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Synchronous-pumped raman all-fibre pulsed laser based on quartz optical fibre doped with phosphorus oxide

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***Abstract**: invention relates to laser equipment. Synchronous-pumped Raman all-fibre pulsed laser based on quartz optical fibre doped with phosphorus oxide, comprises a linear resonator formed by two Bragg gratings, one Bragg grating of resonator completely reflects radiation of a first Stokes component of Raman scattering of phosphorus oxide, and other grating reflects it partially to output radiation from resonator. Active medium used is a piece of quartz optical fibre, doped with phosphorus oxide. Pumping radiation source is a pulse source with radiation pulse duration from 100 to 240 picoseconds, wherein length of optical fibre is in range of 1-100 m. EFFECT: technical result consists in production of laser radiation pulses at a first Stokes component of phosphorus oxide with duration shorter than 300 picoseconds.*
6 cl, 2 dwg

Description

The present invention relates to lasers - devices for the generation of coherent electromagnetic waves and is industrially applicable in devices and systems that use laser light.

From the prior art known to the effect of stimulated Raman scattering (Raman effect) in optical fiber (RH Stolen, EP Ippen, and AR Tynes. Raman oscillation in glass optical waveguide. Appl. Phys. Lett. 20, 62 (1972)), allowing to carry out spectral conversion of radiation to longer wavelengths and create based on this effect, Raman fiber lasers (M. Rinia, I. Cristiania, V. Degiorgioa, A. Kurkov, VM Paramonov. Experimental and numerical optimization of a fiber Raman laser. Opt. Commun. 203 , 139-144 (2002)) using different fibers - germano-silicate, phosphorus silicate, and others.

The disadvantage of this technical solution is that when using the German-silicate fiber Raman effect allows a relatively small spectral shift from entering the fiber composition SiO2 (440 cm-1), And providing a substantially greater spectral shift (1330 cm-1) Phosphor-silicate fiber containing phosphorus oxide (P2ABOUT5), Does not provide a relatively short picosecond pulses of radiation.

Known synchronously pumped stimulated Raman scattering (SRS) fiber laser based on the German-silicate fiber (EM Diana Mamyshev PV, Prokhorov, DG Fursa. Subpicosecond tunable synchronously pumped fiber optical Raman laser. JETP Letters, vol. 45, no. 10, pp. 469-471 (1987)).

A disadvantage of this technical solution is a relatively small spectral shift in an incoming fiber composition SiO2(440 cm-1) And that the laser fiber is not completely - is used for the non-fibrous pumping Nd: YAG laser.

The closest to the claimed technical solution is synchronously pumped Raman all-fiber pulsed laser based on silica fiber doped with phosphorus oxide, containing a linear cavity formed by two Bragg gratings reflection spectra of which are centered on the emission wavelength of the first Stokes component of phosphorus oxide containing between Bragg bars as the active medium length of silica fiber doped with phosphorus oxide, converting the pumping radiation into radiation of the first Stokes component of stimulated Raman (Raman) scattering of phosphorus oxide, one Bragg resonator grille completely reflecting the radiation of the first Stokes component of the Raman scattering of phosphorus oxide and the other grating reflects its partly for the emission output of the Raman pulse laser resonator optically coupled to a periodic switching power pump light with a period of repetition, multiple round-trip time of the generated pulses of the linear resonator (ASKurkov, VV Dvoyrin, VM Paramonov, OI

Medvedkov, EM Dianov. All-fiber pulsed Raman source based on Yb: Bi fiber laser. Laser Phys. Lett. v. 4, No. 6, 449-451 (2007)).

The disadvantage of this solution is the relatively long duration of the output laser pulses is 3 microseconds. The relatively long duration of the output light of the Raman laser pulses caused in this case, the long duration of the pump pulses, operating in Q-switched mode.

The task to be solved by the claimed invention is to provide a substantially shorter (picosecond) laser pulses Raman fiber laser is completely at the first Stokes component of phosphorus oxide.

This problem is solved by the fact that in a synchronously-pumped Raman all-fiber pulsed laser based on silica fiber doped with phosphorus oxide containing a linear cavity formed by two Bragg gratings reflection spectra of which are centered on the emission wavelength of the first Stokes component of phosphorus oxide, containing between Bragg gratings as the active medium length of silica fiber doped with phosphorus oxide, converting the pumping radiation into radiation of the first Stokes component of stimulated Raman (Raman) scattering of phosphorus oxide, one Bragg resonator grille completely reflecting the radiation of the first Stokes component of the Raman scattering of phosphorus oxide and the other grating reflects its part for the emission output of the Raman pulse laser of resonator, optically coupled to a periodic switching power pump light with a period of pulse repetition, multiple round-trip time of the generated pulses of the linear resonator according to the invention of the pump radiation source is a pulse source with a pulse duration of 100 to 240 picoseconds while the fiber length is in the range of 1-100 m.

In particular, the molar concentration of the phosphorus oxide in the fiber core may be in the range 1-30%.

In particular, the diameter of the fiber core may be in the range of 3-25 microns.

In particular, the spectral width of the working areas of the linear resonator Bragg reflectors may exceed 5 nm.

In particular, the pulsed pump light source can be formed as a fiber laser with synchronization radiation modes.

In particular, the pulsed pump light source can be formed as a Raman fiber laser pulse.

The prior art has not disclosed a device having the claimed set of attributes, i.e. it has a novelty.

The technical result provided by the above combination of features is a breakthrough in synchronously pumped Raman all-fiber pulsed laser based on phosphorus-silicate fiber with a linear resonator and a pump provided with a duration of pulses is in the range from 100 to 240 picoseconds, the duration of the output laser pulses less than 300 ps at the first Stokes component of the phosphorus oxide.

The invention is illustrated by the following schemes.

FIG. 1 is a diagram of the synchronous-pumped Raman pulse laser based on silica fiber doped with phosphorus oxide: 1 - pumping radiation source, 2 - pump radiation, 3 - Bragg grating resonator, completely reflecting the radiation of the first Stokes component of the Raman scattering of phosphorus oxide, 4 - silica fiber doped with phosphorus oxide, 5 - Bragg grating resonator, partly reflecting the radiation of the first Stokes component of the Raman scattering of phosphorus oxide, 6 - output radiation synchronously-pumped Raman laser pulse.

FIG. 2 shows the emission share of the first Stokes component of phosphorus oxide in the output radiation pulse Raman laser on the duration of the pump pulse.

The device operates as follows.

Intermittent pulsed pump radiation 2 (FIG. 1), generated by a source 1 of optical pumping radiation enters the linear cavity of the Raman laser formed by the two Bragg gratings 3 and 5, the reflectance spectra which are centered at the emission wavelength of the first Stokes component of phosphorus oxide containing between Bragg gratings as the active medium segment 4 silica fiber doped with phosphorus oxide, converting the pump output radiation in the Raman laser radiation 6 at the first Stokes component of the phosphorus oxide. Pumped Raman laser is used synchronous pumping: pump pulse repetition period is a multiple round-trip time of the generated pulse linear Raman laser resonator. Using multi-pass linear resonator with Bragg gratings to reflect radiation of the first Stokes component of phosphorus oxide can improve the efficiency of generation of pulsed Raman laser at the first Stokes component of phosphorus oxide. As shown by experimental studies of the authors of this application (Fig. 2), the proportion of radiation at the first Stokes component of phosphorus oxide in the output radiation pulse Raman laser can reach 30%. To achieve the fraction of the radiation at the first Stokes component of the phosphorus oxide in the output radiation of the Raman laser pulse in the range of 25-30% (shaded portion in FIG. 2), the pump pulse duration should be in the range of 100-240 ps. Getting a pulse duration is not a scientific, technical or technological problem: known picosecond fiber lasers provide high power (or energy) pulses with duration of a few picoseconds (picoPower company Alphalas GmbH Laser; laser DUETTO company Time-Bandwidth). To increase the duration of the pulses to a value in the range of 100-240 ps additional fiber can be used at the output of the pump laser for the dispersion "stretching" during the pulse time. Temporary "stretching" ("stretching" in Western literature) pulses with the help of passing them through a long fiber (in the tens or hundreds of meters long) is a standard known method of increasing the duration of the laser pulse ("Temporal Stretching of Laser Pulses", chapter 10 in the book " Coherence and Ultrashort Pulse Laser Emission ", edited by FJ Duarte, ISBN 978-953-307-242-5, 698 pages, publisher: InTech). An important advantage of a temporary "stretched" pulse with additional fiber system is that the laser system with fiber remains completely: the additional fiber may be welded at one end to a fiber pumping laser and the other end to the cavity of the Raman laser. the required duration of the pump pulses Preparation can be carried out in another way - by adjusting their length directly to the pump laser (for example, using "Tunable Pulse Stretcher for Ultrafast Fiber Lasers" Company TeraXion).

With a length of optical fiber in the range of 1-100 m achieved the best efficiency of generation of synchronous-pumped Raman fiber completely picosecond laser based on silica fiber doped with phosphorus oxide, at the first Stokes component of phosphorus oxide. At low fiber length (<1 m) can not provide sufficient Raman amplification for relatively efficient generation of radiation at the first Stokes component of phosphorus oxide, and at great length of the fiber (> 100 m) starts to increase significantly at the first Stokes component of phosphorus oxide duration Raman laser pulses of -this noticeable effect of the dispersion of the fiber.

Quartz fiber doped with phosphorus oxide, is commercially available, it can be easily obtained (in Russia, it delivers innovative enterprise "FORC - Photonics").

Claims (6)

1: synchronously pumped Raman fiber pulse laser is completely based on silica fiber doped with phosphorus oxide, containing a linear cavity formed by two Bragg gratings reflection spectra of which are centered on the emission wavelength of the first Stokes component of phosphorus oxide containing between Bragg gratings as the active medium cut quartz optical fiber doped with phosphorus oxide,

converting the pumping radiation into radiation of the first Stokes component of stimulated Raman (Raman) scattering of phosphorus oxide, one Bragg resonator grille completely reflecting the radiation of the first Stokes component of the Raman scattering of phosphorus oxide and the other grating reflects its part to the emission output Raman pulsed laser of resonator, optically coupled to a periodic pulse source with the period of the pulse of the pump radiation, multiple round-trip time of the generated pulses of the linear resonator, characterized in that the pump radiation source is a pulse source with a duration of pulses from 100 to 240 picoseconds, and the length of the fiber is in the range of 1-100 m.

2: The laser of claim. 1, characterized in that the molar concentration of the phosphorus oxide in the fiber core is in the range 1-30%.

3: The laser of claim. 1, characterized in that the core diameter of the fiber is in the range of 3-25 microns.

4: The laser of claim. 1, characterized in that the working width of the spectral regions of the linear resonator Bragg reflectors exceed 5 nm.

5: The laser of claim. 1, characterized in that the pulsed pump light source is designed as a fiber laser with an emission timing modes.

6: The laser of claim. 1, characterized in that the pulsed pump light source is in the form of a Raman fiber laser pulse.