Design and fabrication technology of optical fiber components for lasers and amplifiers

Popular science abstract

Photonics is a scientific discipline that focuses on all aspects of light: methods of its generation, manipulation of its parameters, interaction with matter, and much more. It is an incredibly fast-growing branch of science, and it especially boomed after 1960, when Theodore Maiman, an American engineer, and physicist, built the world's first laser.

Despite several decades of dynamic development of laser technology, fiber optics, or photonics in general, there are still many unsolved technical, technological, and scientific problems associated with the "taming" of laser light. The Maiman's laser was a giant breakthrough, but nowadays, lasers are built very differently. A special class of lasers are the so-called fiber lasers, in which light is "trapped" in optical fibers. The light leaves the fiber only at the very end - forming the output beam. As scientists developing new designs of lasers, we try to ensure that the light will not leave the fiber and will not propagate in free-space. Why do we need this? The process of outcoupling light from the fiber and coupling back is cumbersome: it introduces power losses and requires precise, stable mechanics to ensure long-term stability of such a system. Unfortunately, it is not always possible to construct an all-fiber optic system, as fiber optic components with adequate functionality often do not exist.

This project is a response to the current needs of photonics - to solve the problem of manufacturing non-standard optical fiber components, crucial for developing novel lasers, light sources, amplifiers or next-generation photonic systems. As part of the project, we will design and test new types of structures made of optical fibers that have, for example, the ability to focus light at a certain distance behind the fiber tip. Sounds trivial! But it is an issue that requires in-depth numerical analysis and the development of simple technology for manufacturing such structures. These optical fibers could then be used, for example, as probes in sensors or diagnostic medical equipment - they will have the ability to focus light on the surface of the examined tissue, and receive a backscattered signal and transmit it for further analysis. We will also develop ways to efficiently transmit light between optical fibers and so-called planar waveguides (i.e., light-conducting structures like optical fibers but with much smaller dimensions, e.g., 1x1 μm cross-section). Such planar waveguides are now the main building block of so-called photonic integrated circuit. We are all very familiar with electronic integrated circuits and their impact on the reality around us. The next revolution is fast approaching: photonic integrated circuits. However, on the way to this revolution, we encounter more and more obstacles. One of them is fundamental: the efficient introduction of light into waveguides. In this project, we intend to design and fabricate fiber-optic structures that allow efficient coupling between a laser and a waveguide.

We believe that the proposed four-year research program, which is also the core of the Ph.D. thesis, will contribute to the development of photonics and laser technology and lead to a new type of fiber optic components useful in the development of next-generation lasers and light sources.