

Supporting Information

3D-Printed Multi-Stimuli Responsive Mobile Micromachines

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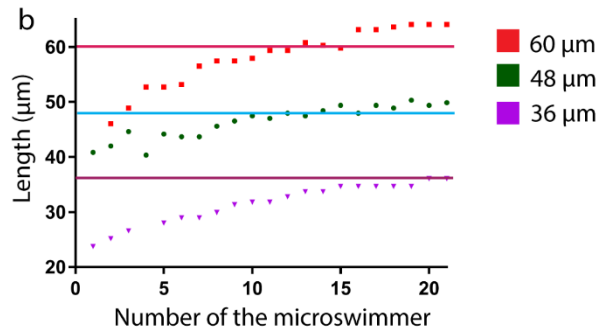
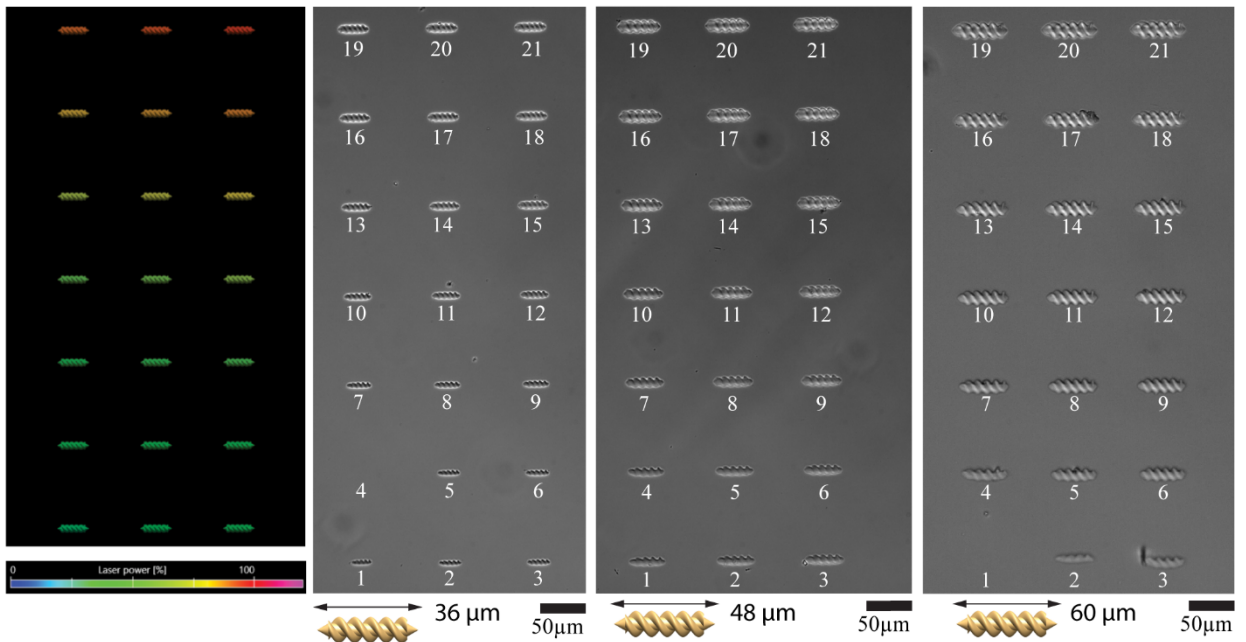


Figure S1. Optimization of the femtosecond laser fabrication for the maximized structural fidelity of microscrews in three different dimensions (36, 48, 60 μm lengths). (a) Color-coded description and microscopic images of a microscrews array design (36, 48, 60 μm) to be fabricated with varying laser powers in the range of 20-80 mW with 3 mW step size. (b) The structural quality was assessed under three classifications: *underdose* where microscrews were exposed to too low laser intensity so that the structures became smaller than their designated dimensions; *overdose* where the solution was exposed to too much laser intensity so that the structures became bigger than the design or were observed structural defects due to local overheating; *acceptable dose* where the dimensions and features met their original design without any defects. The line in the graph indicates the dimension of design.

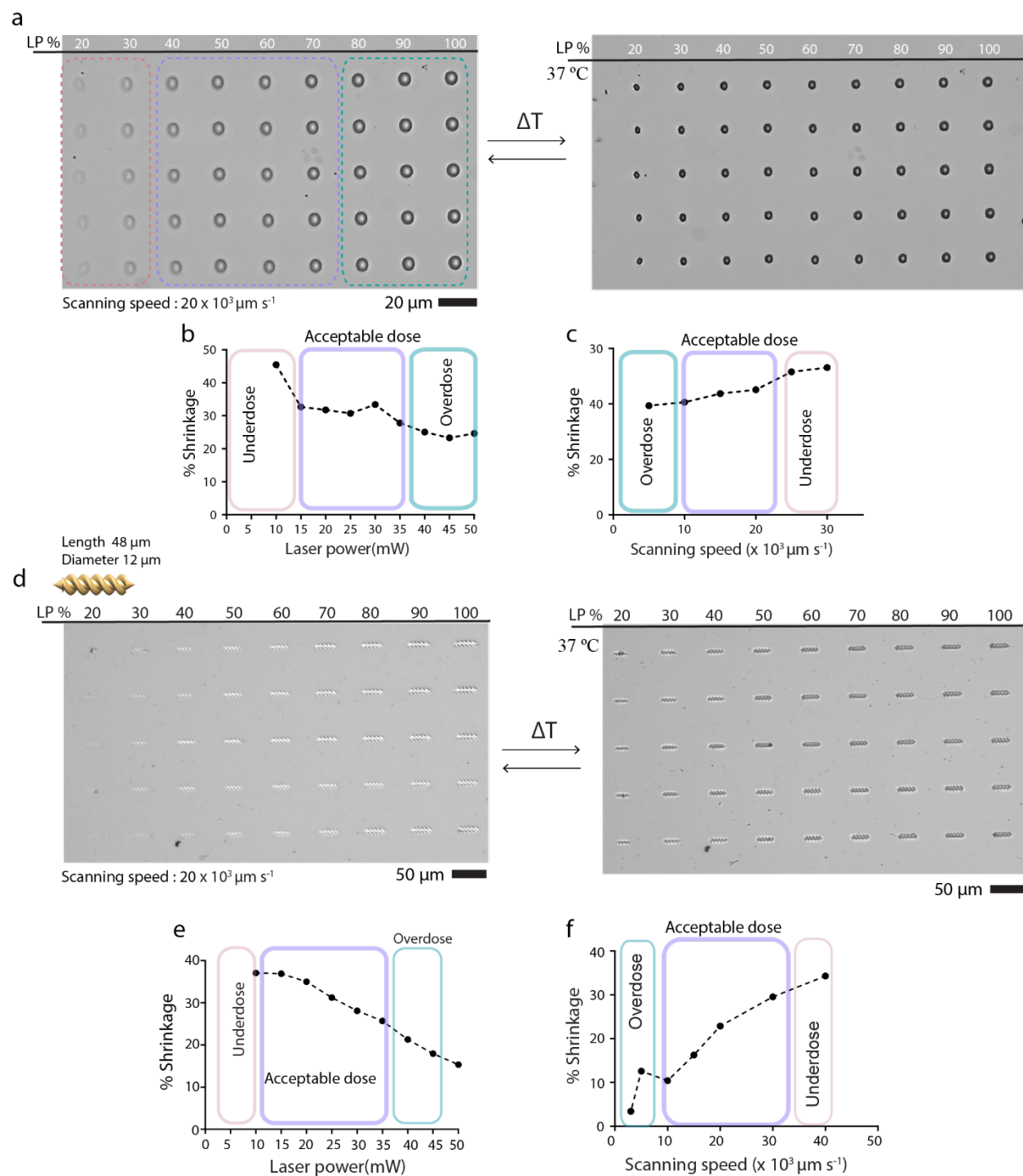


Figure S2. Effect of laser power and scanning speeds on the actuation strain of micro-rollers and microscrews. (a) Microscopic images of micro-rollers changing their size in response to temperature with different laser power. (b) Effect of laser power on the shrinkage of micro-rollers. (c) Effect of scanning speed on the shrinkage of micro-rollers. (d) Microscopic images of microscrews changing their size in response to temperature with different laser power. (e) Effect of laser power on the shrinkage of microscrews. (c) Effect of scanning speed on the shrinkage of

microscrews. The structural quality was assessed under three classifications: Underdose where microswimmers were exposed to too low laser intensity, so that the structures became smaller than their designated dimensions; overdose where the solution was exposed to too much laser intensity, so that the structures became bigger than the design or were observed structural defects due to local overheating; acceptable dose where the dimensions and features met their original design without any defects.

Ion responsiveness of pNIPAM-AAc microrollers

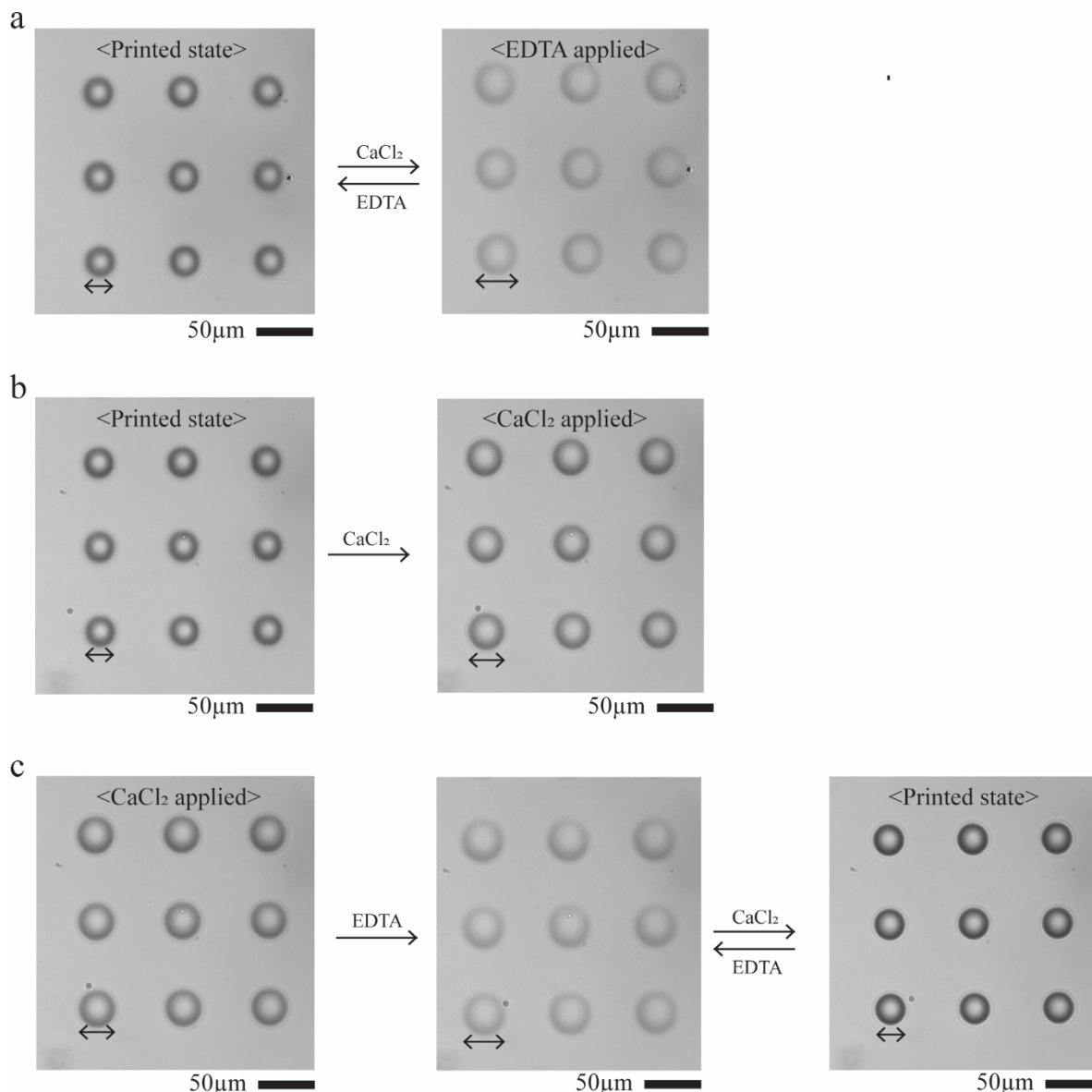


Figure S3. Microscopic images of 3×3 arrays of pNIPAM-AAc microrollers showing swelling and shrinking in response to Ca^{2+} ions (EDTA and Ca^{2+} , respectively). (a) Microscopic images of pNIPAM-AAc microrollers changing their size in response to Ca^{2+} . (b) Microscopic images of pNIPAM-AAc microrollers expanding their size in response to only CaCl_2 solution. (c) Microscopic images of microrollers had exposed to CaCl_2 solution, expanding its radius by 14% by adding EDTA solution and showing shrinkage to become printed state by applying CaCl_2 solution.

Effect of volume fraction of SPIONs on temperature response of the microscrews

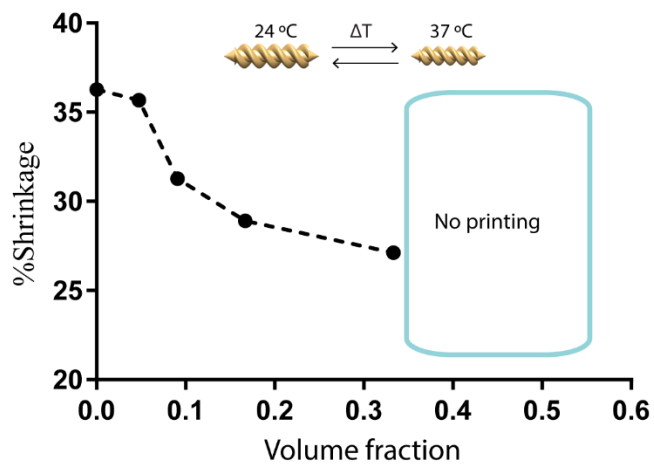


Figure S4. Effect of volume fraction of SPIONs on shrinkage of the microscrews in response to the temperature change. Percentage of the shrinkage decreases with the increased volume fraction of SPIONs.

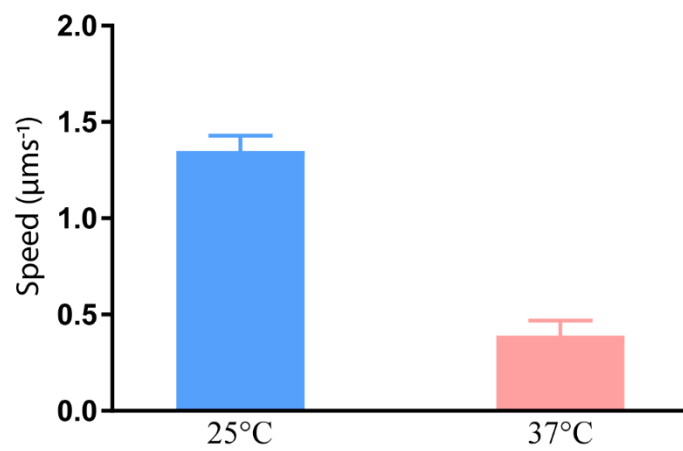


Figure S5. Speed change of the microrollers in response to the temperature change.