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# Supplementary Materials for

## Three-dimensional printing of functionally graded liquid crystal elastomer

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**The PDF file includes:**

Figs. S1 to S7

**Other Supplementary Material for this manuscript includes the following:**

(available at advances.sciencemag.org/cgi/content/full/6/39/eabc0034/DC1)

Movies S1 and S2

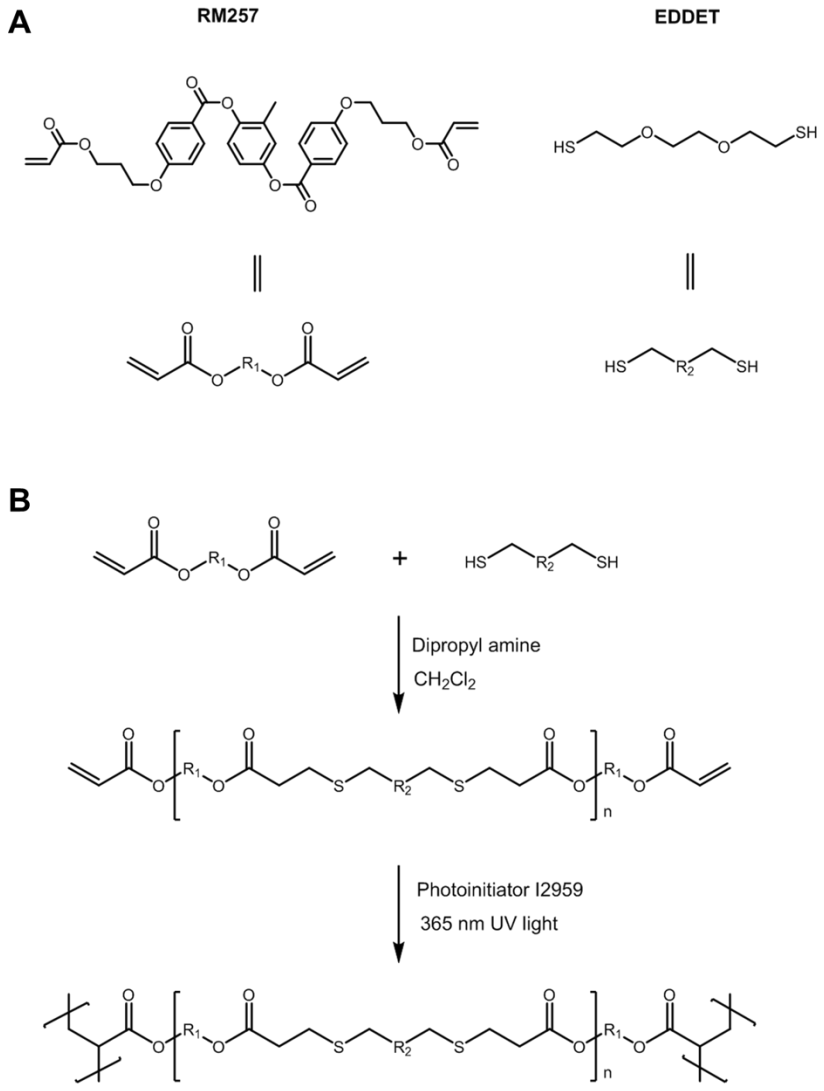


**Figure S1. The synthesis of LCE ink.** (**A**) The chemical structure of liquid crystal mesogen RM257 and chain extender EDDET; (**B**) The synthesis route of photo-polymerizable LCE ink and the crosslinking reaction under UV light.

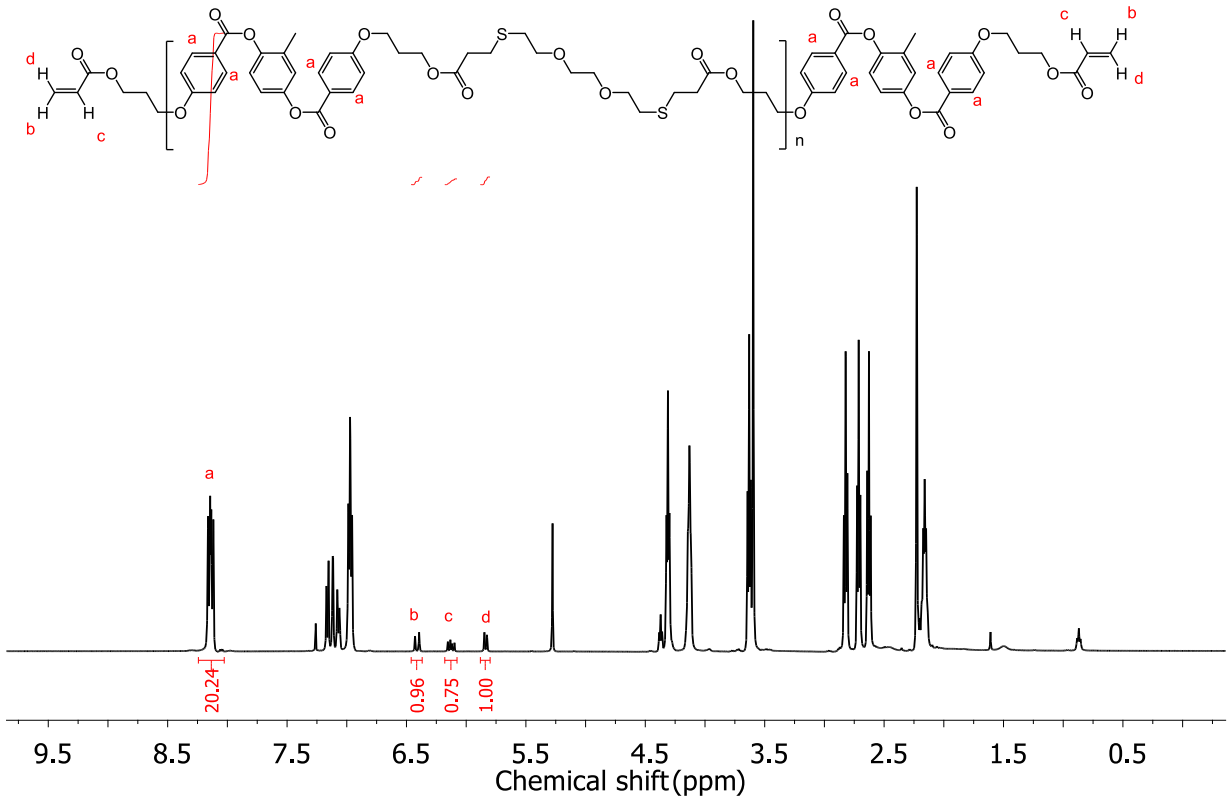


**Figure S2. $^{1}$H NMR spectrum of LCE ink.** The degree of polymerization (DP) of the LCE oligomer can be calculated as $3I(a)/(2I(b)+ 2I(c)+ 2I(d)) -1 = 10.2$, where $I$ is the chemical shift. The number-average molecular weight (Mn) of LCE ink is around 8.6 kDa.

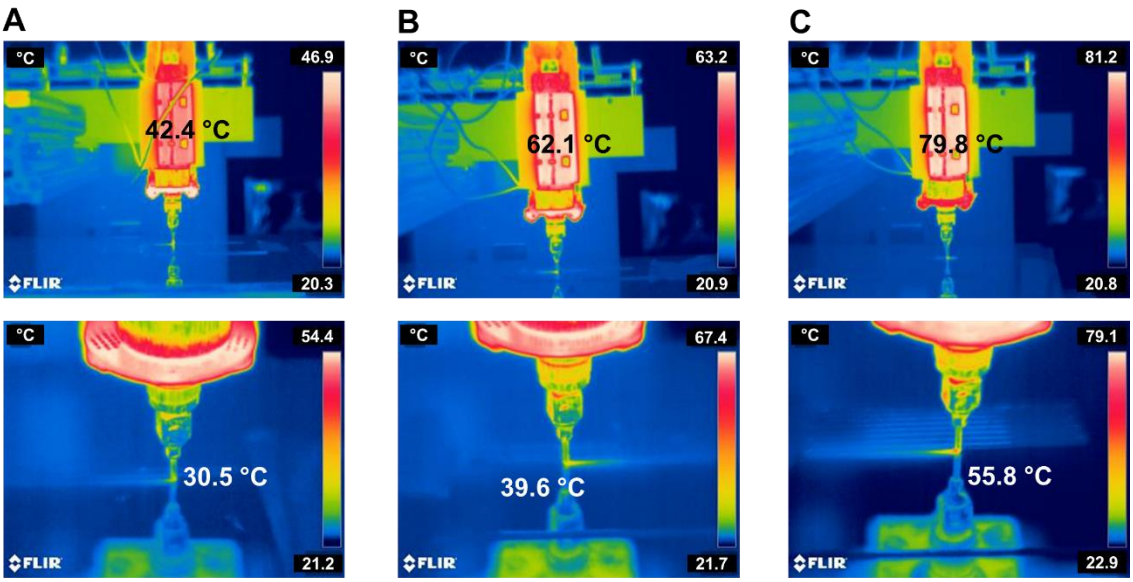


**Figure S3. IR photos of the temperature field near the printing nozzle.** Top row: temperature of the syringe; Bottom row: the temperature of the nozzle and printed LCE filament. The printing temperatures are set to be 40 °C in (**A**), 60 °C in (**B**) and 80 °C in (**C**). Photo credit: Zijun Wang, UCSD.

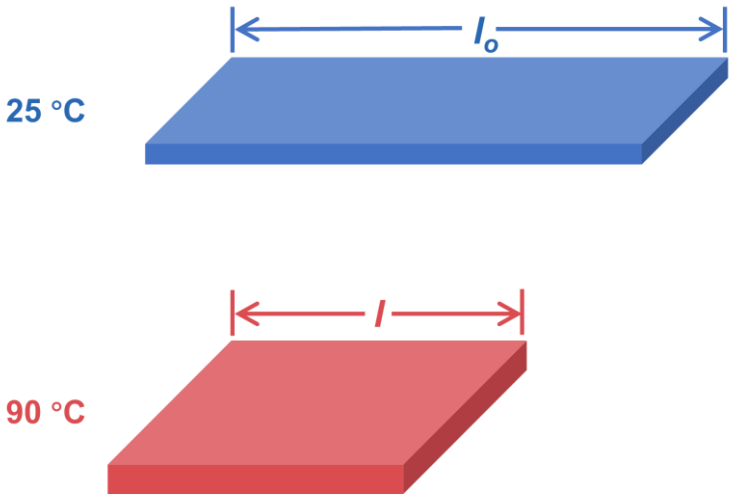


**Figure S4. Definition of the actuation strain.** The actuation strain $\varepsilon_a$ is defined as $\varepsilon_a = -(l - l_o)/l_o$, where $l_o$ is the length of a printed LCE sheet at ambient temperature and $l_o$ is its length at 90 °C.

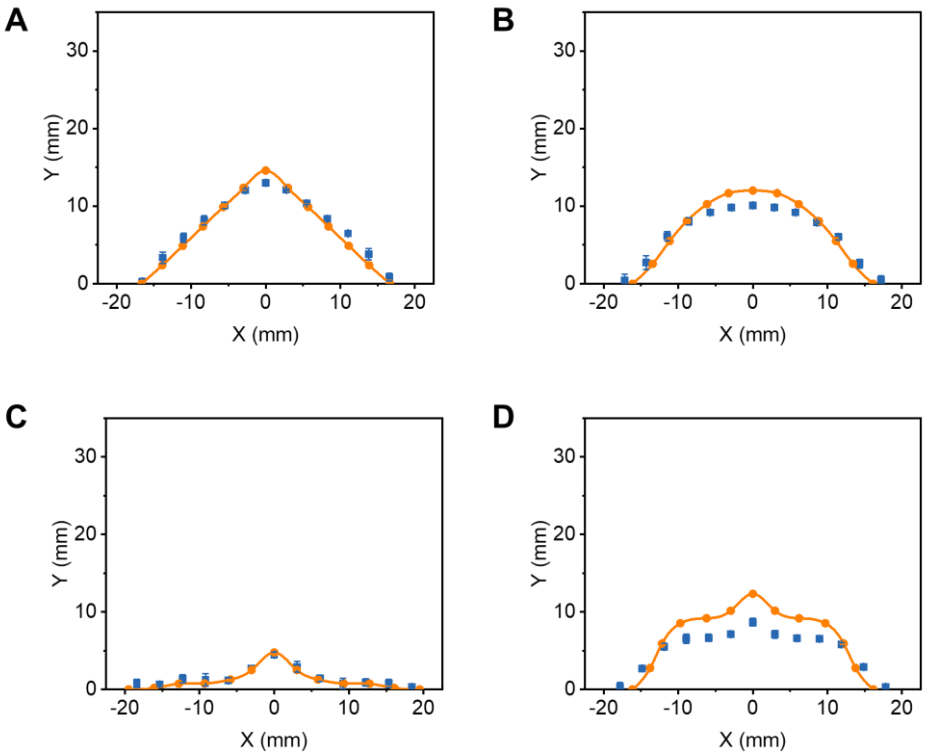


**Figure S5. Quantitative comparisons between the experimental measurements and finite element simulations of the morphing disks.** The printed disks are immersed in hot water (90 °C) for actuation. Photos are taken from the front view. The orange line represents FEA data while the blue dots represent experimental data. (**A** to **D**) correspond to Fig.3 (**A** to **D**). For each sample, three independent measurements are conducted to reduce the inaccuracy from the measurements.

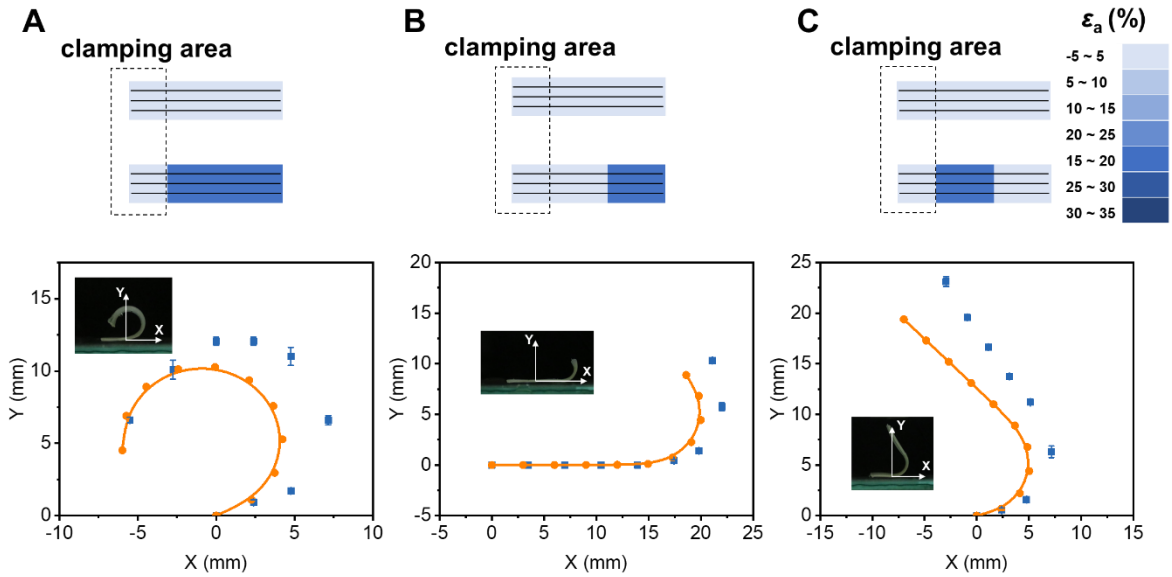


**Figure S6. Quantitative comparisons between experimental measurements and finite element simulations of the petals of the bilayer structures.** The petals are immersed in hot water (90 °C). Photos are taken from the front view. For each sample, an extra area is printed for clamping. When the sample is immersed in hot water, the clamping area is gently pressed to bond with the surface. The orange line represents FEA simulation while the blue dots represent experimental data. (**A** to **C**) correspond to the petals described in Fig.4 (**B** to **D**) correspondingly. For each sample, three independent measurements are conducted to reduce the inaccuracy from the measurements. Photo credit: Zijun Wang, UCSD.

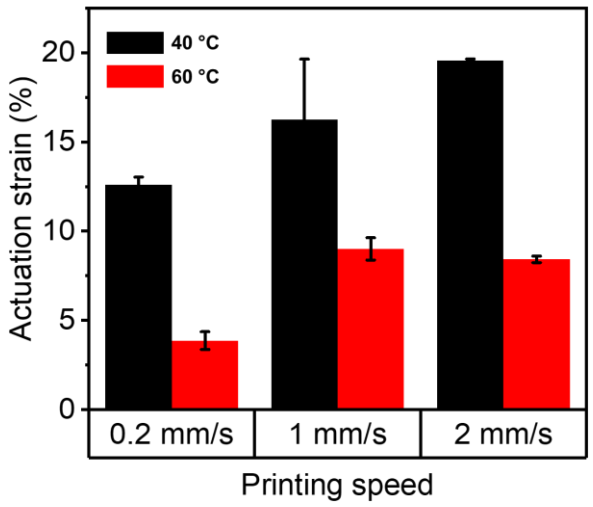


**Figure S7. Actuation strain of LCE sheets printed at different printing speeds.** With a fixed printing temperature of 40 °C, the actuation strain of the printed sheet decreases from 19% to 12% when the printing speed decreases from 2 mm/s to 0.2 mm/s. For a printing temperature of 60 °C, the actuation strain of the printed sheet decreases from 8% to 4% when the printing speed decreases from 2 mm/s to 0.2 mm/s. The distance between the nozzle and build plate $h$ is set to be 0.6 mm. Three samples printed with the same G-code file are measured for each printing speed.