GENERATION AND CONTROL OF HIGH REFLECTION EFFICIENCY PERFECT VORTEX BEAMS BASED ON ALL-DIELECTRIC METASURFACES: SUPPLEMENTAL DOCUMENT

1. Scan results of structural parameters

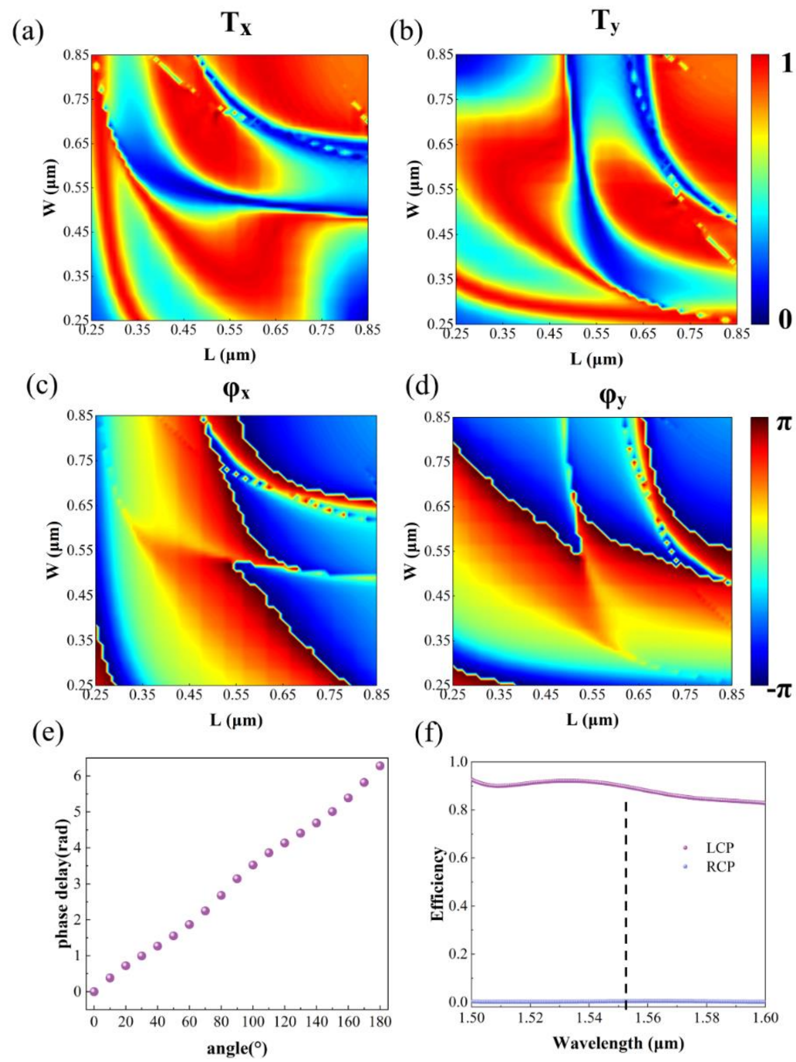

Figure S1. (a)-(d) Relationship between the transmittance (T_x and T_y) and phase shift (φ_x and φ_y) at 1550 nm and the length L and width W of the nanounit size parameters. (e) Phase delay corresponding to different unit rotation angles when the nanounit structure size L=670 nm and W=270 nm is determined. (f) Polarization conversion efficiency of the selected nanounit structure corresponding to (e).

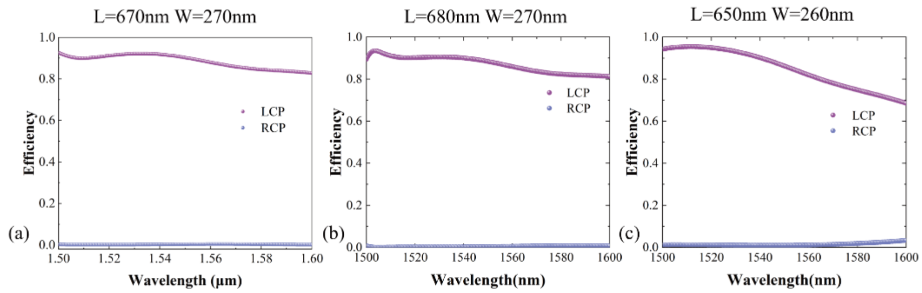

Figure S2. Polarization conversion efficiency of different structure sizes

2. Fresnel diffraction

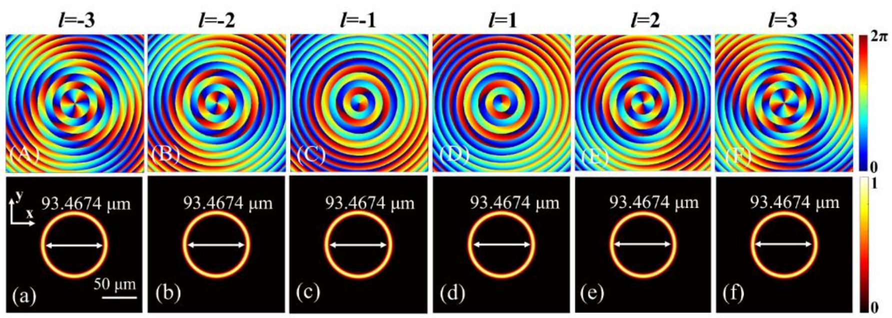

Figure S3. Theoretical calculation of perfect vortex beam control results with different topological charges *l*. (A)~(F) Phase contours when topological charges are *l*= *-3, -2, -1, 1, 2, 3*. (a)~(f) Electric field intensity distribution in the x-y plane when topological charges are *l*= *-3, -2, -1, 1, 2, 3*.

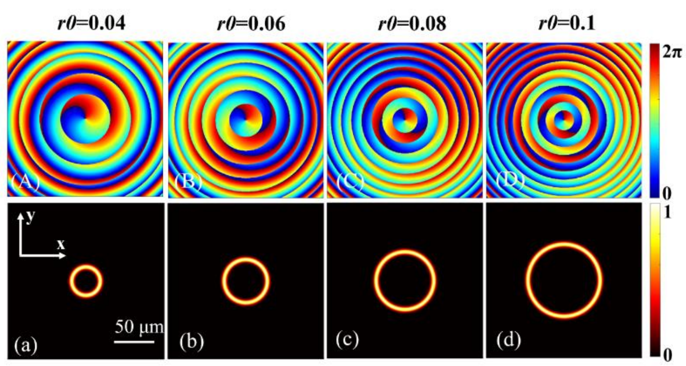

Figure S4. Theoretical calculation results of perfect vortex beam control with different parameters r_0. (A)~(D) Phase profiles when r_0= 0.04, 0.06, 0.08, 0.1. (a)~(d) Electric field intensity distribution in the x-y plane when r_0= 0.04, 0.06, 0.08, 0.1.

3. Method

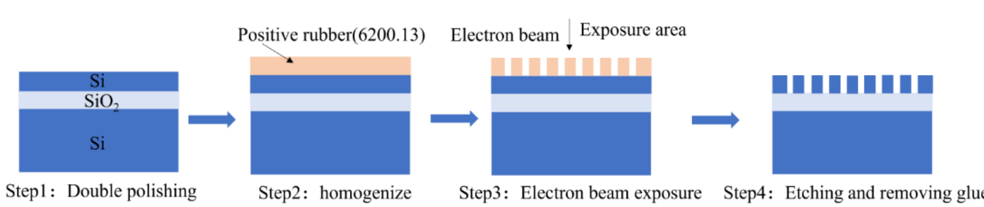

Figure S5. Schematic diagram of the fabrication process of perfect vortex beam metasurface sample.

The silicon-on-insulator (SOI) wafers were first cleaned with acetone and deionized (DI) water. A 180 nm-thick layer of CASR62 resist was spin-coated on the p-type SOI samples at 4000 rpm for 60 s. Then, the wafers were baked at 180 ℃ for 90 s. The CASR62 resist was exposed by electron beam lithography (Vistec EBPG5200) and subsequently developed in MIBK. CASR62 is a positive electron beam resist. After that, the patterns were transferred to the SOI device layer by reactive ion etching (RIE, Sentech ICP Reactive Ion Etching System).

4. Polarization conversion efficiency

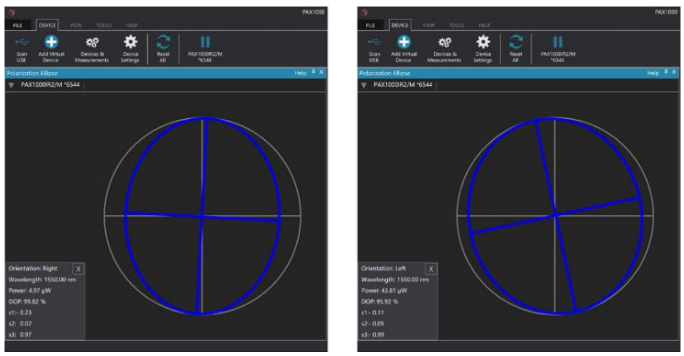

Figure S6. Test results of Polarization conversion efficiency

5. Comparison of the results of the methods

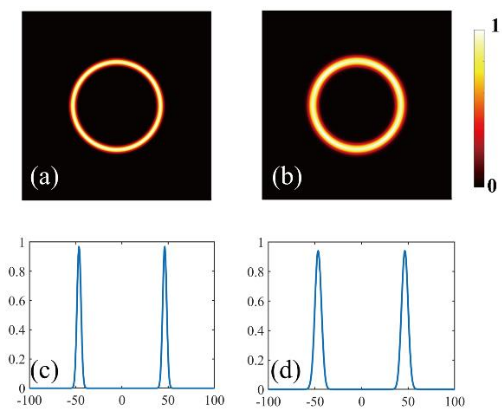

Figure S7. Comparison of the results of the methods. (a) and (c) are the results generated by BBK. (b) and (d) are the results generated by axicon.

6. Calculation of mode purity

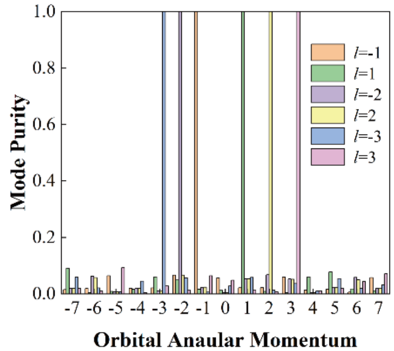

Figure.S8. The mode purity of perfect vortex beams with different topological charges

7. Array consistency analysis

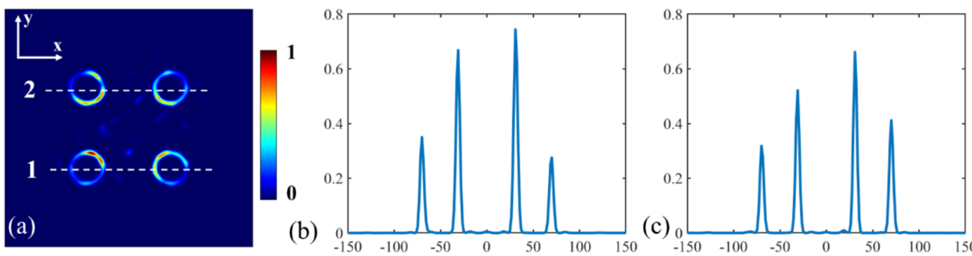

Figure S9. Analysis of the ring characteristics of the array

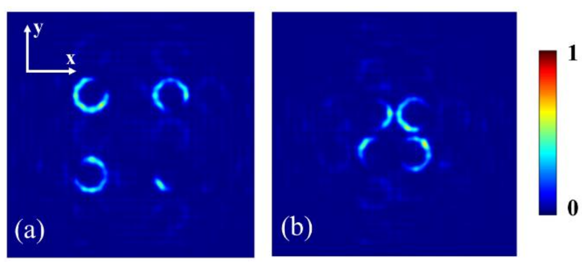

Figure S10. Analysis of the topological characteristics of the array

8. Interference experimental device

The 1550nm laser is collimated by two mirrors and converted into right-handed circularly polarized light by a linear polarizer and a quarter-wave plate. The light beam passes through the 50-micron pinhole and is reflected by a beam splitter prism to an upstream reflector as a reference beam. A 40 mm focal length lens is used to generate spherical waves, while the other portion of the beam is focused onto the metasurface via the objective lens. The reflected light from the metasurface interferes with the reference beam. In this setup, we performed interference experiments using perfect vortex beams with topological charges of

+2, -2, +3, and -3. The corresponding results are presented in the figure below.

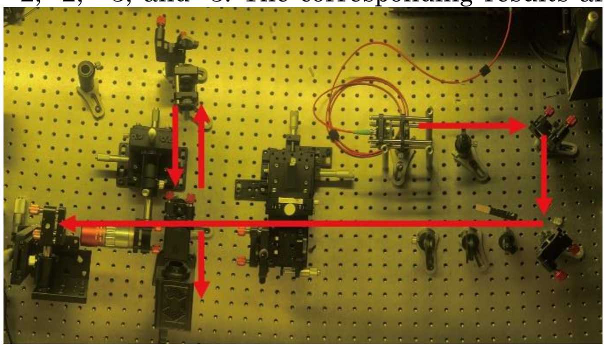

Figure S11. Interference experimental device