Supporting Information

A Color Changing Plasmonic Actuator based on Silver Nanoparticle Array and Liquid Crystalline Elastomer Nanocomposites

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1. The characterization of Ag NPs array

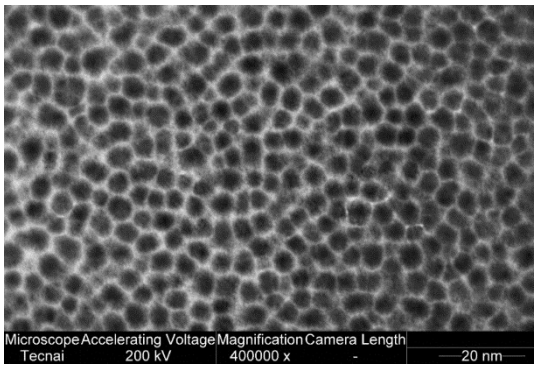

Figure S1 The transmission electron microscope (TEM) image of pre-laminating Ag NPs array.

2. The angle-dependent measurement of Ag NPs array

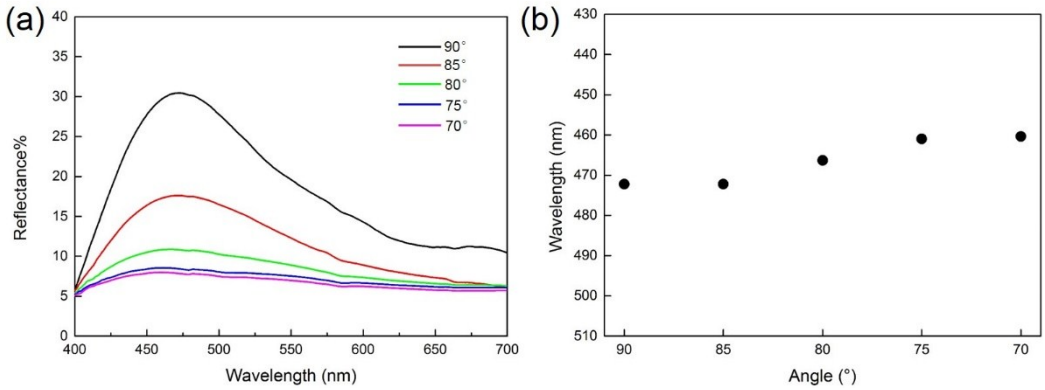

Figure S2 The angle-dependent measurement of Ag NPs array. (a) The reflectance spectra change depends on different angles. (b) The relationship between the location of reflectance peaks and angles.

3. The thermodynamic properties of LC precursor and LCE

From the results of DSC measurement in Figure S3 (a), we find that LC precursor exhibits nematic phase just at cooling process, which may be due to the high crystallizability of A6OCB,[1-4] therefore the UV photopolymerization has been carried out when the LC samples were cooled from clearing point (T_c). As shown in Figure S3 (b), LCE has two transition points, wherein T_g is around 30 °C and T_c is about 110 °C.

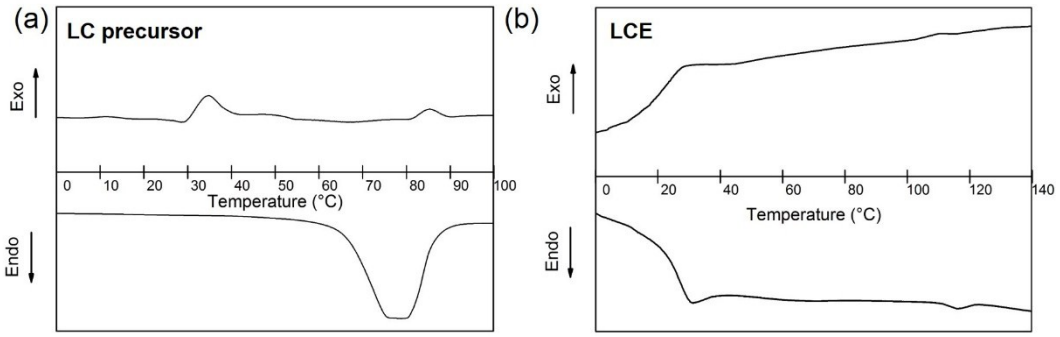

Figure S3 The differential scanning calorimeter (DSC) measurement of LC precursor (a) and LCE (b).

4 The optical simulation of Ag NPs/LCE nanocomposite

The schematic diagram of one unit of Ag NPs array is shown in Figure S4 (a). For ease of calculation, the Ag NPs array is regarded as hexagonally packed array for ideal, and we choose six Ag NPs as one repeated unit. The diameter of Ag NPs in model is the average diameter (5.6 nm), and the gap distance of Ag NPs array is 2 nm. The detailed simulation model is shown in Figure S4 (b). The ligand is considered as a shell around Ag NPs, and Ag NPs array is half inlayed into the LCE layer. The gap distance *s* and diameter of Ag NP *D* are valued as shown in Figure S4 (c).

The gap distance between neighboring Ag NPs is considered the main variable in computer simulated reflectance spectra. We execute the simulation at two conditions: nematic status (30 °C) and isotropic status (130 °C). In nematic case, the diameter and gap distance of hexagonally packed Ag NPs in model are the average diameter and gap distance that was measured from Figure S1. In isotropic case, we have compared the expansion ratio of several quadrate VA Ag NPs/LCE nanocomposite films at 30 °C and 130 °C, and calculated that the average expansion is around 4.27%. As a result, we suppose each gap distance elongates 4.27% for simulating the VA g NPs/LCE nanocomposite reflectance spectrum at 130 °C. In the same way, the elongation ratio of HA Ag NPs/LCE nanocomposite films is 6.28%.

The refractive index of silver is from previously reported,[5] and the refractive index of ligands is used refractive index of oleylamine because more than 90% composition of ligands is oleylamine (n_L = 1.4596). We use the refractive index of 5CB (n_o = 1.5441 and n_e = 1.7336) as a simplified replacement for LCE since the chemical structure of A6OCB used as the main component of LCE is very similar to that of 5CB. More specifically, the refractive index of VA LCE at 30 °C (n_V) is 1.5441 and at 130 °C (n_I) is 1.6097 as the formula shown:

Vertical state: $n_v = n_o$ (1)

Planar state: $$n_P = \sqrt{\frac{1}{2}n_e^{\,2} + \frac{1}{2}n_o^{\,2}} \quad (2)$$

Isotropic state: $$n_I = \sqrt{\frac{1}{3}n_e^{\,2} + \frac{2}{3}n_o^{\,2}} \quad (3)$$

The refractive index of HA LCE in nematic status is 1.5928 which was calculated as $n_H = (n_P + n_I)/2$.

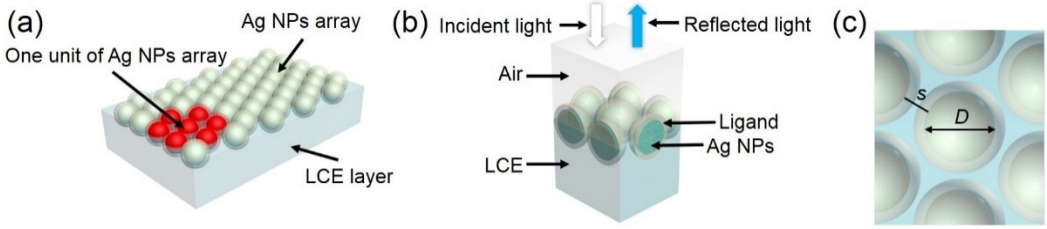

Figure S4 (a) The schematic diagram of one unit of Ag NPs for simulation. (b) The schematic diagram of simulation model. (c) The top view of simulation model.

5. The constitution of dynamically-controlled device

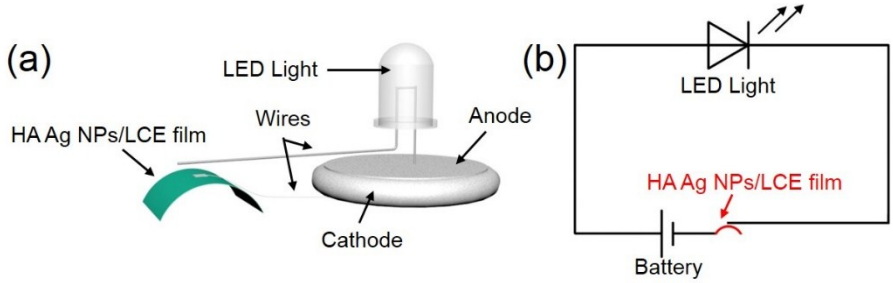

Figure S5 The schematic (a) and circuit (b) diagram of dynamically-controlled system by using HA Ag NPs/LCE nanocomposite as a switch.

References

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