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标题: Programming Shape-Morphing Behavior of Liquid Crystal Elastomers via Parameter-Encoded 4D Printing

作者: Ren, LQ (Ren, Luquan); Li, BQ (Li, Bingqian); He, YL (He, Yulin); Song, ZY (Song, Zhengyi); Zhou, XL (Zhou, Xueli); Liu, QP (Liu, Qingping); Ren, L (Ren, Lei)

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摘要: Currently, four-dimensional (4D) printing programming methods are mainly structure-based, which usually requires more than one material to endow products with site-specific attributes. Here, we propose a new 4D printing programming approach that enables site-specific shape-morphing behaviors in a single material by regulating the printing parameters. Specifically, a direct ink writing three-dimensional (3D) printer with the ability to change printing parameters (e.g., deposition speed) on the fly is reported. By site-specifically adjusting print speed and print path to control the local nematic arrangements of printed liquid crystal elastomers (LCEs), the shape-morphing behaviors of the LCEs can be successfully programmed. In this way, locally programmed popping-up, self-assembling, and oscillating behaviors can be designed by varying the print speed in specific regions. Snake-like curling is realized by uniformly boosting the print speed in a single line. Furthermore, two theories and an ultrasound image diagnostic apparatus are employed to reveal the mechanism behind this behavior. This work provides a feasible way to realize the gradient transition of material properties through a single material. It broadens the design space and pushes the envelope of 4D printing, which is expected to be helpful in the fabrication of soft robotics and flexible electronics.

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地址: [Ren, Luquan; Li, Bingqian; He, Yulin; Song, Zhengyi; Zhou, Xueli; Liu, Qingping; Ren, Lei] Jilin Univ, Key Lab Bion Engn, Minist Educ, Changchun 130022, Peoples R China.
[Ren, Lei] Univ Manchester, Sch Mech Aerosp & Civil Engn, Manchester M13 9PL, Lancs, England.

通讯作者地址: Liu, QP; Ren, L (通讯作者)，Jilin Univ, Key Lab Bion Engn, Minist Educ, Changchun 130022, Peoples R China.
Ren, L (通讯作者)，Univ Manchester, Sch Mech Aerosp & Civil Engn, Manchester M13 9PL, Lancs, England.

电子邮件地址: liuqp@jlu.edu.cn; lei.ren@manchester.ac.uk

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