Supplementary Materials for

Voltage-tunable elastomer composites that use shape instabilities for rapid structural color changes

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This PDF file includes:

Figures. S1 to S13
Movies S1 to S8

Other Supplementary Materials for this manuscript include the following:

Movies S1 to S8

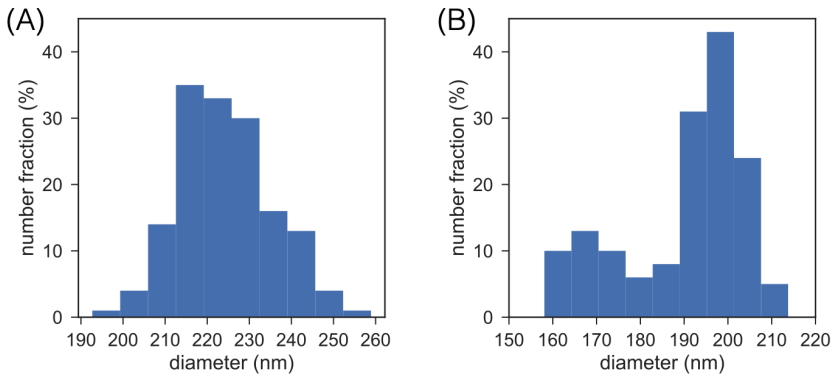

Figure S1. Histogram for the silica particle diameters that are used in **Figure 1**. (A) Monodisperse silica particles with average diameters of 224 ± 11 nm. (B) Bisdisperse silica particles with average diameters of 190 ± 14 nm. Particle diameters were measured from the SEM images using Fiji.

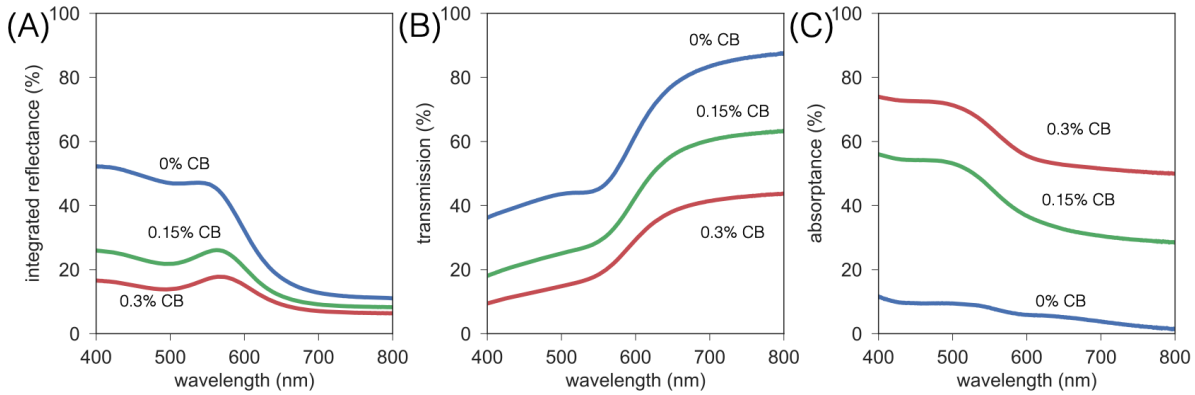

Figure S2. Integrated reflectance (A), transmittance (B), and absorptance spectra of photonic glass composites with different concentrations of carbon black. The 164 nm and 204 nm silica nanoparticles have a volume ratio of 20: 80.

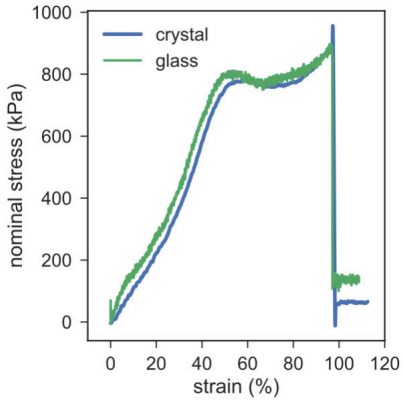

Figure S3. Stress-strain curves of crystalline and glassy photonic films under uniaxial stretching. The stretching speed is 1% strain per second. The Young's modulus was calculated based on the region from 0% to 50% strain.

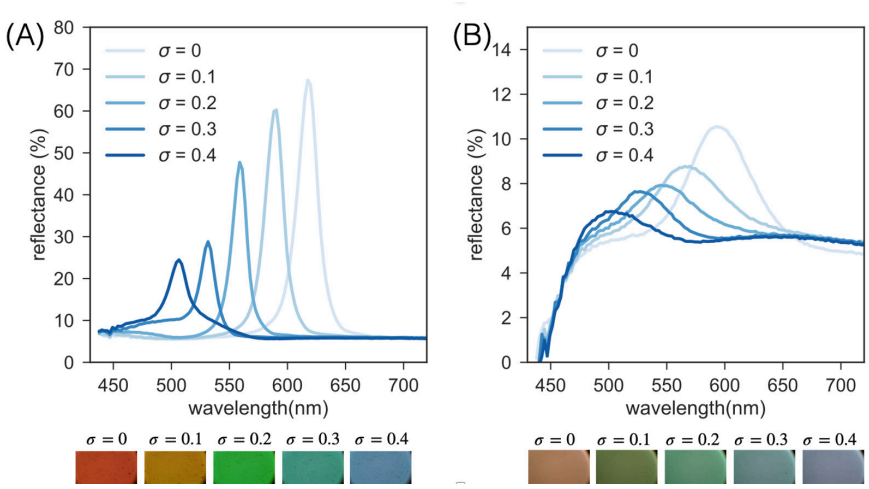

Figure S4. Reflectance spectra of crystalline (A) and glassy (B) samples under uniaxial strains from 0 to 0.4. Underneath color swatches are bright-filed optical microscopic images of samples under different strains, where the incident and detector angles are both normal to the surface.

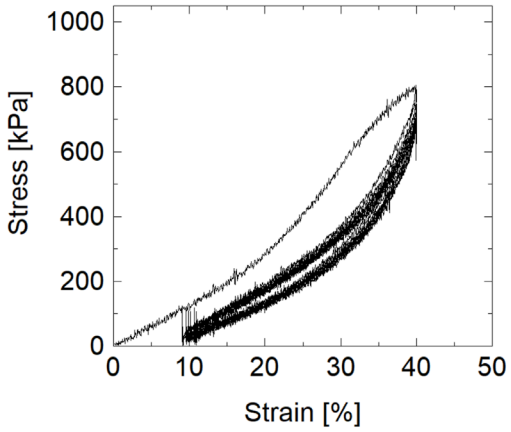

Figure S5. Stress-strain curves of a glassy elastomer under ten cycles of uniaxial tensile tests. The stretching speed is 1% strain per second. See the corresponding Movie S3.

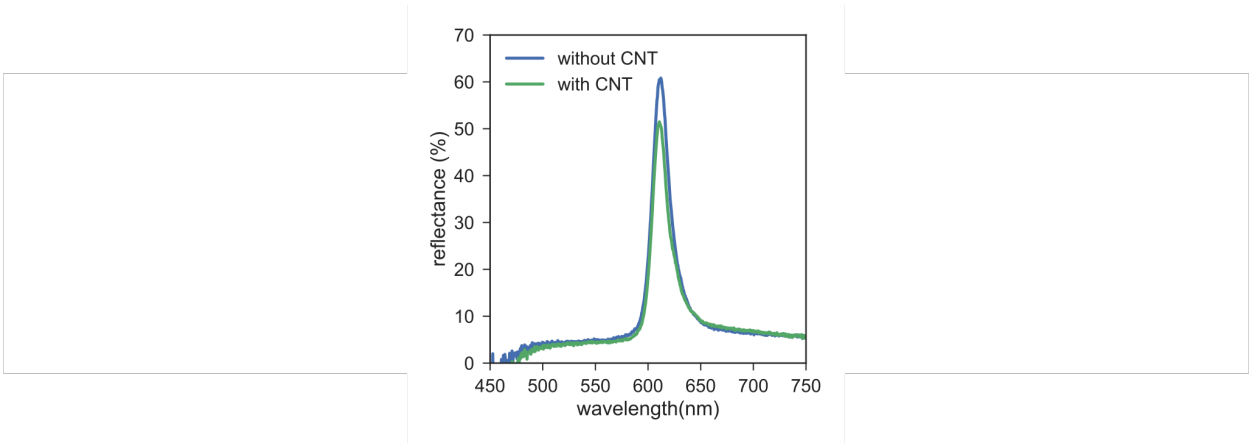

Figure S6. Reflectance spectra of a photonic elastomer before and after coating with CNT electrode.

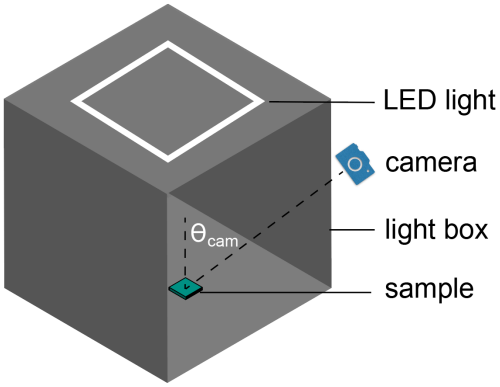

Figure S7. Schematic of the light box used to create diffuse illumination. The light box is covered with white reflecting film inside. The camera angle is defined as the angle between the surface normal and the camera.

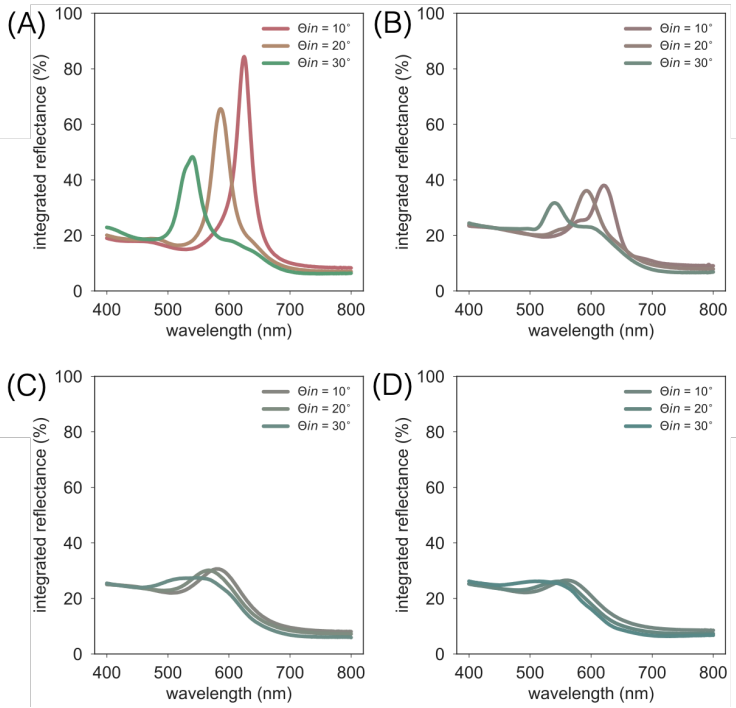

Figure S8. Integrated reflectance spectra for photonic elastomers with different volume fractions of secondary silica nanoparticles. All contain 40% v/v of silica nanoparticles. The volume ratios between 204 nm and 164 nm silica nanoparticles are 100:0, 90:10, 80:20, 60:40 from (A) to (D). The colors of the different curves are based on CIELAB calculations of how the colors are perceived by the human eye.

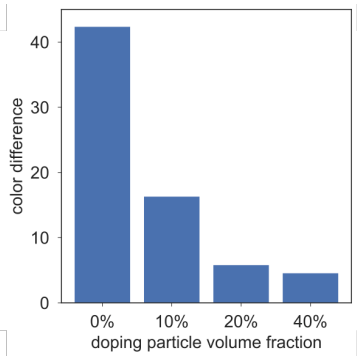

Figure S9. The CIELAB color difference between 10 degrees and 30 degrees for all four samples in **Figure S8**. A color difference of 2.3 corresponds to the "just noticeable difference", at which 50% of observers would perceive a color difference.

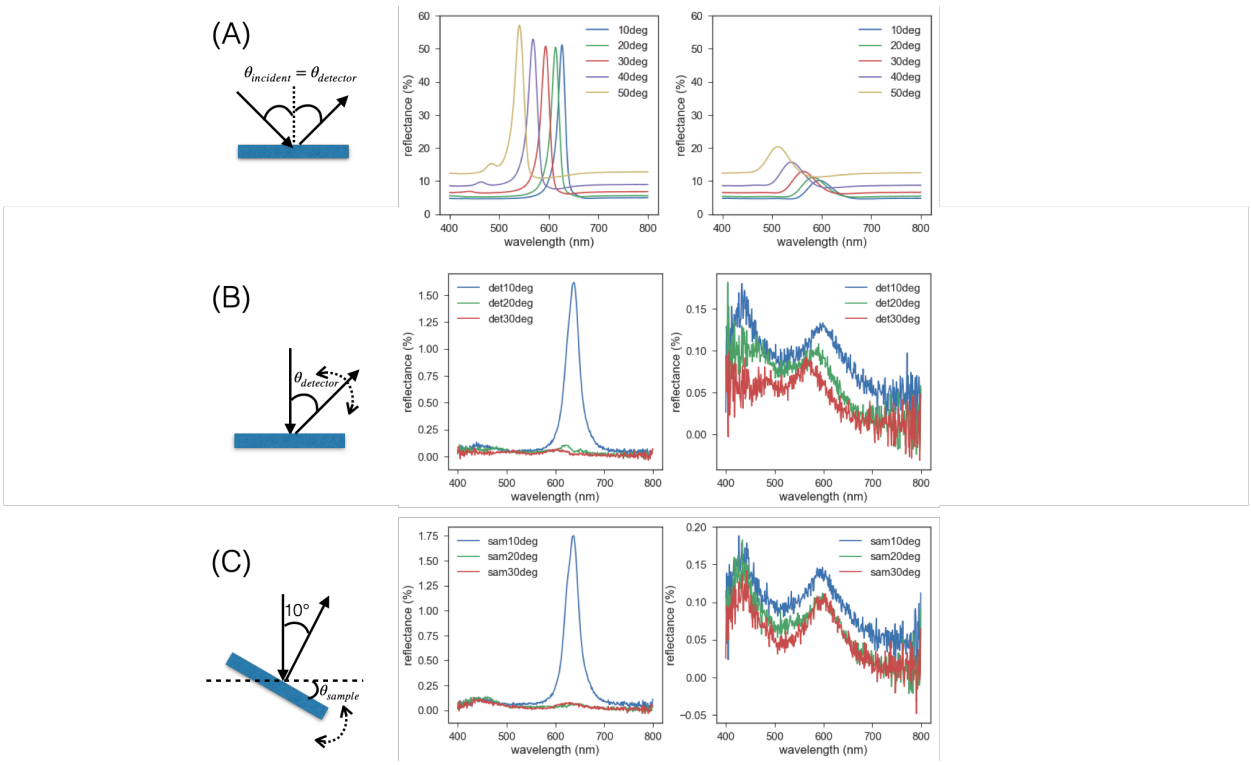

Figure S10. Angle-resolved scattering measurements under three different geometries for both crystalline and glassy composites. Diagrams of measurement geometry are shown at left. Results for crystalline samples are shown in the middle column, and results for the glassy samples are shown in the right column.

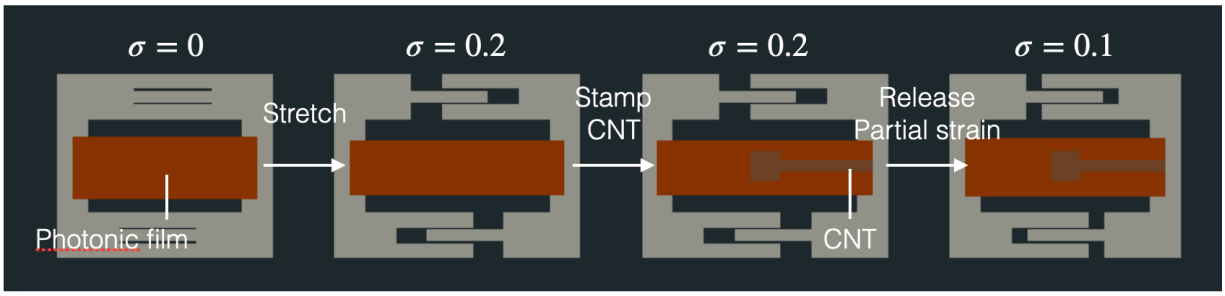

Figure S11. A 2D top view of the stretch-release method we used to increase the robustness of the device.

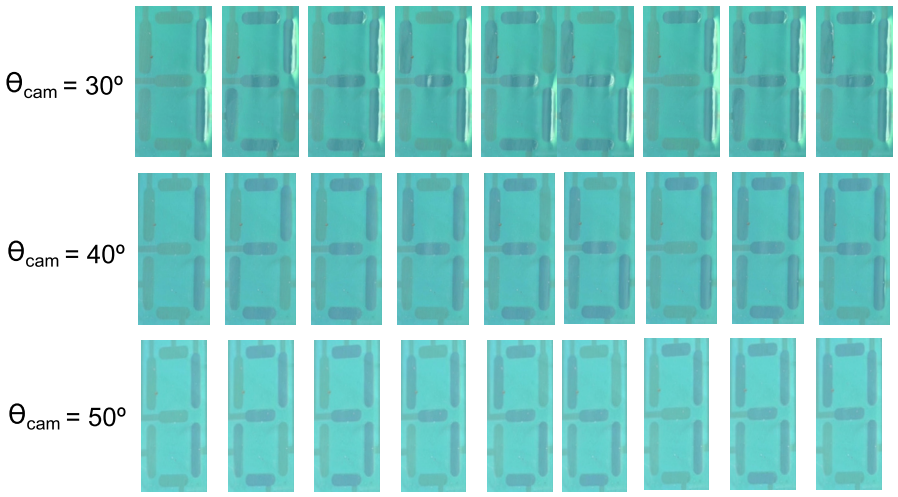

Figure S12. Digit pixelated color display with different camera angles. The actuation voltage is 2.0 kV. The colors are almost similar with varying angles. The slight difference between 30° and the other two angles is mainly caused by specular reflection.

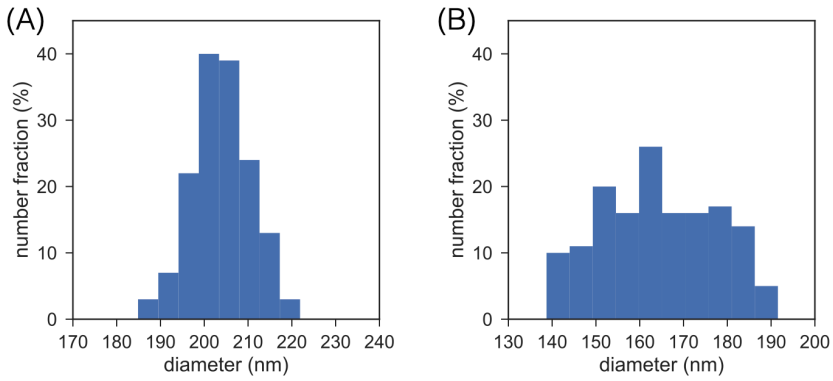

Figure S13. Histogram for silica particle diameters that are used in **Figures 2-4**. (A) Monodisperse silica particles with average diameter of 204 ± 7 nm; (B) Monodispere silica particles with average diameter of 164 ± 13 nm. Particle diameters were measured from the SEM images.

Movie S1.
A crystalline composite is stretched uniaxially until rupture. The play speed is 4x.

Movie S2.
A glassy composite is stretched uniaxially until rupture. The play speed is 4x.

Movie S3.
Uniaxially stretching of a glassy elastomer for 10 cycles. The maximum strain is 40 %. The play speed is 20x.

Movie S4.
A crystalline elastomer buckles and shows inhomogeneous color when it is actuated under a sinusoidal voltage of 1.7 kV at 0.33 Hz. The play speed is in real time.

Movie S5.
A glassy elastomer buckles and shows homogeneous color when it is actuated under a sinusoidal voltage of 1.7 kV at 0.33 Hz. The play speed is in real time.

Movie S6.
A glassy elastomer with pre-stretch and warm-up treatment wrinkles and shows homogeneous color when it is actuated under a sinusoidal voltage of 3 kV at 0.5 Hz. The play speed is in real time.

Movie S7.
A digit color display change colors of each pixel independently to show numbers from 0 to 9. The voltage is 2 kV of 0.5Hz and two cycles are performed for each number. The play speed is in real time.

Movie S8.
A digit color display shows Arabic number 3 on and off at different frequencies from 0.5 Hz to 10 Hz. The actuation voltage is 2 kV. The play speed is in real time.