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Magnetic Micropillar Structures for Programmable and Reprogrammable Actuation

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ABSTRACT

Stimuli-responsive micropillar structures that can perform dynamics and reversible deformations according to external stimuli have been applied in a wide spectrum of fields, including object manipulation, soft miniature robots, and functional surfaces. However, it remains a challenge to exhibit programmable actuation behaviors for applications that require on-demand deformation response. Herein, a two-step photomask-assisted template casting technique is developed to fabricate a hybrid magnetic micropillar array for programmable actuation. By modulating the spatial distribution of the magnetic nanoparticles within the elastomer micropillars, the bending deformations of the micropillars with different particle distributions can vary near one order of magnitude under the same magnetic field. Through the two-step technique, the micropillars with different deformation responses can be arranged into any desired spatial pattern for various exciting novel applications, as demonstrated in encryptable surface and track-programmable micro-target transportation. Furthermore, to overcome the limitation that the bent deformation of the micropillars is fixed once the fabrication is completed, a concept for core-shell magnetic micropillars, which can achieve not only programmable but also reprogrammable actuation in response to external magnetic stimuli. The micropillars are composed of elastomeric hollow shells encapsulating liquid magnetic nanocomposite resin. The spatial distribution of the magnetic nanoparticles inside the liquid resin core can be dynamically modulated within one single micropillar to regulate the actuation configuration of the pillar. In this way, the spatial pattern of the micropillars with contrast bending configurations can be dynamically and repeatedly configured through a local magnetic field for writing and a global magnetic field for erasing, which can be applied in the applications of rewritable paper and recyclable displays. The hybrid and core-shell magnetic micropillars reported here provide versatile prototypes and inspirations for the programmable and reprogrammable stimuli-responsive microstructures.

KEYWORDS

Stimuli-responsive microstructures; magnetic micropillars; programmable; reprogrammable

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