Abstract of doctoral dissertation

Experimental studies of selected modal conversion processes in structured optical fibers

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The experimental research carried out in the framework of this dissertation was aimed at proving that the structuring of optical fiber parameters in combination with the structuring of the input beam provides new, previously unattainable possibilities of linear and non-linear mode conversion. Several new conversion processes have been proposed and experimentally investigated, including nonlinear conversion occurring between LP_{01} and LP_{11} polarization modes in a Panda birefringent optical fiber. For this purpose, a new method of selective excitation of various combinations of LP_{01} and LP_{11} modes using a Wollaston prism was developed, which allowed for the first experimental demonstration of the four-wave mixing process occurring in orthogonally polarized modes from different spatial groups. The conversion of LP_{11} modes to vortex modes by gradient twisting of the fiber output section was demonstrated on the example of side-bands generated in LP_{11} modes as a result of vector modulation instabilities. In a twisted Side-Hole optical fiber, the process of vector modulation instabilities taking place in a circularly birefringent fiber has been observed for the first time. This effect was also analyzed numerically, proving that in the circularly birefringent fibers the conversion efficiency is not limited by the critical power.

The linear mode conversion processes induced by fiber twisting and/or bending were also investigated. In a fiber with an asymmetric microstructure located near the core, the possibilities of bend-induced modulation of chromatic dispersion and coupling of polarization modes was demonstrated. The latter effect was used to tune the spectral position and polarization of the optical solitons generated when pumping with a femtosecond laser. In the microstructured fiber with the core formed by open rings of holes, the width of the transmitted spectral band was shown to be dependent on the twist period, bend radius, distance of the core from the cladding symmetry axis and the number of air channels forming the core, which was exploited to demonstrate the displacement sensor. In the twisted dual-core fiber, a new effect of generation of bend-induced long-period gratings is shown, as a result of which resonant couplings were observed at different wavelengths, depending on the twist period, bend radius, distance between the cores and a level of dopant concentrations.

A method of broadband selective higher-order mode excitation with the use of a liquid crystal spatial light modulator was also developed. A partially automated setup was built to measure the chromatic dispersion and the group refractive index in a selected fiber spatial mode in a very wide spectral range of 600-3400 nm using the spectral interference method. Moreover, two algorithms for the analysis of measurement data enabling the determination of chromatic dispersion with an accuracy of a few ps/km/nm were developed. The first one allows for the automatic determination of the position of the zero-order interference fringe from a series of spectral interferograms registered for a fiber of a length of up to two meters, and the second one relies on retrieving the spectral phase difference function from a single interferogram registered for a fiber of a length of several centimeters.