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Supporting Information

Visible and Infrared Optical Modulation of PSLC Smart Films Doped with ATO Nanoparticles

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Simulation methods

The threshold voltage of PDLC is shown in equation S1:

$$V_{th} = \frac{d}{3a} \times (\frac{\sigma_{LC}}{\sigma_p} + 2) \times (\frac{K(l^2 - 1)}{\varepsilon_0 \nabla\varepsilon})^{\frac{1}{2}} \tag{S1}$$

where d is thickness of PSLC films, ε_0 is dielectric constant of vacuum, $\Delta\varepsilon$ is dielectric anisotropy of liquid crystals, a is semimajor axis of liquid crystal molecules, l is aspect ratio of liquid crystal molecules, K is elastic constants of liquid crystal molecules, σ_p is conductivity of polymer, σ_{LC} is conductivity of liquid crystal. The decrease of conductivity ratio will lead to the decrease of threshold voltage. Since the conductivity is proportional to the conductivity, equation S1 is equivalent to:

$$V_{th} = \frac{d}{3a} \times (\frac{G'_{LC}}{G'_p} + 2) \times (\frac{K(l^2 - 1)}{\varepsilon_0 \nabla\varepsilon})^{\frac{1}{2}} \tag{S2}$$

G'_{LC} and G'_p are the equivalent conductivities of liquid crystal doped with ATO NPs and polymer doped with ATO NPs, respectively. Assuming that the phase separation of PSLC is complete, the polymer and liquid crystal can be equivalent to small cubes. ATO nanoparticles can be equivalent to smaller cubes because of its size. As shown in Fig. 1b, L_{LC}、 L_p and a are the side lengths of liquid crystal cube, polymer cube and ATO NPs cube respectively.

The doping percentage (W %) of ATO NPs can be expressed as follows:

$$W\% = \frac{(N_1 + N_2)\rho_A v}{(\rho_p V_p + \rho_{LC} V_{LC}) + (N_1 + N_2)\rho_A v} \tag{S3}$$

where, ρ_p, ρ_{LC} and ρ_A are the density of polymer, liquid crystal and ATO NPs respectively. V_p, V_{LC} and v are the volume of polymer, liquid crystal and ATO nanoparticles respectively. N_1 and N_2 are the number of ATO nanoparticles in polymer and liquid crystal respectively. In order to discuss the influence of the distribution of ATO NPs in the two phases on the threshold voltage, suppose that the proportion of

ATO NPs in liquid crystal is *n*, then:

$$\frac{N_1}{N_2}=\frac{1-n}{n} \tag{S4}$$

For polymers, liquid crystals and ATO NPs:

$$V_p = L_p{}^3 N_1, \quad V_{LC} = L_{LC}{}^3 N_2 \quad v = a^3 \tag{S5}$$

$$\frac{V_P}{V_{LC}}=\frac{M_p \rho_{LC}}{M_{LC}\rho_p} \tag{S6}$$

where, M_p and M_{LC} are the mass of polymer and liquid crystal respectively, Combining equation S3 and equation S6:

$$\frac{L_p}{a}=\sqrt[3]{\frac{\rho_M}{1-n}\cdot\frac{1-W\%}{W\%}\cdot\frac{1}{\rho_p(1+\frac{M_{LC}}{M_p})}} \tag{S7}$$

$$\frac{L_{LC}}{a}=\sqrt[3]{\frac{\rho_M}{n}\cdot\frac{1-W\%}{W\%}\cdot\frac{1}{\rho_{LC}(1+\frac{M_p}{M_{LC}})}} \tag{S8}$$

Each polymer and liquid crystal equivalent cube containing ATO NPs in Fig. 1b can be represented as the equivalent circuit in Fig. 1c, C_1, C_2 and C_3 are capacitance of liquid crystal, ATO NPs and polymer respectively; G_1, G_2 and G_3 are conductivity of liquid crystal, ATO NPs and polymer respectively.

According to the definition of conductance and capacitance, then:

$$G_1=\sigma_1 L_{LC}, C_1=\varepsilon_1 L_{LC} \tag{S9}$$

$$G_2=\sigma_2 a, C_2=\varepsilon_2 a \tag{S10}$$

$$G_3=\sigma_3 L_p, C_3=\varepsilon_3 L_p \tag{S11}$$

where σ_1, σ_2 and $\sigma_3$are the conductivity of liquid crystal, ATO NPs and polymer respectively, ε_1, ε_2 and ε_3 are the dielectric constant of liquid crystal, ATO NPs and polymer respectively. According to Fig. 1c, the equation is as follows:

$$Y'_{LC} = G'_{LC} + j\omega C'_{LC} = \frac{(G_1 + j\omega C_1)(G_2 + j\omega C_2)}{(G_1 + G_2) + j\omega(C_1 + C_2)} \tag{S12}$$

$$Y'_p = G'_p + j\omega C'_p = \frac{(G_3 + j\omega C_3)(G_2 + j\omega C_2)}{(G_3 + G_2) + j\omega(C_3 + C_2)} \tag{S13}$$

where, Y'_{LC} and Y'_p are the total admittance of liquid crystal and polymer equivalent circuit, G'_{LC} and G'_p are the equivalent conductance of ATO doped liquid crystal and polymer, C'_{LC} and C'_p are the equivalent capacitance of ATO doped liquid crystal and polymer, and ω is the electric field frequency. From equations S12 and S13, it can be concluded that:

$$G'_{LC} = \frac{(G_1G_2 - \omega^2 C_1C_2)(G_1 + G_2) + \omega^2(C_1G_2 + C_2G_1)(C_1 + C_2)}{(G_1 + G_2)^2 + \omega^2(C_1 + C_2)^2} \tag{S14}$$

$$G'_p = \frac{(G_3G_2 - \omega^2 C_3C_2)(G_3 + G_2) + \omega^2(C_3G_2 + C_2G_3)(C_3 + C_2)}{(G_3 + G_2)^2 + \omega^2(C_3 + C_2)^2} \tag{S15}$$

The threshold voltage is proportional to G'_{LC} / G'_p according to equation S2. And the variation trend of G'_{LC} / G'_p with W % ATO NPs doping content can be calculated by equations S14 and S15.

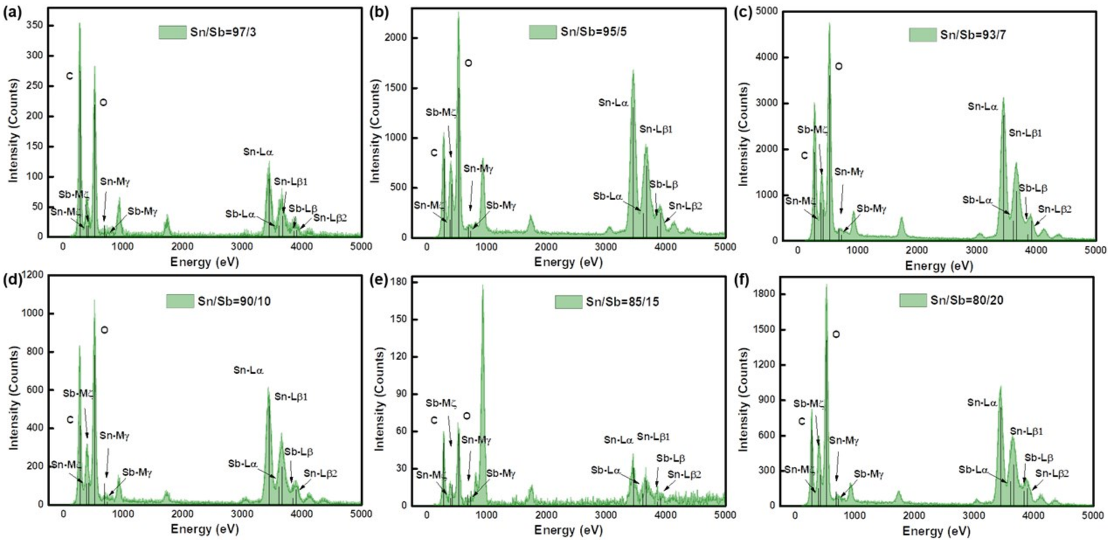

Figure S1. EDS SPEC measurement of ATO NPs. (a) Mole ratio of Sn / Sb=97/3. (b) Mole ratio of Sn / Sb=95/5. (c) Mole ratio of Sn / Sb=93/7. (d) Mole ratio of Sn / Sb=90/10. (e) Mole ratio of Sn / Sb=85/15. (f) Mole ratio of Sn / Sb=80/20.