200 km-long single-ended random fiber laser and sensor with ULLF

Bing Han[a], Han Wu[b], Yang Liu[a], Shisheng Dong[a], Yunjiang Rao[a,c], Zinan Wang[a], Jiangming Xu[a] and Lingmei Ma[c]

[a] *Key Laboratory of Optical Fiber Sensing and Communications (Education Ministry of China), University of Electronic Science and Technology of China, Chengdu 611731, China.*

[b] *College of Electronics and Information Engineering, Sichuan University, Chengdu 610064, China.*

[c] *Research Center for Optical Fiber Sensing, Zhejiang Laboratory, Hangzhou 310000, China.*

Ultra-long fiber lasers are of great interest in fundamental laser science and random fiber laser (RFL) based on distributed Raman gain is an ideal platform to realize ultra-long laser [1]. Recently, ultra-low-loss fiber (ULLF) has been successfully used in optical fiber communication systems to improve performances [2]. However, the potential of such a new generation of ULLF in lasers and sensors remains untapped.

In this paper, we proposed an ultra-long RFL and sensor, as shown in Fig. 1(a), based on high-order pump and ULLF that has low attenuation coefficient, low Rayleigh backscattering intensity and low Raman gain coefficient, for the first time. The 1090 nm pump is delivered into the fiber span by the wavelength division multiplexer (WDM) 1. The laser cavity consists of two segments of 100 km-long ULLF (G.654.E fiber) with a 10 m-long erbium-doped fiber inserted. A fiber Bragg grating (FBG) is placed at the far-end to provide backward reflection and determine the lasing wavelength. A fiber loop mirror is spliced to the pass port of the WDM2 to provide point feedback. The normalized spectrum of the 1st- to 5th-order random lasing measured at point A is shown in Fig. 1(b). With the central wavelength of the FBG changing successively, the corresponding normalized lasing spectra measured at point B with optical signal-to-noise ratio of 25 dB are depicted in Fig. 1(c). The FBG at the fiber end can also be used for angle sensing. The sensing spectra and central wavelengths versus different angles are shown in Fig. 1(d) and 1(e) with angle sensitivity of 70.3 pm/°. The ULLF-based random fiber laser and sensor could be a novel solution for long-distance safety monitoring.

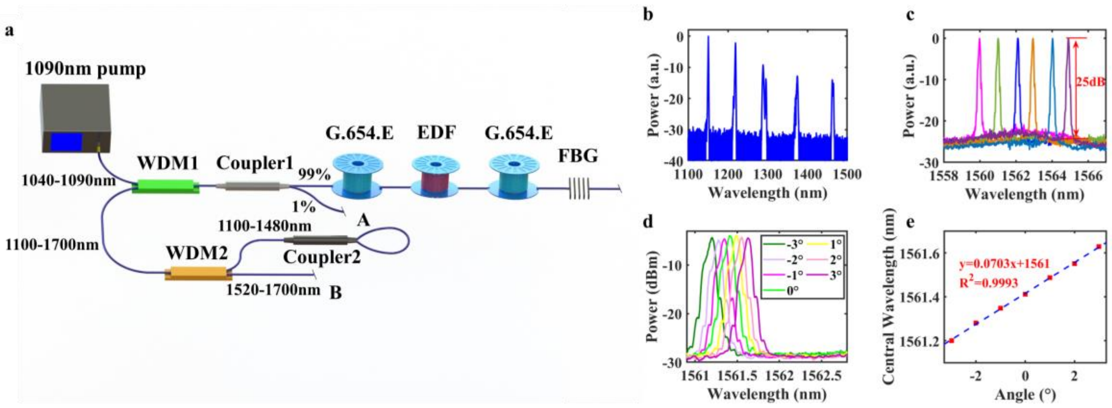

Figure 1. (a) Schematic diagram of the ultra-long 6th-order RFL. Normalized spectrum of (b) the cascaded random lasing and (c) the tunable 6th-order random lasing. (d) Sensing spectra and (e) central wavelengths of the FBG versus different angles.

[1] S. K. Turitsyn, S. A. Babin, A. E. El-Taher, et al. *Nat. Photon.* **4**, 231 (2010).
[2] J. Wu, J. Xu, Q. Hu, et al. *Optical Fiber Communication*, F4G.3 (2021).