Raman laser based on a 7-core fiber with cross-coupling between the cores

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Raman lasers based on multicore fibers (MCFs) with cross-coupling between the cores are promising high-power sources, since the power density in this type of lasers decreases as compared with single-core lasers, leading to a decrease in nonlinear effects inside the laser cavity. For example, in [1], a Raman fiber laser based on a polarization- maintaining (PM) twin-core fiber (TCF) with random distributed feedback was presented. In this case, a fiber loop mirror based on a 50/50 PM coupler at 1064 nm is used to form a half-open cavity. The linewidth of this laser was found to be about 5 times narrower than the linewidth of a random Raman laser in a similar configuration based on a single-core fiber. It was shown that the narrowing of the lasing line is due to weakening of nonlinear effects and spectral-selective properties of a TCF. The femtosecond point-by-point technique [2], which allows writing fiber Bragg gratings (FBGs) in selected cores with high positioning accuracy, was used in [3, 4] to form different cavity configurations of a Raman laser based on TCF. Thus, in [3], a scheme with point reflectors was demonstrated, where the laser cavity was formed by highly reflective FBG selectively inscribed in a single core and a right angle cleavage or a weakly reflecting FBG at the output end of the laser. In [4], a method of additional spectral filtering is presented due to the writing of two highly reflective FBGs in different cores at the cavity input, which are displaced relative to each other in the longitudinal direction, thereby forming a Michelson interferometer. Compared with [1], it was shown that the use of FBGs in TCF Raman laser cavity improve the stability of the laser power characteristics and provide the narrow linewidth.

In this work, we demonstrate a Raman fiber laser configuration based on a 7-core fiber (Fig.1a) and point reflectors consisting of highly reflective FBGs. Core-selective inscription of FBGs was carried out using the femtosecond point-by-point technique in the peripheral cores at the input and output of the laser cavity. The effective reflection coefficient of the FBG array for each side of the cavity is estimated to be $\approx$80%. To reduce the effect of nonresonant losses, single-mode fiber guiding the pump signal was spliced to the central core. The lasing threshold was reached at a pump power of $\approx$3 W, while the maximum lasing linewidth at an output power of $\approx$2.5 W was less than 350 pm (Fig. 1b).

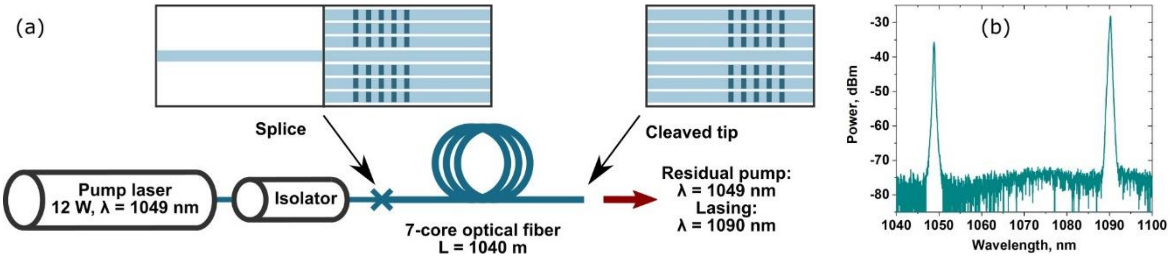

Figure: 1. (a) Experimental setup of a Raman fiber laser based on a 7-core fiber. (b) Spectrum of pump (≈ 1049 nm) and Stokes lasing (≈ 1090 nm)

Since highly reflective FBGs at the Stokes wavelength were inscribed only in the peripheral cores, the maximum Raman power was observed for the central core. Thus, the use of the femtosecond laser for writing FBGs in the selected cores makes it possible to set the spatial distribution of the transverse modes for a Raman fiber laser based on an MCF. An increase in the effective area of transverse modes, as well as the spectral-selective properties of MCF provide the possibility to create high-power Raman fiber lasers with a narrow linewidth.

In the report, we are going to discuss the specifics of the lasing regimes of this type of Raman fiber laser, as well as its spectral and power characteristics.

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