High-efficiency structured beam manipulations by a cascaded dielectric metasurface system

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Structured optical fields, such as high-order vortex beams (VB) and vectorial optical fields (VOF) with complex wavefronts and/or local polarization distributions, play an important role in modern optics and photonics due to their unique properties and broad potential applications. Conventional methods for creating complex optical fields suffer from the problems of the bulky systems, limited efficiencies and functionalities. In this study, we propose a novel approach for designing cascaded transmissive dielectric meta-devices working in the Terahertz regime to efficiently generate high-order VBs and VOFs. We first demonstrate the capabilities of the cascaded meta-devices that can generate high-order scalar VB with its order gradually increased. Next, we will present another cascaded metadevices that can first generate the VOFs and then reform them back to the original state of the input beam. Our idea has been nicely verified by both full wave simulations and experimental measurements. This work establishes a highly compact and efficient platform for creating or reforming the complex optical fields, which many find potential applications in information communication, bio-sensing, optical force, and so on.

.References

1. S. Sun, et al, Nat. Mater. **11**, 426 (2012) .
2. W. Luo, et al, Phys. Rev. Appl. **7**, 044033 (2017).
3. D. Wang, et al, Nanophotonics **10**, 685 (2020).
4. D. Wang, et al, Light Sci. Appl. **10**, 67 (2021).
5. Z. Wang, et al, Adv. Sci. **10**, 2205499 (2023).
6. F. Liu, et al, Laser Photon. Rev. 2201001 (2023).
7. C. Dai, et al, PhotoniX. **5**, 11 (2024).
8. Y. Zhou, et al, Opto-Electron Adv. **7**, 240086 (2024).
9. C. Dai, et al, Nanophotonics. DOI: 10.1515/nanoph-2024-0677
10. Z. Wang, et al, Opto-Electron Sci **4**, 240024 (2025).