Broadband spin and angle co-multiplexed six-channel metahologram based on a flat waveguide

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Multi-channel metaholograms, capable of switching between multiple projected images by tuning the properties of illuminating light, have emerged as a promising solution for realizing switchable and dynamic holographic displays. Yet, existing designs typically grapple with challenges such as limited multiplexing channels and unwanted crosstalk, which significantly constrain their practical use. Here, we present a new type of waveguide-based multi-channel metaholograms [1], which can support six independent and fully crosstalk-free holographic display channels, simultaneously multiplexed by the spin and angle of guided incident light within the glass waveguide (Fig. 1a).

The metahologram device is integrated atop a planar glass waveguide and consists of silicon (Si) nanopillars with spatially-varying orientation angles to enable the geometric phase modulation (Fig. 1b). Six different images (capital letters "A" to "F") are chosen as the target holographic images and encoded into the evanescent-wave region of *k*-space. We employ a *k*-space translation strategy that allows each of the six distinct target images be selectively moved to the center of propagation-wave region of *k*-space and projected into free space when the metahologram is under the illumination of a guided light with specific spin and azimuthal angle (Fig. 1c). To fabricate the device, a poly-Si layer of the nanopillars' height is first deposited on fused silica substrate through low pressure chemical vapor deposition (LPCVD). After that, a layer of hydrogen silesquioxane (HSQ) resist is spin-coated on the substrate, followed by a 120 °C bake for 2 minutes. The metahologram pattern is defined on the HSQ resist by electron beam lithography. Using the developed HSQ layer as the etch mask, inductively coupled-plasma (ICP) reactive ion etching is performed to transfer the metahologram pattern into the poly-Si layer.

Our work provides a novel approach towards realization of high-performance, compact holographic optical elements with substantial information capacity, opening avenues for applications in AR/VR displays, image encryption, and information storage.

(1) Z. Liu, et al, Broadband spin and angle co-multiplexed waveguide-based metasurface for six-channel crosstalk-free holographic projection, *Under Review* (2024)

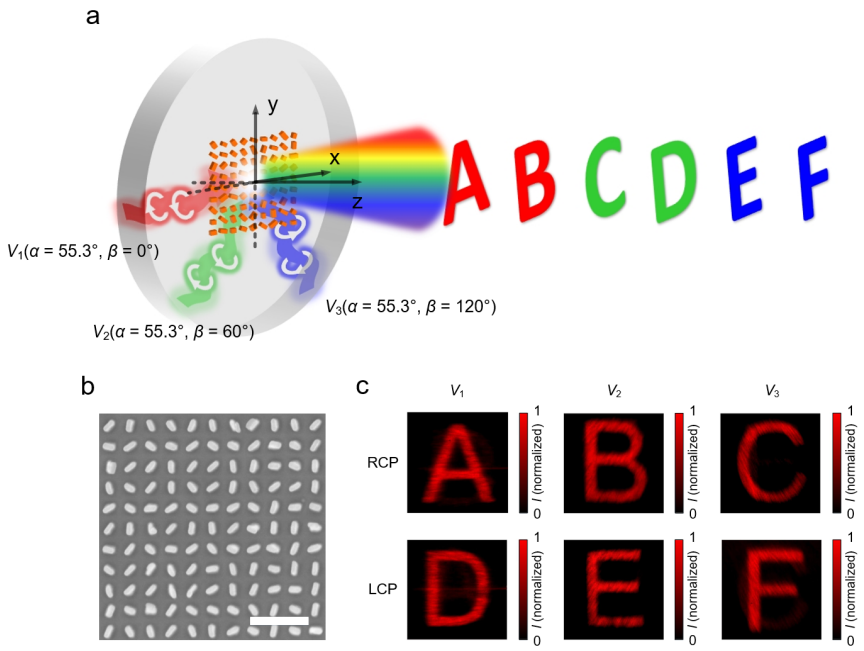

Fig. 1: Waveguide-based spin and angle co-multiplexed six-channel metahologram. (a) Holographic projection schematic of the broadband six-channel metahologram under guided light illumination. Six crosstalk-free holographic images can be selectively projected when the metahologram is illuminated by a guided incident light following different directions (V_1, V_2, V_3) and having different spin states (RCP and LCP). Here, α denotes the guided light's TIR angle and β denotes the guided light's azimuthal angle with respect to the positive x-axis. (b) Scanning electron micrograph (SEM) of the details of the fabricated metahologram. Scale bar: 500 nm. (c) Experimental results of holographic images (capital letters "A" to "F") projected by the metahologram, which are free of crosstalk and in good accordance with the design.