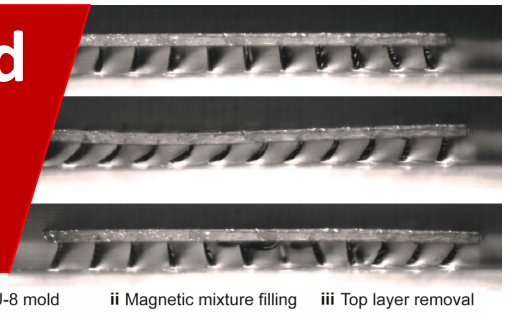
Miniature micromixer based on artificial cilia

Master thesis project



Introduction

Magnetically responsive materials have drawn extensive attention in various applications including soft robots, droplet and particle manipulators, self-cleaning and anti-fouling surfaces, and on-chip integrated liquid mixers and pumps. This is enabled by such merits of magnetically responsive materials as fast and reversible response, and remote activation without the need for physical connections to an external actuation setup.

In nature, the collective motion of biological **cilia** (hair-like structures) forms a versatile tool featured by organism locomotion, mucus clearance in the human respiration system, feeding assistance, and cell/particle manipulation [1].

Project

Inspired by the versatility of biological cilia, we propose to create a miniature micromixer using microscopic magnetic artificial cilia (**μMAC**). This work will be based on the group's prior experience in creating metacrhonal motion of **μMAC.**

Previously, we fabricated μMAC using a micro-molding method, during which the distribution of paramagnetic particles in the μMAC were well programmed (Fig. 1). Thanks to this, we created climbing ciliated soft robots (Fig. 2) [2].

In this project, first, you will fabricate μMAC based on the micro-molding method shown in Fig. 1. You may modify this process by replacing the rod-shaped magnets with e.g. spherical magnets, to create nonuniform alignment of the paramagnetic particles in the μMAC. Then, you will characterize the magnetic properties of the fabricated μMAC, and study their response in a uniform magnetic field generated by a 2-pole electromagnetic setup [3]. Finally, you will explore the mixing capability of the μMAC array by integrating them in microfluidic device.

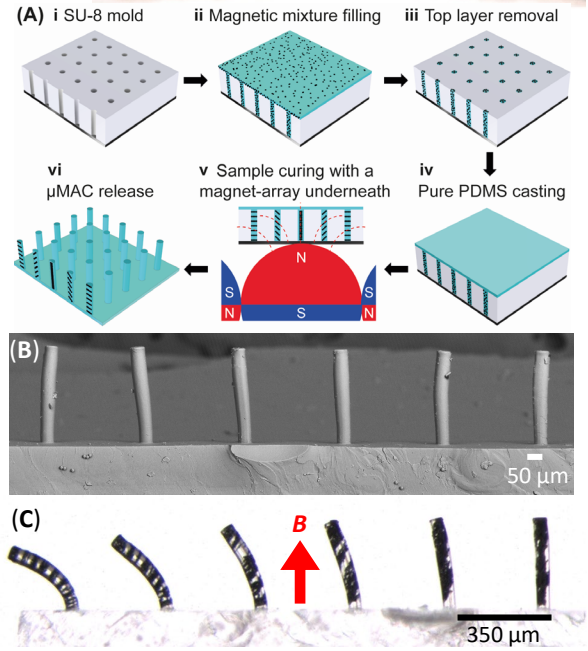


Fig. 1. (**A**) Schematic of the micro-molding process of the μMAC. (**B**) Side-view SEM image of the fabricated μMAC. (**C**) Optical microscopy image of the fabricated μMAC in a uniform magnetic field of 280 mT, exhibiting bending difference.

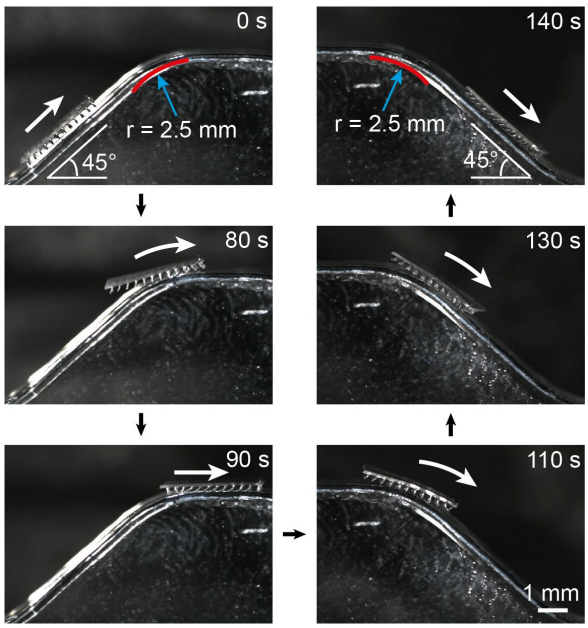


Fig. 2. Ciliated soft robot climbing across a hill.

References

[1] J. M. J. den Toonder and P. R. Onck, *Artificial cilia*, 2013.
[2] S. Zhang et al. manuscript submitted, 2020.
[3] Y. Wang et al. *Lab Chip*, 2015.

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