

Intelligent Magnetic Soft Millirobots Fabricated by 3D Printing for *In Vitro* Diagnostics

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3D printing via vat photopolymerization (VP) is a highly promising approach for fabricating magnetic soft millirobots (MSMRs) with accurate miniature 3D structures; however, magnetic filler materials added to resin either strongly interfere with the photon energy source or sediment too fast, resulting in the nonuniformity of the filler distribution or failed prints, which limits the application of VP. To this end, a circulating vat photopolymerization (CVP) platform that can print MSMRs with high uniformity, high particle loading and strong magnetic response is presented in this study. After extensive characterization of materials and 3D printed parts, it is found that $\text{SrFe}_{12}\text{O}_{19}$ is an ideal magnetic filler for CVP and can be printed with 30% particle loading and high uniformity. By using CVP, various tethered and untethered MSMRs are 3D printed monolithically and demonstrate the capability of reversible 3D-to-3D transformation and liquid droplet manipulation in 3D, an important task for in vitro diagnostics that have not been shown with conventional MSMRs. An AI-enabled and fully automated liquid droplet handling platform that manipulates droplets with MSMR is presented for detecting carbapenem antibiotic resistance in hazardous biosamples as a proof of concept, and the results agree with the benchmark.



About the author

Yi Zhang is currently a Professor at the University of Electronic Science and Technology of China. Previously he served as an assistant professor at the School of Mechanical and Aerospace Engineering at Nanyang Technological University, Singapore. He was also an affiliated faculty of China Singapore Joint International Research Institute, Singapore Center for 3D Printing, NTU-HP Digital Manufacturing Corp Lab, and Nanyang Quantum Science and Engineering Center.

He received his Ph.D in Biomedical Engineering from Johns Hopkins University School of Medicine, USA, in 2013 and B.Eng in Bioengineering from Nanyang Technological University, Singapore, in 2007. He received his postdoc training in the Institute of Bioengineering and Nanotechnology, the Agency of Science Technology and Research (A*STAR), Singapore from 2013–2015, and subsequently worked there as a Research Scientist from 2015–2016. His research aims to develop micro and nano systems to bridge the gap between engineering advancement and current medicine practice. His achievement is recognized by a series of awards including Nanyang Young Alumni Award, Outstanding Self-Financed Student Overseas, Hodson Fellowship, Siebel Scholar, and various Young Scientist Awards, Best Conference Awards and Art in Science Awards.