Supporting Information

Dielectric Polarization-Filtering Metasurface Doublet for Trifunctional Control of Full-Space Visible Light

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Figure S1

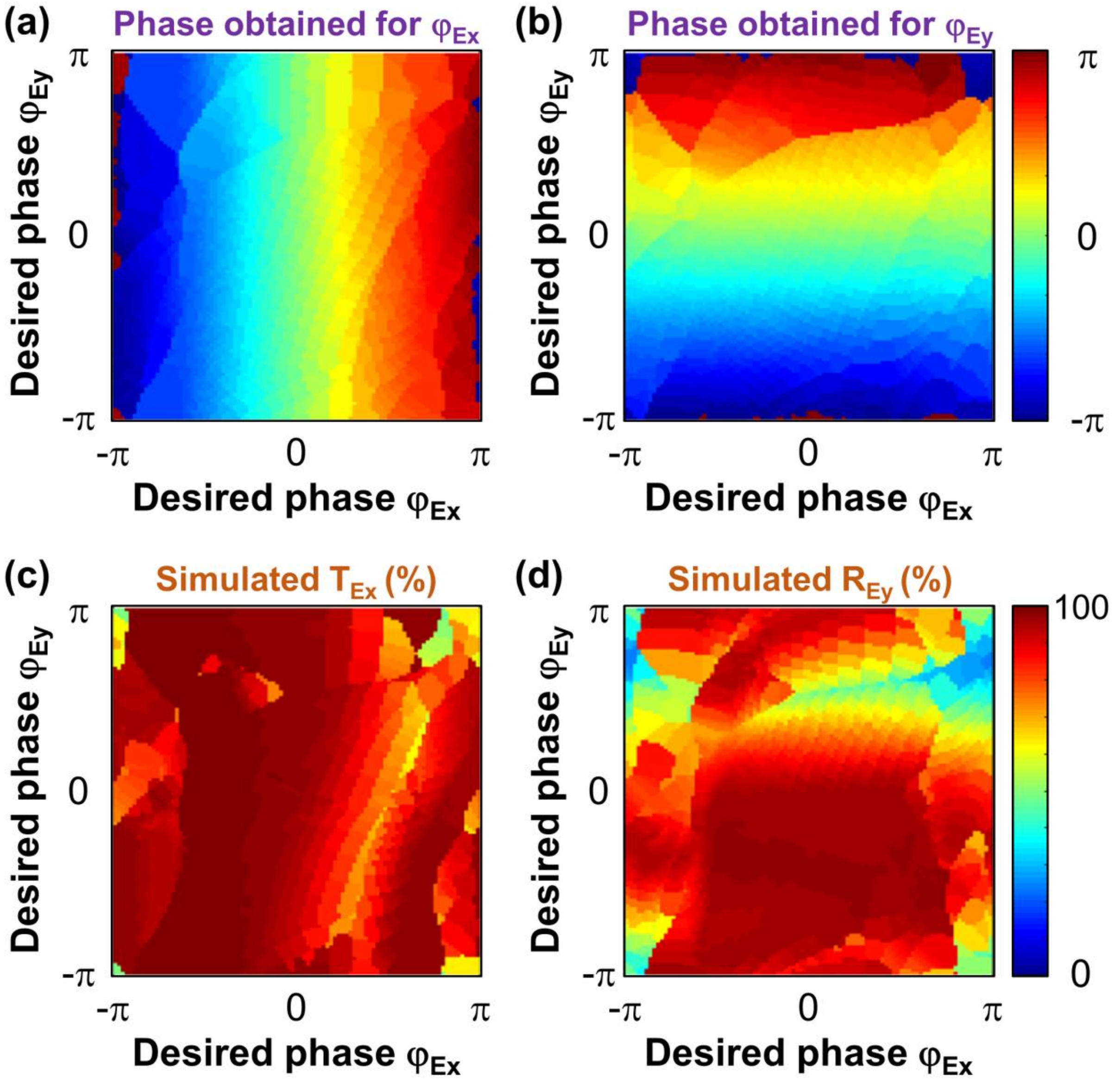

Figure S1. (a) transmission phase φ_{Ex}, (b) reflection phase φ_{Ey}, (c) transmission efficiency T_{Ex}, and (d) reflection efficiency T_{Ey} for the selected meta-atoms shown in Figure 1e of the main text.

Figure S2

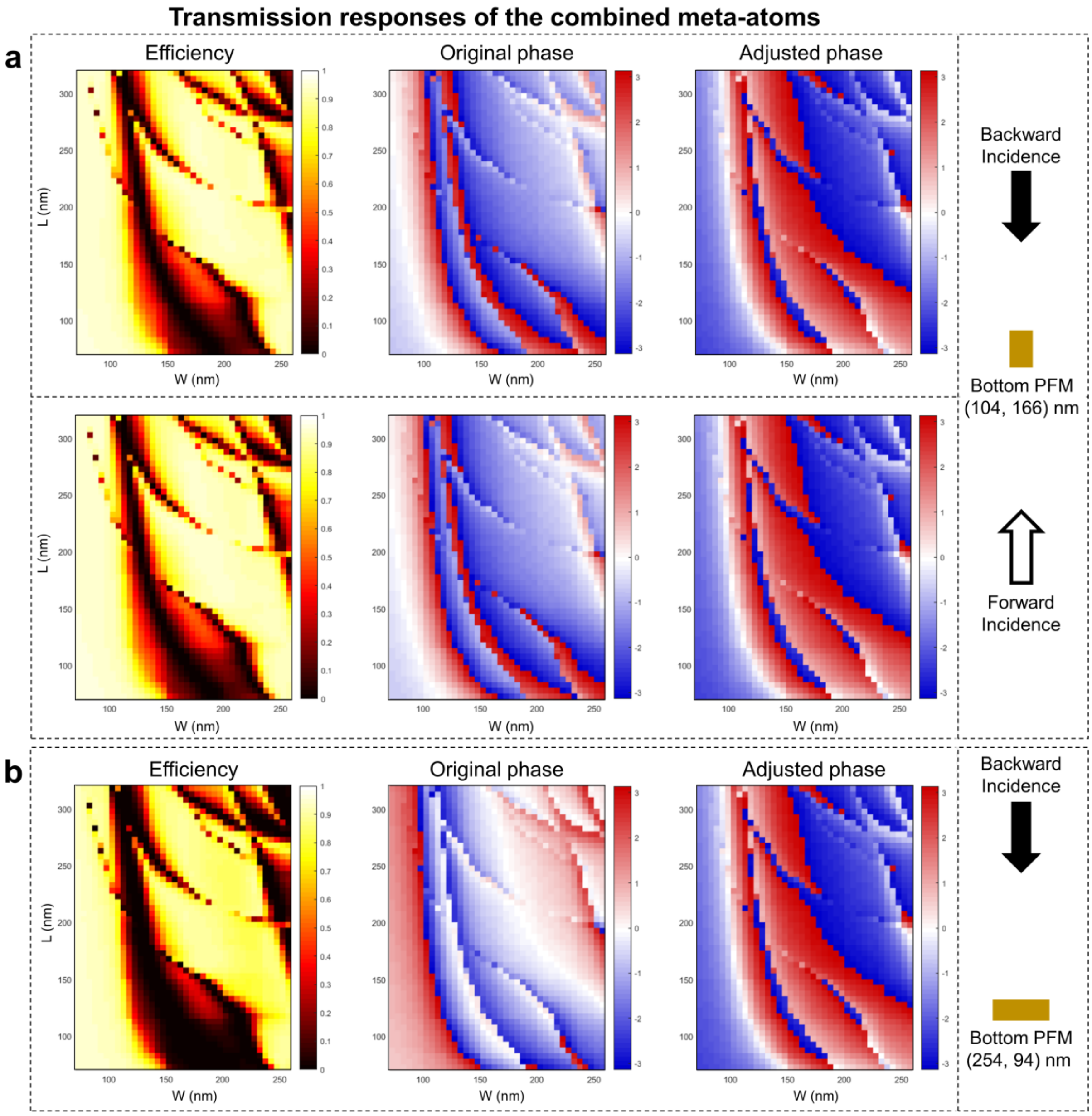

Figure S2. Simulated transmission responses (efficiency, original phase, and adjusted phase) of the combined meta-atoms as a function of the width and length of the top meta-atom, when the width and length of the bottom PFM is (a) 104 nm and 166 nm, respectively, or (b) 254 nm and 94 nm, respectively.

It is known that the proposed and selected PFM can allow high transmission of Ex polarization and high reflection of Ey polarization, along with independent 2π phase control. For the constructed DMD, since the incident Ey-polarized light gets reflected by the first PFM right away, it has no chance to meet the second PFM layer, thus the combined meta-atoms based on selected PFMs do not have any effect on the response of reflected light. Nevertheless, for the Ex-polarized light, it will transmit through two PFMs and thus the joint effect of combined meta-atoms should be considered. As explained in the main text, to construct a DMD, only the top MS1 layer is used to impart different desired phase modulations for Ex polarization, whereas all PFMs in the bottom MS2 layer realize identical phase modulation for Ex polarization. Therefore, the remaining issue is to check whether the selected PFM in one layer affects the transmission response of the one in another layer. Here, we choose to fix the bottom PFM with width of 104 nm and length of 166 nm and scan the width (W) and length (L) of the top meta-atom to check the responses of the combined meta-atoms. All simulation procedures are identical to that of the unit cell simulation in the main text, only the scanning step is set to be 5 nm to reduce the simulation time. The simulated transmission efficiency and phase distributions for both backward and forward Ex-polarized incidences can be found in Figure S2a. It can be seen the transmission efficiency distributions of the combined meta-atoms are nearly identical to that in Figure 1c the main manuscript. In terms of the simulated phase, the original phase distributions in Figure S2 at first sight look quite different from the one in Figure 1d. Nevertheless, it is understood that all simulated phase values are recorded in reference to the first meta-atom with (W, L) = (70, 70) nm. While keeping all phase values in the range from -π to π, the phase values of the combined meta-atoms are then adjusted by simultaneously subtracting an identical value to make its first value equal to that of the one in Figure 1d. The adjusted phase distributions in Figure S2 now becomes highly consistent with the results in Figure 1d. In order to show that this is not a result for a special case, identical simulations for calculating the transmission response of the DMD incorporating a distinct PFM with fixed width of 254 nm and length of 94 nm is additionally performed. The simulation results are depicted in Figure S2b, which also show very good agreement with the results in Figure S2a. These results obviously demonstrate the effectiveness of the method for constructing the proposed DMD with combined meta-atoms.

Figure S3

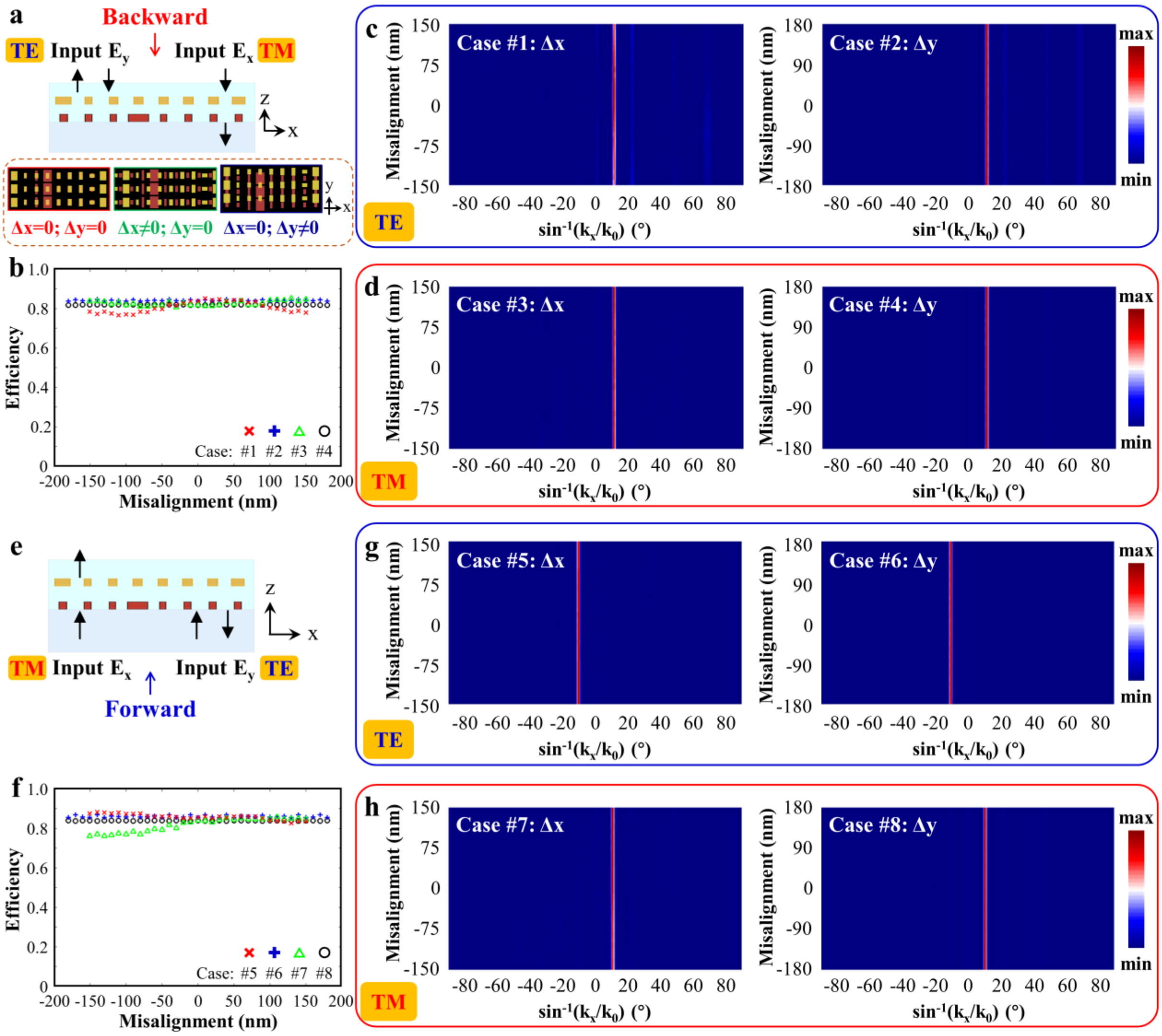

Figure S3. Effect of the misalignment (-150 to 150 nm along x-axis, and -180 to 180 nm along y-axis) between the two metasurface layers on the performance of the anomalous beam deflections. (a) Schematic of backward illumination case. (b) Simulated total transmission and reflection efficiencies for different misalignment cases along x- and y-directions under backward illumination. (c) Simulated far-field distributions of reflected light under TE illumination case for various misalignment Δx (case 1) and Δy (case 2), and (d) transmitted light under TM illumination case for various misalignment Δx (case 3) and Δy (case 4), for backward illumination case. (e) Schematic of forward illumination case. (f) Simulated total transmission and reflection efficiencies for different misalignment cases along x- and y-directions under forward illumination. (g) Simulated far-field distributions of reflected light under TE illumination case for various misalignment Δx (case 1) and Δy (case 2), and (h) transmitted light under TM illumination case for various misalignment Δx (case 3) and Δy (case 4), for forward illumination case.

Figure S4

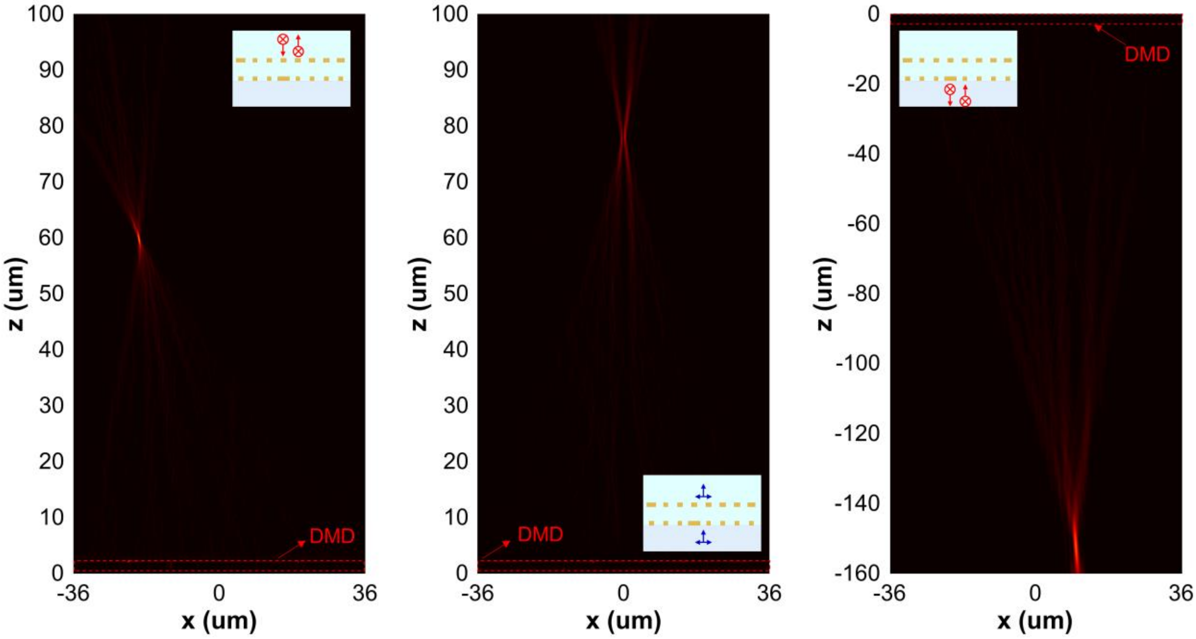

Figure S4. Simulated field-profiles (xz-plane) for forward or backward illumination of x- or y-polarizations. The phenomena of off-axis light focusing and focused vortex beam generation can be clearly obtained.

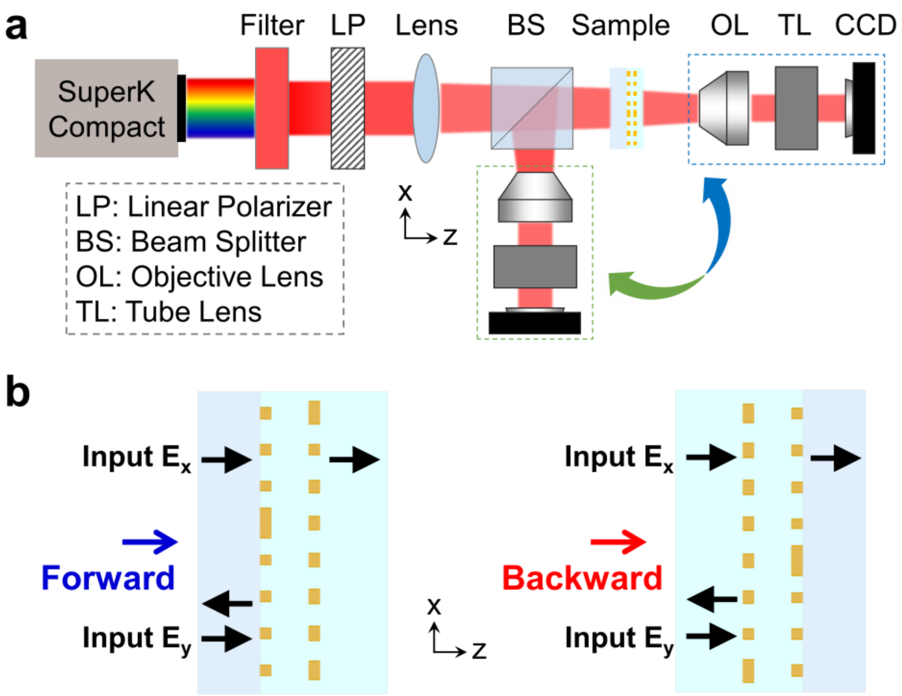

Figure S5. Schematics for measurement setup and sample flipping. (a) Measurement setup for characterizing the fabricated multifunctional DMD. (b) Schematics illustrating the realized backward and forward incidences in experiment.