

## Supporting Information

### **LMPA-Based Magnetically Actuated Continuum Robots with Real-Time Reprogramming Capability for Minimally Invasive Biomedical Applications**

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**This PDF file includes:**

Supplementary Text

## 1. Comparison of the performance of this magnetic robot with previous reports

We have systematically compared the core performance and functional characteristics of reprogrammable magnetic soft robots, with reference to the four references mentioned by the reviewer. All original data for the compared works are derived from the original published papers and their supplementary materials.

**Table S1. Comparison of representative reprogrammable magnetic soft robotic systems.**

Comparison Dimension	Polymer-Based	Elastomer-Based	This Work
	Reconfigurable MCR <sup>1-3</sup>	Reconfigurable MCR <sup>4</sup>	
<b>Reprogramming Mechanism</b>	Thermally triggered polymer matrix melting → free rotation of NdFeB microparticles under a weak magnetic field → particle orientation locked by matrix solidification upon cooling.	Heating triggers Diels-Alder bond cleavage, allowing rearrangement of NdFeB particles.	Electrical heating melts the LMPA → releases the embedded bulk permanent magnet → external magnetic field adjusts the overall magnetic moment direction → metallic rigid mechanical locking upon cooling. ~28 s (22 s heating for melting + 6 s cooling for solidification), representing the fastest in vivo applicable reprogramming scheme reported to date.
<b>Reprogramming Cycle</b>	30 s ~ 6 min (faster with localized laser heating; slower with bulk oven heating).	~5-20 min (faster with localized laser heating; slower with bulk oven heating).	
<b>Phase-Change Locking Material</b>	Gelatin-PVA, PEG, PCL.	Dynamic covalent polymer.	Low-melting-point alloy, a pure metallic system.
<b>Heating Method</b>	External laser local heating or bulk oven heating.	External laser local heating or bulk oven heating.	Built-in copper wire electrical heating, eliminating the need for external optical systems and having no tissue penetration depth limitation. 47.2°C, only 10.2°C above human body temperature; fully meets in vivo thermal safety requirements when combined with silicone insulation.
<b>Phase-Transition Temperature</b>	41 ~ 60°C	~100°C	
<b>Core Advantages</b>	Mature material systems, simple fabrication process, enabling high-resolution	Modular welding assembly, permanent structural reconfiguration, recyclability.	Dual-drive-unit large deformation, proximal remote programming, highest metallic

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magnetization patterns.

locking stiffness, no  
dependence on external light  
source, optimal biosafety.

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## References:

1. H. Deng, K. Sattari, Y. Xie, P. Liao, Z. Yan and J. Lin, *Nature Communications*, 2020, **11**, 6325.
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