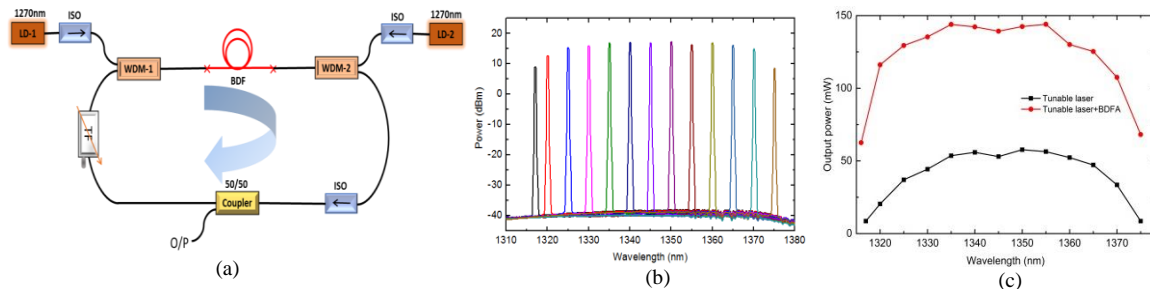


Fig. 1 (a) Schematic experimental setup of tunable Bi-doped fiber laser (b) spectra of the tunable Bi-doped fiber laser from 1317nm to 1375nm with 5nm spacing (c) output power with a wavelength of the tunable Bi-doped fiber laser before and after Bi-doped fiber amplifier

The schematic of the tunable Bi-doped fiber laser is shown in Fig. 1 (a). The set up comprised of two laser diodes (LDs) both operating at 1270nm to pump the Bi-doped fiber with a total pump power of 790mW. A 50/50 coupler and a tunable filter were used to construct the tunable laser in a ring cavity configuration. A fiber length of 70m was used. Maximum output power of 57mW was obtained at 1355nm. Moreover, the output power was tunable from 1317 to 1375nm. The spectra of the tunable laser are shown in Fig. 1 (b). Further, a Bi-doped fiber amplifier (BDFFA) was used to increase the output power of the tunable Bi-doped fiber laser. Two pump LDs operating at 1270nm and 1240nm with a combined pump power of 763mW was used in the amplifier. The output power with wavelength before and after the amplifier is shown in Fig. 1 (c). A maximum output power of 144mW was measured at 1355nm. Moreover, the output power of more than 100mW was obtained from 1318 to 1370nm in 52nm bandwidth, which is the maximum output power reported to the best of our knowledge from a tunable Bi-doped phosphosilicate fiber source. Also, the output power from 1317 to 1375nm is more than 60mW with an optical signal to noise ratio (OSNR) of ≥ 40 dB with 0.5nm resolution bandwidth for the optical spectrum analyzer.

Funding: EP/P030181/1 and through a II-VI Foundation studentship (S Wang). Research data is available at <https://doi.org/10.5258/SOTON/D0786>

References

- [1] I. A. Bufetov, M. A. Melkumov, S. V. Firstov, K. E. Riumkin, A. V. Shubin, V. F. Khopin, E. M. Dianov, "Bi-Doped Optical Fibers and Fiber Lasers," *IEEE J. Sel. Topics Quantum Electron.* **20**, 111 (2014).
- [2] N. K. Thipparapu, S. Jain, A. A. Umnikov, P. Barua, and J. K. Sahu, "1120 nm diode-pumped Bi-doped fiber amplifier," *Opt. Lett.* **40**, 2441-2444 (2015).
- [3] N. K. Thipparapu, C. Guo, A. A. Umnikov, P. Barua, A. Taranta, and J. K. Sahu, "Bismuth-doped all-fiber mode-locked laser operating at 1340 nm," *Opt. Lett.* **42**, 5102-5105 (2017).
- [4] V. M. Paramonov, M. I. Belovolov, V. F. Khopin, A. N. Gur'yanov, S. A. Vasil'ev, O. I. Medvedkov and E. M. Dianov, "Bismuth-doped fiber laser continuously tunable within the range from 1.36 to 1.51 μ m," *Quantum Electronics*, **46**, 1068, (2016).