Silica fiber technology is one of the main fields of optoelectronics and is a platform for the development of new constructions of fiber lasers (including high-power lasers). Currently, the most frequently used profile of the optical beam in many applications of laser technology is the Gaussian shape (usually described by the parameter $M^2 \approx 1$) or as close as possible to it. This is due to the fact of a well-defined profile and the ability to focus this type of beam on a small area, which allows for obtaining significant power densities. Unfortunately, from the point of view of laser processing of materials, only the central part of the Gaussian profile of the optical beam (above the material processing threshold) is its useful part. The energy carried by the sidebands heats only the processed material, which can lead to unfavorable phenomena such as heating the material, obtaining poorer quality of the cut edge, and unintended surface treatment (e.g. surface hardening).
All these disadvantages can be minimized by optimizing the shape of the optical beam to obtain a flat-top (also called top-hat) profile with a constant power density in the cross-section. The use of such a laser beam profile enables precise control of the width of the laser beam path, obtaining sharp cutting edges and precise surface treatment. In addition, it often allows to increase the efficiency of the process by increasing the speed of ablation. Flat-top systems are beneficial in laser micromachining of materials (cutting, welding, additive methods - printing, including metals, laser-induced damage threshold (LIDT), micro and nanostructuring, processing of semiconductor wafers, production of nanostructures mechanical (MEMS) and optomechanical (MOEMS). Currently, to transform the Gaussian beam into a flat-top profile, special diffraction systems (Diffractive Optical Elements, DOE) are used, based on correction of the shape of the optical beam through specially shaped spatially changing phase lenses or nanostructured wave plates. Unfortunately, such systems are sensitive to the correct spatial justification of elements depending on the diameter of the input beam.
The project aims to develop a new construction of optical fibers with a multi-ring core and a large mode area (Large Mode Area, LMA) in which the optimization of the refractive profile and the arrangement of the active dopant (thulium, holmium) will allow obtaining an optical beam with a constant power density in the cross-section (flat -top) directly in the optical fiber. To achieve the assumed goal and test the research hypothesis, optimization (simulation) works will be carried out and will be produced using the phase deposition method gas - MCVD-CDT (Modified Chemical Vapor Deposition - Chelate Doping Technique) providing the ability to control this type of doped structures. The key stage in the development of the optical fiber structure will be the verification of the achievement of the assumed parameters (deposition efficiency, optical and structural characterization of the preforms), allowing for the development and optimization of the parameters of the MCVD-CDT process. Scaling of preforms to produce active double-clad optical fibers with emission in the range of 1.7-2.1μm (emission defined as safe for the eyes). The developed doped optical fibers (thulium and holmium) will be used to build laser systems emitting in the assumed spectral ranges. Optimization of the construction of the laser system will also be carried out to obtain a high-quality optical beam of laser emission using the manufactured optical fibers.
These issues are a significant contribution to the field of photonics and active fiber technology. An undoubted contribution to their development will be a set of basic research on optimization (simulation works), manufacturing (MCVD-CDT technology), structural and luminescent silica fibers (MRC) allowing for the construction of new laser radiation sources with constant power density beam emission in the cross-section, well-defined spectral profile and working in the eye-safe range.