Linearly-polarized Ho-doped fiber laser with wavelength self-sweeping near 2.09 μm

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The sources with lasing near 2 μm are of particular interest due to presence of strong absorption lines of water and carbon dioxide in this spectral range. Spectral analysis of the molecules can be used in bioatmospheric analysis as well as in medicine. In particular, the *Helicobacter Pylori* bacteria can be detected by analyzing carbon dioxide isotopes in human expired air [1]. The method is based on measurement of relative difference between concentration ratio of 12- and 13-isotopes of carbon dioxides in the test sample and standard one for the isotopes. For this purpose, a spectrometer based on a tunable laser with lasing near 2 μm can be applied. There are many methods for laser's frequency tuning, such as application of diffraction gratings, Bragg gratings or interferometers. However, the wavelength tuning can be obtained without tunable elements in fiber lasers with self-induced frequency sweeping ("self-sweeping" for short) [2]. The lasing near 2 μm can be achieved in fiber lasers based on Thulium- as well as Holmium-doped active fibers. Such a self-sweeping Ho-doped fiber laser with lasing near 2100 nm has been demonstrated in [3]. However, stability of lasing was violated due to thermal and mechanical impact. It makes difficult to use this lasing source for continuous measurements. Probably, the lasing instability has been caused because of using non-polarized active fiber. In this paper, we present the Ho-doped fiber laser with self-sweeping near 2.09 μm which suits better for described practical tasks.

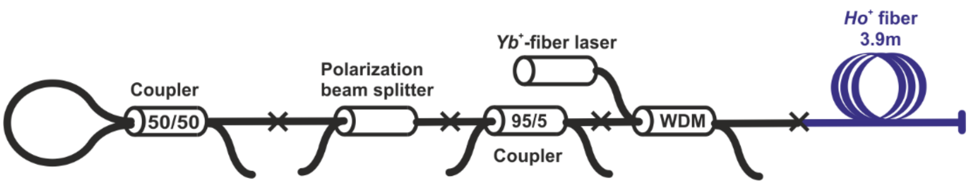

Fig.1. Schematics of the Ho-doped self-sweeping fiber laser.

The experimental scheme of the laser is presented in Fig.1. We have used polarization maintaining (PM) active fiber and components in this work to prevent the effect of mechanical deformations on the output lasing. The active medium of the fiber laser is 3.9 m long Ho-doped silica fiber (IXBlue IXF-HDF-PM-8-125). The fiber has a core diameter of 8 μm, and absorption of 8.9 dB/m at 1125 nm wavelength. An Yb-doped fiber laser with maximum output power of 4.8 W at wavelength of 1125 nm is used as the pump. This pump is significantly different from a thulium fiber laser with lasing in range of 2020-2030 nm which was used in paper [3]. The laser cavity is formed by a high-reflective fiber loop mirror (FLM), based on a 50/50 coupler at 2000 nm wavelength at one side and a right-angle cleaved active fiber end at the other side. The Ho-doped fiber is pumped through 1310/1960 wavelength division multiplexer (WDM). Mismatch of the WDM and the pump wavelengths affects the lasing efficiency. A polarization beam splitter is used as a polarizer in the laser. 5 percent ports of 95/5 intracavity coupler are used for measurements of the laser parameters.

The laser operates in a reverse self-sweeping regime near wavelength of 2.09 μm in a range of pump powers from 0.75 to 1.05 W. The sweeping range and rate is about 5 nm and 1.1 nm/s correspondingly (Fig. 2a). The generated power at cleaved output end is about 150 mW. The intensity dynamics is quasi-CW, which differs from the results of [3], where the output generation is self-sustained pulsations, which are usually observed in the self-sweeping regime. It is also worth noting that the laser operation mode lasted for a long time (more than 1 hour), it also differs from results of work [3], where duration of the operation was limited to a few minutes. We believe that the developed self-sweeping source can be used for spectroscopy of 12- and 13-isotopes of carbon dioxides (Fig.2b).

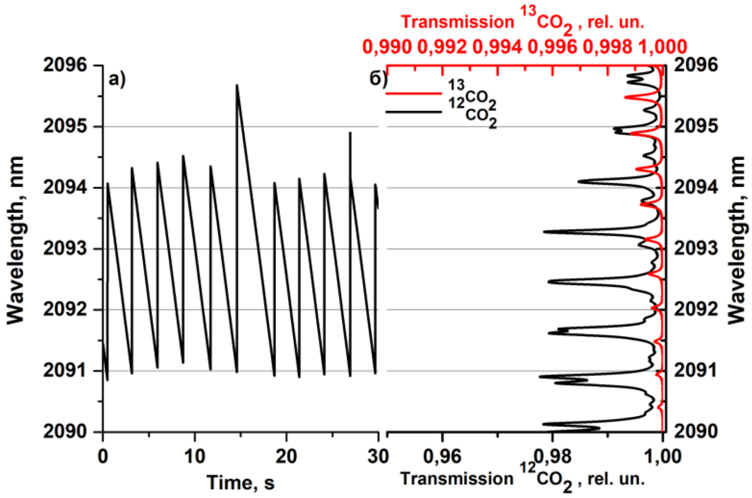

Fig.2. Spectral dynamics of the laser (a) and transmission spectra of 12- and 13-isotopes of carbon dioxides (b).

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