3D printed Polarization Micro-Optics: Fresnel Rhomb printed on an optical fiber

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Abstract: A miniaturized and fiber-integrated Fresnel Rhomb has been 3D printed with Direct Laser Writing on a polarization-maintaining fiber to act as a broadband quarter waveplate, allowing generation of circularly polarized light.
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1. Introduction

Direct Laser Writing (DLW) based 3D printing has shown recently its unique potential towards miniaturization of bulk optical elements. This has been so far mainly demonstrated for the fabrication of reflective, refractive and phase-mask micro-optics [1,2]. Here we show the use of DLW for the fabrication of a polarization optics element, a Fresnel Rhomb, integrated onto a polarization-maintaining (PM) optical fiber to obtain a miniaturized on-fiber source of circularly polarized light.

The Fresnel Rhomb is a prism in which light experiences two total internal reflections at a precisely tuned incidence angle so that the phase shift difference between *s* and *p* polarizations at the output of the prism is 90° [3]. The Fresnel rhomb acts as a quarter waveplate and features a very broad spectral range because it is not based on material birefringence.

2. Design

The designed micro-structure (total height 320 μm) is composed of two main parts (see fig. 1a): a collimating microlens (blue) and a Fresnel rhomb (green), oriented at 45 deg with respect to the axis of a PM fiber, to convert a linear polarization to a circular one.
The micro-lens is needed as the beam coming out of the fiber is divergent, while the phase shift in the Fresnel rhomb is dependent on the incidence angle, so collimation allows obtaining a uniform circular polarization across the output beam. We calculated the radius of curvature (ROC=51 μm) for the collimating lens and the angle of the prism (α=51.82 deg) starting from the refractive index of photopolymer (IP-S, Nanoscribe GmbH) used in the fabrications step [4].

3. Fabrication and experimental results

We used a DLW 3D printer based on two-photon lithography (Photonic Professional GT, Nanoscribe GmbH) to print the designed micro-structure on top of a PM panda fiber (PM780-HP, Thorlabs) (fig. 1b). The relative alignment of the structure with respect to the axis of the PM fiber is achieved thanks to the built-in camera of the 3D printing system, which allows to clearly distinguish the fiber stress rods.
To characterize the performance of our device, we measured the Stokes parameters of the output beam with the classical "quarter waveplate - polarizer" method at 1064 nm. The resulting Stokes parameters are S=(1, -0.0005, 0.0223, 0.9529) indicating that the beam is mostly circularly polarized. The Degree of Polarization (DOP) of the output beam is 0.9532.

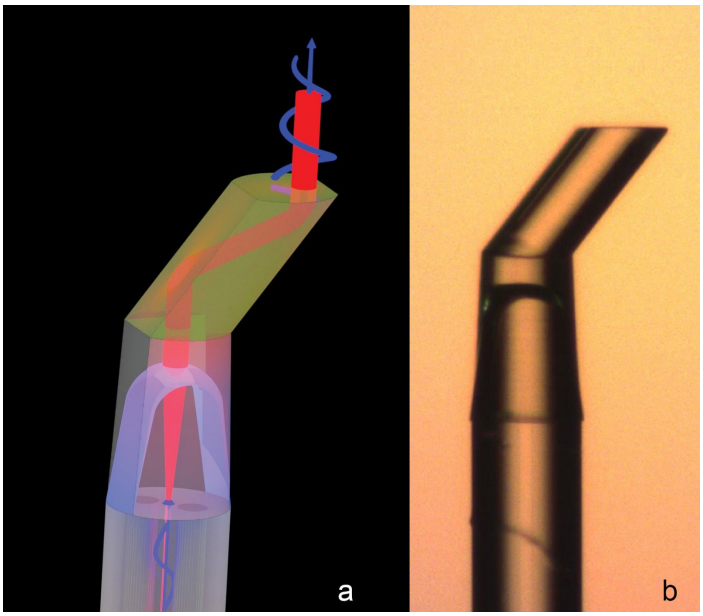

Fig. 1. a) Sketch of the designed microstructure. A linearly polarized beam exits from the PM fiber (bottom part, grey), is collimated by a lens (in the middle, blue) and is transformed to a circularly polarized beam in the Fresnel Rhomb (top part, green). b) Optical image of the microfabricated structure on top of the PM optical fiber

4. References

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