Cascaded Metasurfaces Enabling Adaptive Aberration Corrections for Focus Scanning

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Abstract:

Scanning focused light with corrected aberrations holds great importance in high-precision optical systems. However, conventional optical systems, relying on additional dynamical correctors to eliminate scanning aberrations, inevitably result in undesired bulkiness and complexity. In this paper, we propose achieving adaptive aberration corrections coordinated with focus scanning by rotating only two cascaded transmissive metasurfaces. Each metasurface is carefully designed by searching for optimal phase-profile parameters of three coherently worked phase functions, allowing flexible control of both the longitudinal and lateral focal position to scan on any custom-designed curved surfaces. As proof-of-concept, we engineer and fabricate two all-silicon terahertz meta-devices capable of scanning the focal spot with adaptively corrected aberrations. Experimental results demonstrate that the first one dynamically scans the focal spot on a planar surface, achieving an average scanning aberration of 1.18% within the scanning range of ±30°. Meanwhile, the second meta-device scans two focal points on a planar surface and a conical surface with 2.5% and 4.6% scanning aberrations, respectively. Our work pioneers a breakthrough pathway enabling the development of high-precision yet compact optical devices across various practical domains.

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