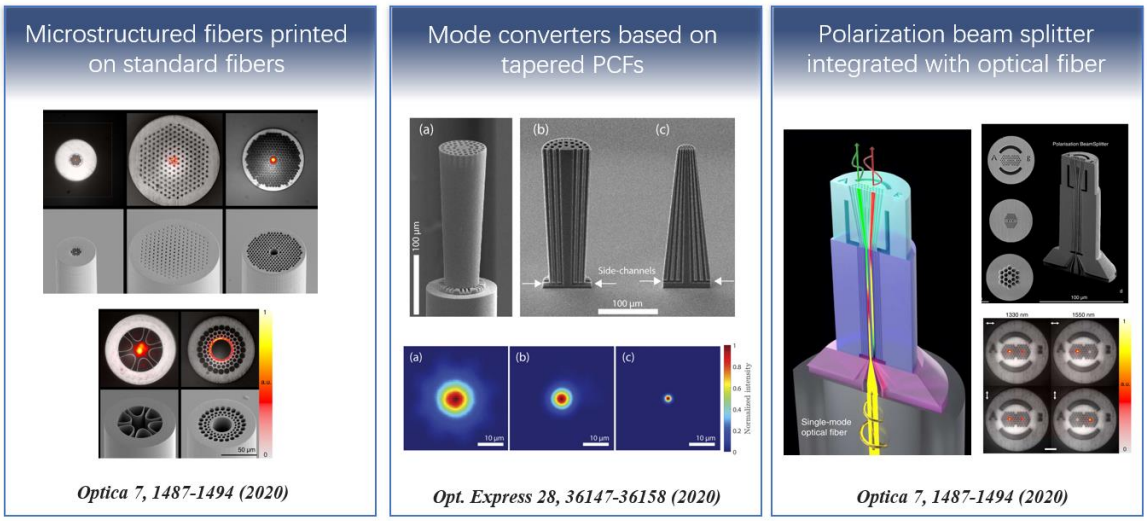
HIT-MODCON - Highly-integrated tunable and broadband microstructured fiber-optic mode converters

An optical fiber mode describes the pattern of light waves that are used to transmit information through the fiber. Optical fibers can support multiple modes, what means that they can transmit multiple patterns of light waves at the same time. By using mode converters, it's possible to change or combine different modes of light to increase an amount of data that can be transmitted through the fiber. Mode converters help to increase the amount of data that can be transmitted through the fiber by changing or combining the different modes of light travelling through the fiber. In 2020 in Japan, it was demonstrated that by using multi-core fiber and special mode converters in the so-called SDM (Spatial Division Multiplexing) systems, it was possible to transmit more than 10 Peta-bits of data per second, which is about 100 times more than the maximum capacity of a regular single-mode fiber (https://doi.org/10.1364/OFC.2020.Th3H.1). Recently, also Japanese researchers were able to transmit 1.53 Peta-bits of data per second through a single-core multi-mode fiber by using mode converters and multiplexing 55 modes (ECOC 2022, paper Th3C.3). It's clear that future of telecommunications depends on SDM, and creating ultra-high-speed transmission systems will require basic components as mode converters, mode multiplexers, and mode filters.

In the frame of HIT-MODCON project a new kind of mode converters that works with optical fibers and can help transmit lots of data quickly will be developed. The project aims to design tiny three-dimensional microstructures that can be put into the fiber to modify the way of light propagation. Elaborated in the project mode converters will be adjustable and tunable so the output modes can be easily modified to work in different ways. The final objective is to make a mode converter that can create different types of light patterns directly from the fiber, including so called optical vortex beams. Figure below shows first attempts to create microstructured 3-dimensional mode-converters integrated with optical fiber (fabricated by Italian and Belgium researchers):



The new types of fiber optic devices proposed in the project (as mode converters that can be adjusted, broadband fiber-integrated mode splitters that can split light into different modes, and switchable fiber-integrated vortex beam generators) could be used not only in telecommunication systems but also in super-resolution microscopic imaging, optical trapping and fiber-optic sensing.

Realization of such highly-innovative fiber-optic functional microstructures would not be possible without participation of three teams: from Poland (WUT) and China (GUT, SUSTech) that have complementary research capabilities. *Guangdong University of Technology* (GUT) has great experience in mode conversion and its applications in telecommunication system, moreover it has expertise in fabrication with fs laser machining. *Warsaw University of Technology* (WUT) has experience in tunable fiber optic devices (including both electro-optic and all-optical tuning) and microfabrication of three-dimensional structures directly at the top of the fiber (by two-photon polymerization). Finally, *Southern University of Science and Technology* (SUSTech) has very high expertise level in the field of optical vortex beams and its application in fiber-optic systems. Hence, all these three teams can have significant and unique contribution in development, creation, characterization as well validation of new types of mode converters.