Abstract

This dissertation is focused on the investigation of the waveguiding properties of liquid crystal-filled microstructured fibers. These photonic crystal fibers exhibit a two-dimensional periodic microstructured profile. The latter microstructure enables the guidance of electromagnetic radiation with a propagation constant perpendicular to the profile. Light can be guided in these fibers over longer distances. Even the first photonic crystal fibers in practical existence had superior waveguiding properties compared to conventional optical fibers. For example, single-mode fibers, which are used in laser applications, could be improved by enhancing the core diameter. Furthermore, waveguiding mechanisms with a high index cladding can be applied in photonic crystal fibers in order to guide light over large distances. ‘Cladding’ is a technical term for the surrounding of the waveguiding core region of a fiber. Generally, a high reflectivity of the cladding is required in order to confine and guide light in the core.

Liquid crystals show highly interesting optical properties. These fluidic and optically highly anisotropic substances are predetermined to be applied as active elements in optical modulators. Typical nematic liquid crystals are only weakly absorbing in the visible and near infrared spectral region. Even though, the latter show a high and additionally anisotropic optical damping. The application as core material in terms of waveguides is possible only very limitedly for liquid crystals. However, only relatively short fibers in the range of several to several tens of millimeters are required in the field of fiberoptical modulators.

It is well established to fill the microstructured cladding of selected photonic crystal fibers with liquid crystals. In the current dissertation, a technique is developed to homogeneously fill rather long pieces of photonic crystal fibers. Systematical investigations are conducted. The attenuation properties and the switching characteristics of liquid crystal-filled photonic crystal fibers are investigated experimentally and by means of electromagnetic field simulations.

Two liquid crystal-filled microstructured silica glass fibers are investigated in the experimental part. The fibers show structured attenuation spectra with intervals of small attenuations where values even lower than 1 dB/cm are achieved. Fiber optical modulators are shown in switching experiments where polarization dependent and independent responses are investigated. Moreover, the response times of these modulators are optimized.

Electromagnetic field simulations are conducted in order to obtain approximate theoretical attenuation spectra. In this model, the light scattering due to thermal fluctuations of the molecular orientation of the liquid crystal is considered as damping mechanism. The parameters of the experimental system are considered in the simulations. Reasonable agreement of the simulations and the experimental results is obtained. Thus, the simulation can be used as a tool in order to understand the attenuation properties of real fibers in more detail.