Artificial Rayleigh fibers and its laser’s application

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At the moment, optical fibers (OF) are used in various branches of science and technology. In addition, optical fibers common using in information systems (communication lines and fiber sensors). The use of optical fiber in laser systems is also developing. Usually, OFs are doped with such rare-earth ions as erbium, ytterbium, bismuth, thulium, etc. are used to obtain lasing. Recently, a new direction so-called random fiber lasers [1–3] are actively developing. This direction of photonics has become a subject of great interest for researchers around the world due to the fact that random fiber lasers are able to generate light with unique performance characteristics without imposing strict requirements on the optical cavity. In this case, amplification is achieved as due to the Raman scattering effects [2] as stimulated Brillouin scattering (SBS) [3]. The feedback in the optical fibers is achieved due to weak stationary ("frozen into the glass grid") scattering centers uniformly distributed over the fiber length (Rayleigh scattering). This leads to the fact that cavity of random lasers are constructed using long (1–100 km) OFs. Current trends in random fiber lasers are associated with the transition to lasers with cavities [4] based on short artificial Rayleigh optical fibers (OFs containing an array of fiber Bragg gratings - FBGs) [5].

We have developed an OF with FBG. The inscription of which is performed during the OF drawing process [5]. The formation of an FBG array in such an optical fiber is performed using pulsed radiation from an excimer UV laser passing through a phase mask. The number of FBGs of such OF can reach 10,000 ones per 100 meters. The increase in the return signal in comparison with the Rayleigh scattering level reaches 50 dB at the wavelength of λ = 1550 nm. The typical width of the reflection spectrum of the FBG array is 0.3 nm. The width of the reflection spectrum of the array reaches 4 nm using a chirped phase mask. It is also possible to expand of the reflection spectrum up to 4 nm by means of the tapering of the optical fiber with the FBG array. It is possible to inscribe FBG array both in an optical fiber drawn from a photosensitive preform and in a conventional single-mode telecommunication optical fiber of the SMF-28 type. In the latter case, the inscription contrast reaches 25 dB at the wavelength of λ = 1550, which significantly increases the Rayleigh scattering level and expands the possibilities of using such an optical fiber in a coherent reflectometry system [6-7].

We obtained narrow-band lasing with a lasing line width of less than 10 kHz at the wavelength of 1552 nm [8] using an OF with an FBG array 100 meters long. Additionally, a short section (~ 1 m) of an Er-doped with erbium ions was added to the cavity of a random laser, which was used as a dynamic mode filter [9]. The tapered optical fiber with an FBG array can be used as a resonator [10] to obtain tunable lasing in a band of up to 4 nm.

It is also possible to inscribe FBG arrays during the drawing process of the OF doped with erbium ions [11–12]. It makes possible to create OFs that combine both increased reflectivity and the possibility of forming dynamic gratings, which are extremely important for spectral selection of laser radiation. In fig. 1 (a) shows the frequency reflectogram (OFDR) trace of an OF doped with erbium ions. The inscription contrast reaches 30 dB at the wavelength of 1547.6 nm with a reflection spectrum width of up to 0.3 nm. The lasing radio-frequency spectrum measured by the self-heterodyne method is shown on Fig. 1 (b). The lasing efficiency reaches 2.5% at a pump power of 300 mW at the wavelength of 976 nm. The cavity length is 5 m.

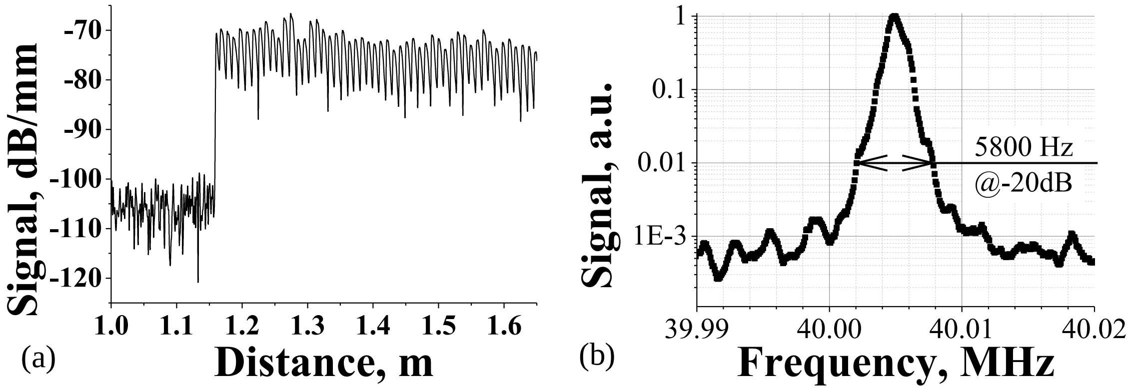

Fig. 1. Frequency reflectogram (OFDR) trace (a) of erbium ions doped OF with an FBG array, and (b) lasing radio-frequency spectrum, measured by the self-heterodyne method.

The design of the laser ensures the predominance of the reflectivity created by the dynamic grating of the inverted population over the stationary centers of reflection. It makes it possible to effectively carry out nonlinear filtering directly in the OF cavity [12]. In this case, the width of the laser line is narrowed to a frequency range of less than 1 kHz.

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