

## Supplementary Information

### Electrically tunable liquid crystal terahertz phase shifter driven with polymer transparent electrodes

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transparent electrode; liquid crystal; phase shifter

#### 1. Film morphology.

The surface morphology of 15 vol% DMSO-doped-PEDOT:PSS electrodes was investigated using atomic force microscopy (AFM) with Fig.S1 showing AFM height images of single layer films.

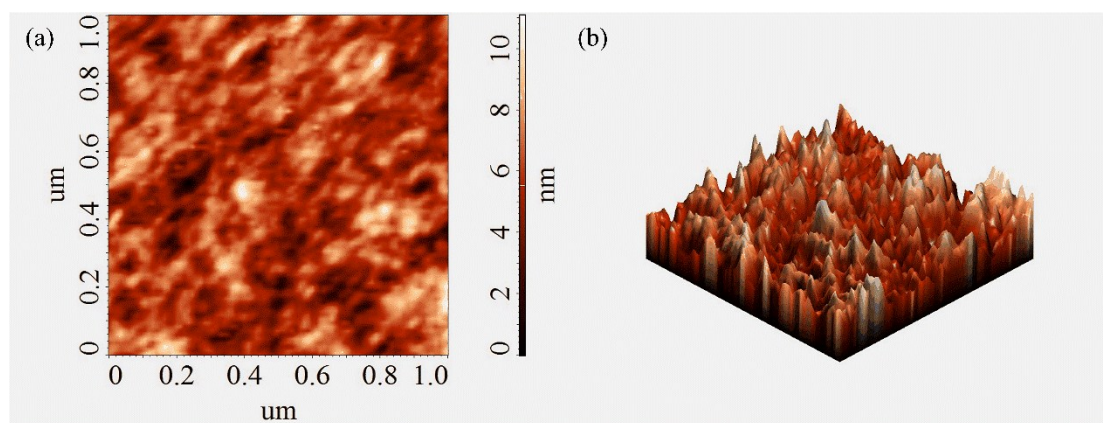


Fig. S1 2D and 3D AFM height images of 15 vol% DMSO-doped-PEDOT:PSS film.

#### 2. Transmittance of phase shifter with THz-TDS.

The THz transmittance of the phase shifter without bias voltage is shown in Fig. S2. The transmittance in the high-frequency range decreases sharply due to the absorption of THz wave by liquid crystal.  $T_0$  is the transmittance when voltage is zero. In order to better show the THz transmittance change with respect to the bias voltage, we plot  $T_v/T_0$  at THz frequencies (Fig. S3).  $T_v$  is the transmittance of phase shifter with different

voltages. For a voltage  $V > V_{th}$ , the LC molecules are essentially aligned with the electric field, thus leads to the transmittance change.

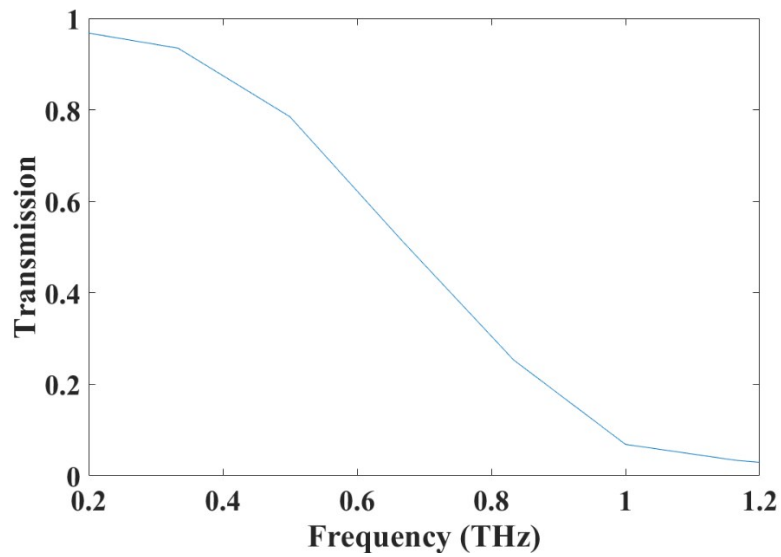


Fig. S2 THz transmittance of the phase shifter without bias voltage.

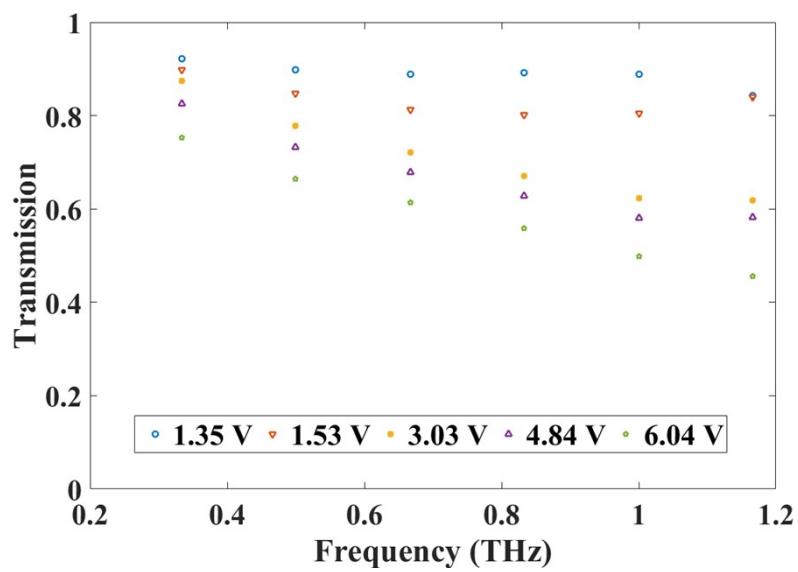


Fig. S3  $T_V/T_0$  as a function of THz frequencies at different voltages.