Supplementary Information

Full-parallax High-resolution Light Field 3D Display Based on Time-sequential Polarization Liquid Crystal Lens Array

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S1. Fabrication process of the liquid crystal lens array

Fig. S1 shows the fabrication process of the liquid crystal (LC) lens array. A planar indium tin oxide (ITO) is sputtered onto the upper surface of the bottom glass substrate, and the planar ITO is etched into electrodes. The thin alignment material polyimide (PI) is spin-coated on the upper surface of the bottom glass substrates. The substrates are preheated at 100°C for 1 hour and then baked at 200°C for 2 hours. It is then rubbed in the direction perpendicular to the electrodes. An ITO electrode is sputtered and coated with PI in the same manner on the lower surface of the top glass substrate to align the LC molecules. The PI layer of the upper ITO glass substrate is rubbed in the direction that is anti-parallel with respect to the lower glass substrate. At last, an LC mixture is injected into the cell, homogeneous alignment is induced by the buffed layers, and then the LC director is homogeneously aligned perpendicular to the periodic strip electrodes' direction.

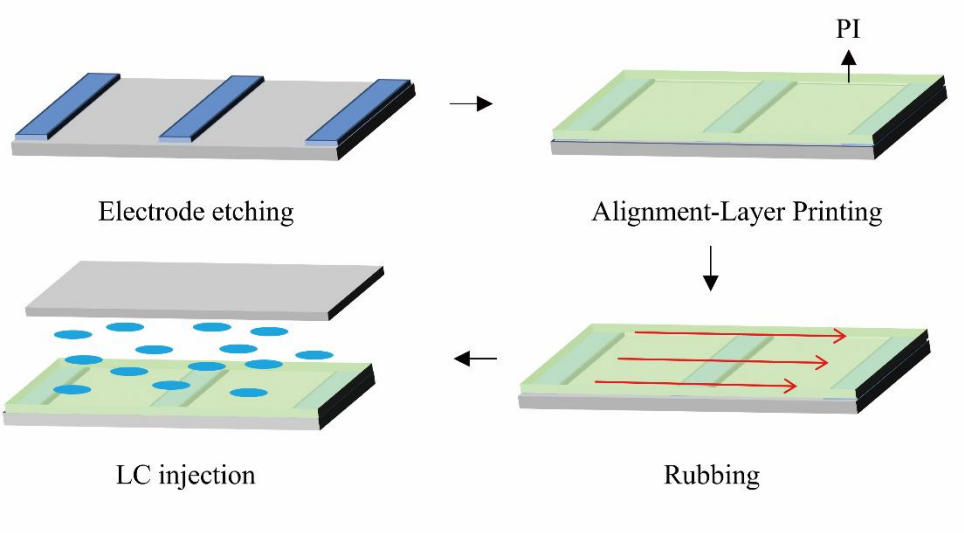

Fig. S1 Fabrication process of the LC lens array

S2. Distribution of the liquid crystal directors

The LC director distributions under different voltages are shown in **Figs. S2(a)-(d)**. As demonstrated in **Fig. S2**, the director distribution of the LC molecules gradually changes as the voltage increases. The tilt angle of the LC molecules close to the electrodes increases due to the electric field force, whereas the LC molecules at the center of the LC lens are balanced by the electric field force, which is basically parallel to the substrate. Since the orientation of the LC molecules has a refractive effect on the light, the LC lens array with a gradient refractive index distribution is generated in the LC layer, which has a focusing effect on the linearly polarized light. **Fig. S3** shows the refractive index distribution, which has been calculated based on the LC director distribution in **Fig. S2**. **Fig. S3** shows that the refractive index difference of the LC lens array gradually increases as the driving voltage increases. When the driving voltage is 2V, 4V, 6V, and 8V, the refractive index differences are 0.0002, 0.0245, 0.1823, and 0.1965, respectively. When the driving voltage is 8V, the refractive index difference of the LC lens array is close to the birefringence of the LC material. In addition, under different driving voltages, the refractive index distribution of the LC lens array is centrally symmetrical, which helps to form a relatively good imaging effect.

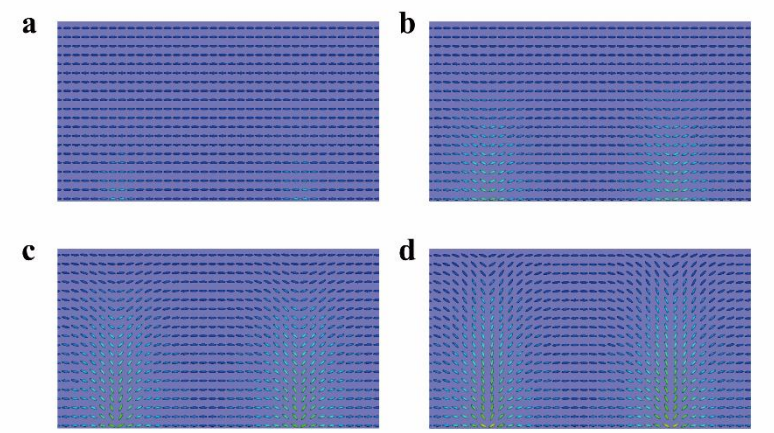

Fig. S2 LC director distribution under different driving voltages. a 2V. **b** 4V. **c** 6V. **d** 8V.

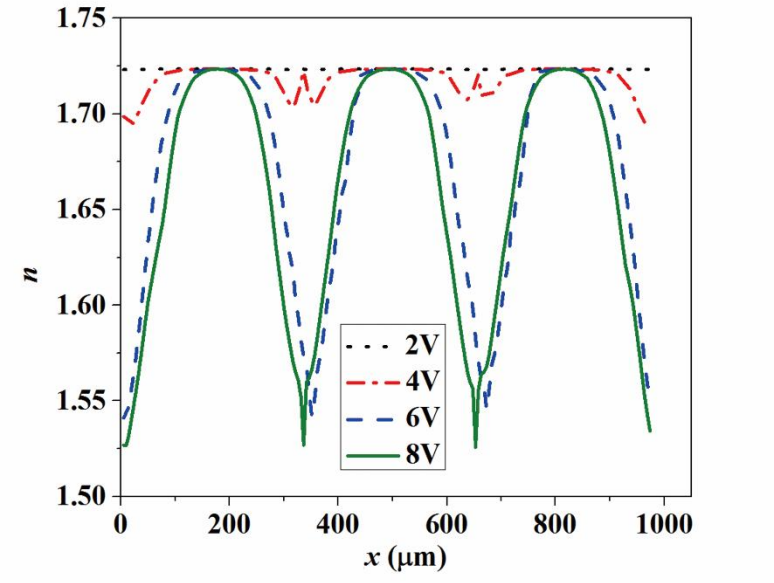

Fig. S3 Refractive index distribution under different driving voltages.

S3. Comparison of Modulation Transfer Functions of different lens array

The Modulation Transfer Function (MTF) of the LC lens array has been simulated and compared with that of the lenticular lens array and microlens array. Since it is difficult to calculate the MTF of the LC lens array after time-division multiplexing directly, The MTFs of top LC lens array and bottom LC lens array are simulated separately, which are shown in **Fig. S4(a)** and **S4(b)**, The MTFs of the top and bottom LC lens arrays are roughly the same. The proposed top and bottom LC lens arrays modulate the light in only one direction, respectively, resulting in a large difference in the MTFs between the meridian and sagittal planes in the LC lens array. The top and bottom LC lens arrays exhibit high MTF in only one direction. The MTF of the lenticular lens and the MTF of the microlens are shown in **Fig. S4(c)** and **S4(d)**. The simulation results show that the MTF of the lenticular lens is high in one direction, and there is also a difference between the meridian and sagittal planes. Therefore, the light field 3D display based on the lenticular lens array can reconstruct a high-resolution 3D image in only one direction. The MTF of the microlens array decreases rapidly as the viewing angle increases. The details of the 3D image reconstructed by the microlens array cannot be distinguished at a large viewing angle. As demonstrated by the comparison results of the MTFs of different lens arrays, it is evident that the top LC lens array and bottom LC lens array in the proposed time-sequential polarization LC lens array

exhibit high MTF in horizontal and vertical directions, respectively. And full-parallax high-resolution 3D images can be reconstructed after time-division multiplexing.

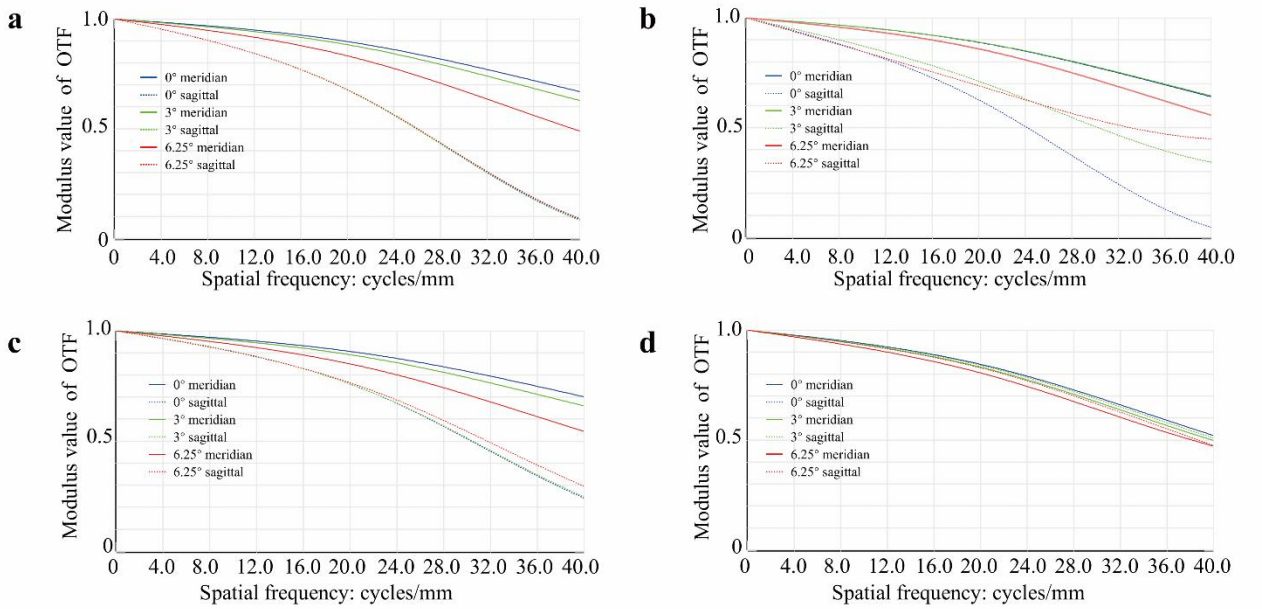

Fig. S4 MTFs of different lens array. **a** Top LC lens array. **b.** Bottom LC lens array **c** Lenticular lens array. **d** Microlens array.