Abstract for SPIE 2025

Zhiyu Xu, Camron Nourshargh, Nathan Spiller, Tessar Wang, Alec Xu, Martin J Booth, Steve J Elston, and Stephen M Morris.

Department of Engineering Science, University of Oxford, Oxford, United Kingdom.

Future advancement of AR/VR headsets requires the introduction of new ‘flat optics’ elements to reduce the weight and decrease the form factor. In this presentation, we show how the form factor could be reduced by substituting refractive optical lenses with innovative alternatives. Our methodology involves using two-photon polymerization direct laser writing (2PP-DLW) to fabricate three-dimensional Fresnel Zone Plates (3D FZPs), functioning as diffractive lenses. 2PP DLW allows for precise control over the structure and functionality of the FZPs due to the nonlinear polymerization process creating tiny voxels of very high resolution. This method also enables the creation of complex 3D spatial profiles of the refractive indices that are not possible with traditional fabrication methods such as photolithography.

In addition to the 3D FZPs, we demonstrate an approach to polarization insensitivity using combinations of binary FZPs. Importantly, fabricating FZPs in nematic liquid crystals allows the lenses to be switched on or off based on the voltage applied, providing dynamic control over the optical properties. Our findings demonstrate the successful fabrication of polarization-independent binary FZPs as well as 3D FZPs that exhibit higher optical efficiency. For 3D FZPs, characterization includes an examination of the sharpness of the focus and the phase profile for both experiments and simulations. We believe that the implementation of these diffractive lenses in AR/VR headsets could lead to a significant reduction in size and weight, providing extra degree of freedom to control the focal length, while maintaining similar image quality.