An achromatic metafibre for focusing and imaging across the entire telecommunication range

Haoran Ren[a], Jaehyuck Jang[b], Chenhao Li[c], Andreas Aigner[c], Malte Plidschun[d,e], Jisoo Kim[d,e], Junsuk Rho[b,f,g], Markus A. Schmidt[d,e,h], and Stefan A. Maier[a,c,i]

[a]*School of Physics and Astronomy, Faculty of Science, Monash University, Clayton, Victoria 3800, Australia.*

[b]*Department of Chemical Engineering, Pohang University of Science and Technology (POSTECH), Pohang, 37673, Republic of Korea.*

[c]*Chair in Hybrid Nanosystems, Nanoinstitute Munich, Faculty of Physics, Ludwig-Maximilians-Universität München, München, 80539, Germany.*

[d]*Leibniz Institute of Photonic Technology, 07745 Jena, Germany.*

[e]*Abbe Center of Photonics and Faculty of Physics, FSU Jena, 07745 Jena, Germany.*

[f]*Department of Mechanical Engineering, Pohang University of Science and Technology (POSTECH), Pohang, 37673, Republic of Korea.*

[g]*POSCO-POSTECH-RIST Convergence Research Center for Flat Optics and Metaphotonics, Pohang 37673, Republic of Korea*

[h]*Otto Schott Institute of Material Research, FSU Jena, 07745 Jena, Germany.*

[i]*Department of Physics, Imperial College London, London SW7 2AZ, United Kingdom.*

We fabricate a 3D achromatic diffractive metalens on the end face of a single-mode fiber, useful for endoscopic applications. We demonstrate achromatic and polarization-insensitive focusing across the entire near-infrared telecommunication wavelength band ranging from 1.25 to 1.65 μm.

Dispersion engineering is essential to the performance of most modern optical systems including fiber-optic devices. Even though the chromatic dispersion of a meter-scale single-mode fiber used for endoscopic applications is negligible, optical lenses located on the fiber end face for optical focusing and imaging suffer from strong chromatic aberration. Here we present the design and nanoprinting of a 3D achromatic diffractive metalens on the end face of a single-mode fiber, capable of performing achromatic and polarization-insensitive focusing across the entire near-infrared telecommunication wavelength band ranging from 1.25 to 1.65 μm. This represents the whole single-mode domain of commercially used fibers. The unlocked height degree of freedom in a 3D nanopillar meta-atom largely increases the upper bound of the time-bandwidth product of an achromatic metalens up to 21.34, leading to a wide group delay modulation range spanning from -8 to 14 fs. Furthermore, we demonstrate the use of our compact and flexible achromatic metafiber for fiber-optic confocal imaging, capable of creating in-focus sharp images under broadband light illumination. These results may unleash the full potential of fiber meta-optics for widespread applications including hyperspectral endoscopic imaging, femtosecond laser-assisted treatment, deep tissue imaging, wavelength-multiplexing fiber-optic communications, fiber sensing, and fiber lasers.