High-efficiency Generation of Ultraviolet Structured Light via Low-loss Dielectric Metasurfaces

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Structured light, characterized by spatially varying distributions of amplitude, phase, or polarization, plays a crucial role in various applications. However, flexibly generating structured light in the ultraviolet (UV) region with conventional optical elements remains challenging due to material absorption and system complexity[1]. Here, we demonstrate high-efficiency, versatile UV structured light generation using low-loss dielectric metasurfaces capable of creating spatial light fields with arbitrary polarization and phase distributions. The metasurfaces are composed of hafnium oxide (HfO_2), a UV-transparent, high-refractive-index dielectric material, and fabricated via a resist-based Damascene lithography process[2]. By integrating geometric and propagation phase modulations, we achieve independent control over both the polarization and phase of the incident beam, enabling flexible generation of customized vector vortex beams. As a proof of concept, we implement metasurfaces to convert a Gaussian beam into various structured light modes, including zero-order Laguerre-Gaussian vector beams, zero-order Laguerre-Gaussian vector vortex beams, and higher-order Laguerre-Gaussian vector beams. The metasurfaces exhibit operational efficiencies of up to 72% at a free-space wavelength of 360 nm. Additionally, the metasurfaces support polarization multiplexing, enabling dynamic switching between radial and azimuthal polarization distributions for the generated structured beams by simply adjusting the polarization of the incident beam. This work establishes a new platform for compact and flexible UV structured light generation via flat optics, with promising applications in photolithography, high-resolution imaging, biosensing, and quantum information processing.

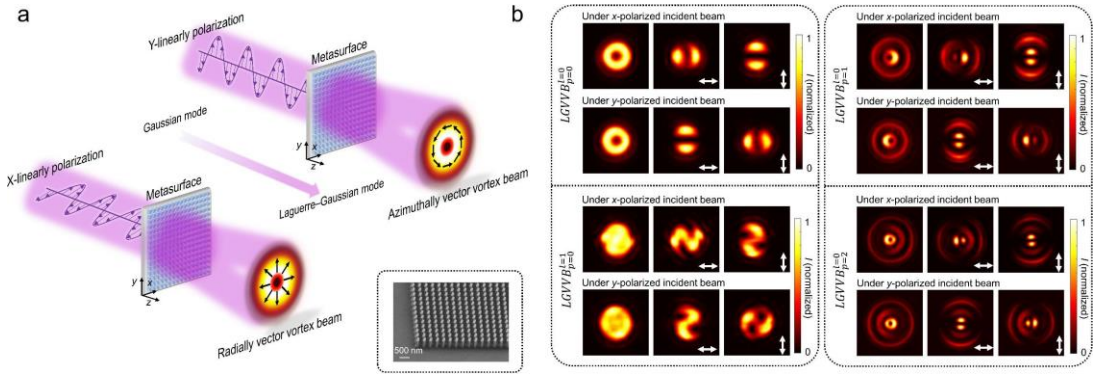

Fig. 1. a) Schematic of UV structured light generation via a low-loss dielectric metasurface. The inset shows a scanning electron microscope (SEM) image showing details of a fabricated HfO_2 metasurface. Viewing angle: 50°. **b**) Experimentally recorded intensity profiles of the generated UV Laguerre-Gaussian vector vortex beams at z = 60 mm under x- and y-polarized Gaussian beam illumination, without and with a linear polarizer analyzer. The solid arrow indicates the transmission axis of the polarizer analyzer.

References

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2. C. Zhang, S. Divitt, Q. Fan, W. Zhu, et al., Low-loss metasurface optics down to the deep ultraviolet region, *Light Sci. Appl.* **2020**, *9*, 55.