Science Advances
AAAS

Supplementary Materials for

Programmable aniso-electrodeposited modular hydrogel microrobots

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Sci. Adv. **8**, eade6135 (2022)
DOI: 10.1126/sciadv.ade6135

The PDF file includes:

Other Supplementary Material for this manuscript includes the following:

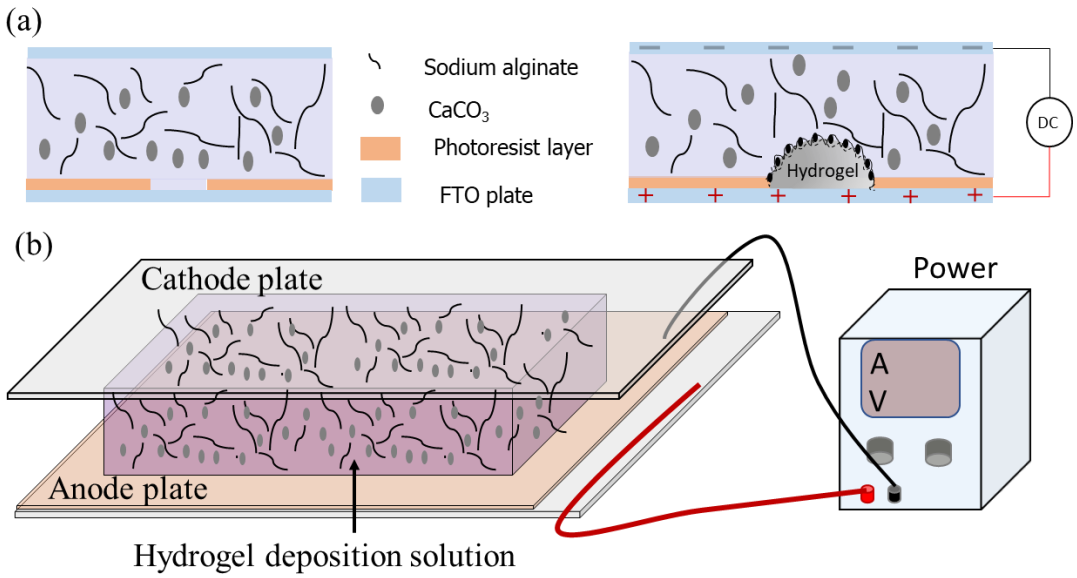

Fig. S1. The schematic of electrodeposition processes and setup. (a) The hydrogel microstructures are fabricated through inhomogeneous electrodeposition. (b) The composition of the electrodeposition setup.

$$survival\ ratio = \frac{initial\ cell\ number}{cell\ number\ in\ time\ points} \times 100\%$$

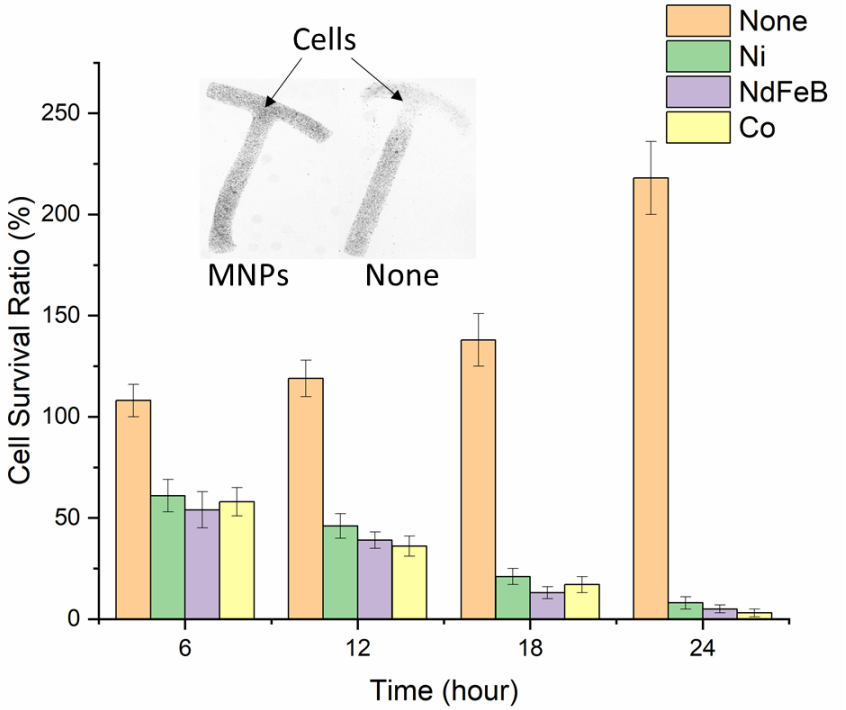

Fig. S2. Cell survival ratio after embedding HUVECs in the horizontal part of the MMR with or without various types of 4 % (w/w) magnetic nanoparticles. Survival ratio equals to

initial cell number divided by cell number in different time points. Each column represents the average survival ratio of three different two fingered shaped MMRs ± s.e.m.

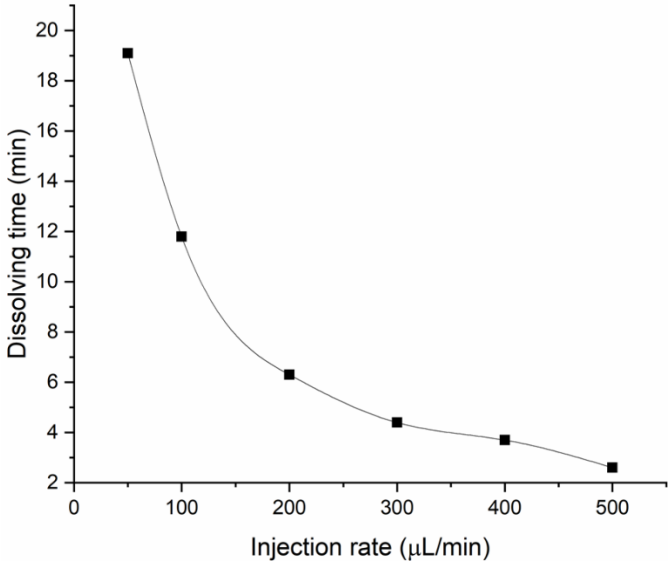

Fig. S3. The dissolving time of MMR in different injection rate of artificial intestine liquid.

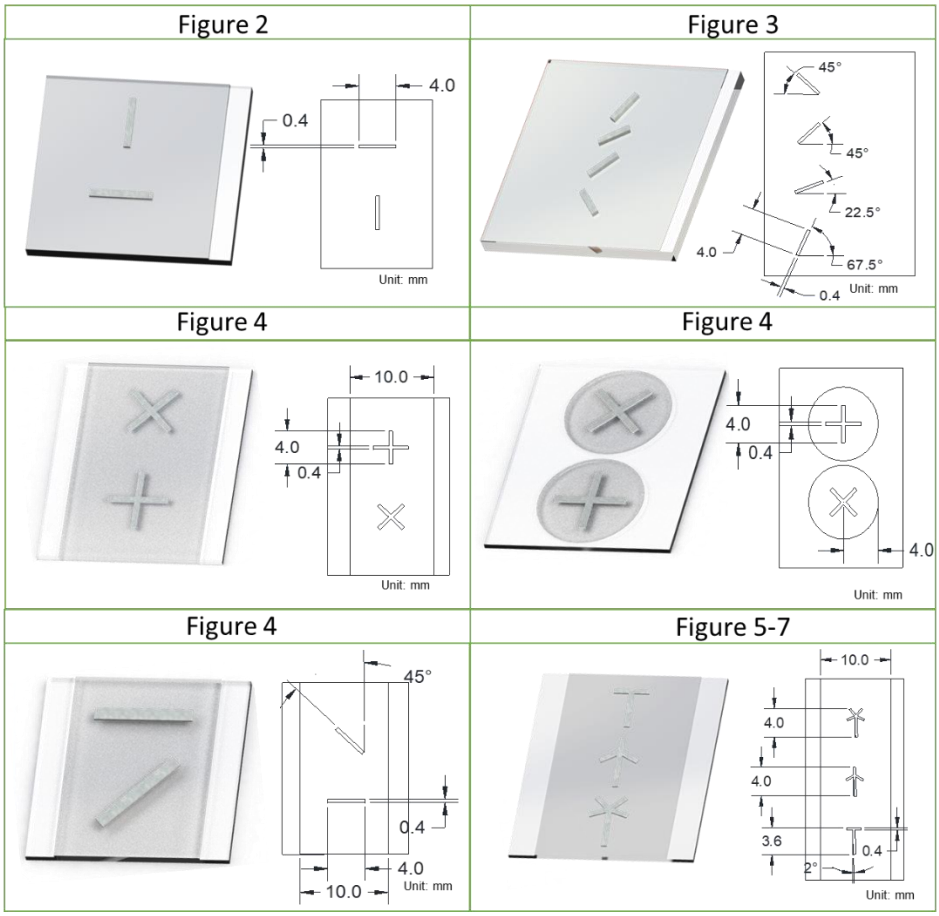

Fig. S4. The design and parameter of various electrodes in each figure of manuscript.

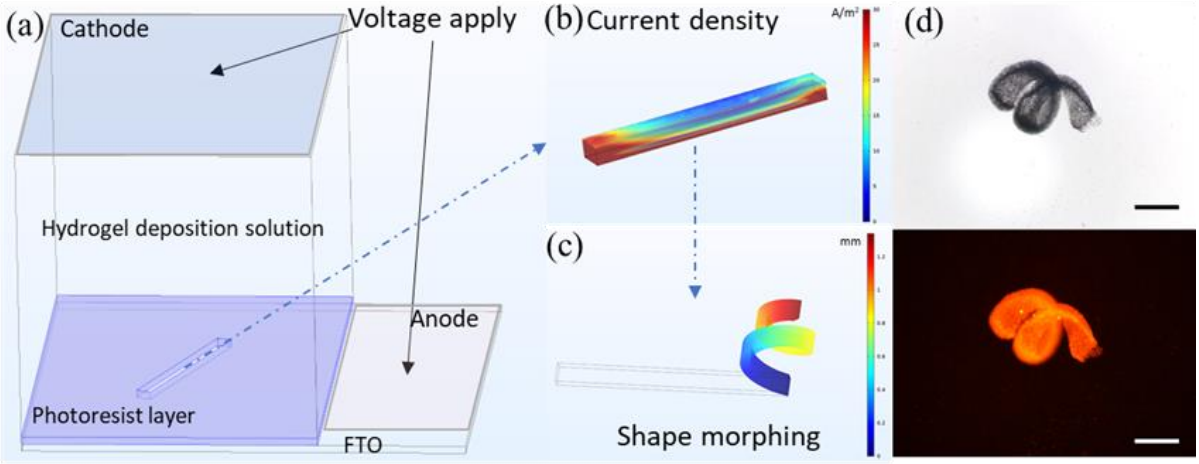

Fig. S5. Analysis on shape morphing results by using FEA. (a) The 3D model of hydrogel deposition solution, photoresist and FTO plate. The cathode and anode plane are indicated in blue and red colors. (b) The current density simulation result. (c) The transformation simulation result. (d) The experimental results in bright and fluorescent fields. Scale bar: 300 μm.

The conductivities of the photoresist, FTO and hydrogel deposition solution are set to be 10^{-10} S/m, 1000 S/m and 13.1 S/m. The relative dielectric constant of photoresist, FTO and hydrogel deposition solution were set to be 1000, 1, 90. The reference impedance was set to be 50 Ω. The voltage was set on the top of hydrogel deposition solution and FTO surface as shown in the Fig. S5 (a). Based on the current density simulation, we can have the 3D current density distribution (Fig S5(b)). We used Multiphysics to couple the current density simulation and a solid mechanics. The young's modulus was set to be 100 Pa. The poisson's ratio was set to be 0.5. the density of the hydrogel was set to be 1.2 kg/m^3. Based on the current density dependent swelling ratio, we can have the shape morphing result as shown in the Fig. S5 (c). And the experimental results were given in the Fig. S5 (d).

Supplementary movie captions:

Movie S1. Stripe microstructure self-shape morphing into spiral structure with 0° along electric field.

Movie S2. Stripe microstructure self-shape morphing into mobius ring with 90° along electric field.

Movie S3. Stripe microstructure self-shape morphing into helical structure with 45° along electric field.

Movie S4. Bidirectional stripe microstructures shape morphing into heart and helical shapes.

Movie S5. Central and axial symmetry cross microstructures shape morphing.

Movie S6. Two-fingered microrobot shape morphing.

Movie S7. Three-fingered microrobot shape morphing.

Movie S8. Four-fingered microrobot shape morphing.

Movie S9. Fish-like locomotion of two-fingered MMR.

Movie S10. Caterpillar-like locomotion of four-fingered MMR.

Movie S11. Fluorescent nanoparticle delivery on the sphere target by four-fingered MMR.

Movie S12. Precise cell delivery on the tubular structure by two-fingered MMR.

Movie S13. Ex-vivo motion and visualization under ultrasound imaging in the rat intestine.

Movie S14. Ex-vivo fluorescent local visualization in the rat intestine.