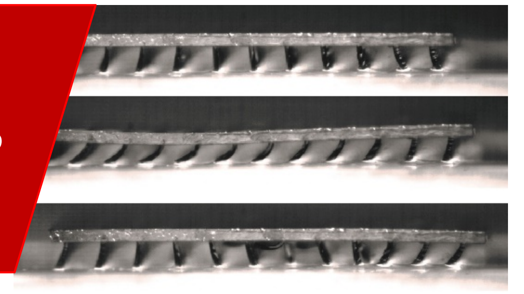
Walking ciliated soft robots

Master thesis project



Introduction

Soft robots have shown remarkable potential for applications ranging from bioengineering such as single-cell manipulation and biosensing, to healthcare such as targeted drug delivery and minimally invasive surgery [1]. **Magnetically responsive materials** enable the integration of such merits as fast and reversible response, and remote activation without the need for physical connections to an external actuation setup. Moreover, magnetic actuation has unique potential for medical applications of microrobots inside nontransparent tissues at high penetration depths [2].

In nature, **metachronal wave motion** of biological **cilia**, i.e. neighboring cilia move out of phase creating a traveling wave, enables propulsion and locomotion of many creatures. However, there is no study on creating **magnetic soft robots** using metachronally actuated microscopic magnetic artificial cilia (**μMAC**).

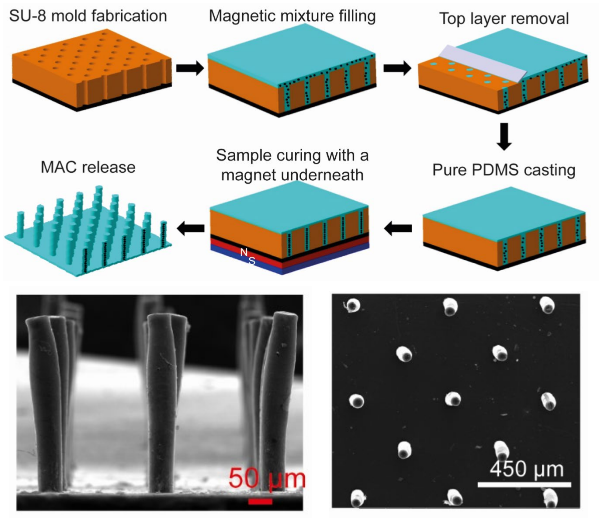


Fig. 1. Schematic of the micro-molding process to fabricate μMAC (top), and SEM images of the fabricated μMAC from both top (bottom left) and side view (bottom right) [3].

Project

Here, we propose to create **magnetic walking soft robots** using μMAC (Fig. 1) that can be actuated metachronally. Previously we demonstrated the metachronal motion of μMAC using a magnet-belt actuation setup (Fig. 2), which can generate substantial microfluidic flow in a microfluidic chip [3].

Based on this pioneering work, we aim to create walking ciliated soft robots using the same actuation setup. In this project, you will (1) fabricate μMAC using the micro-molding method shown in Fig. 1, (2) study the walking capability of the μMAC array, (3) explore the working principle behind the walking, and (4) study the cargo-carrying capacity of the ciliated robots. You may also fabricate molds featured with a different structure than cylindrical wells using a Femtosecond laser machine, so that the fabricated μMAC have e.g. a tapered shape reducing the adhesion between the μMAC and the surface.

The final aim is to create walking ciliated soft robots using metachronal μMAC and demonstrate their versatility.

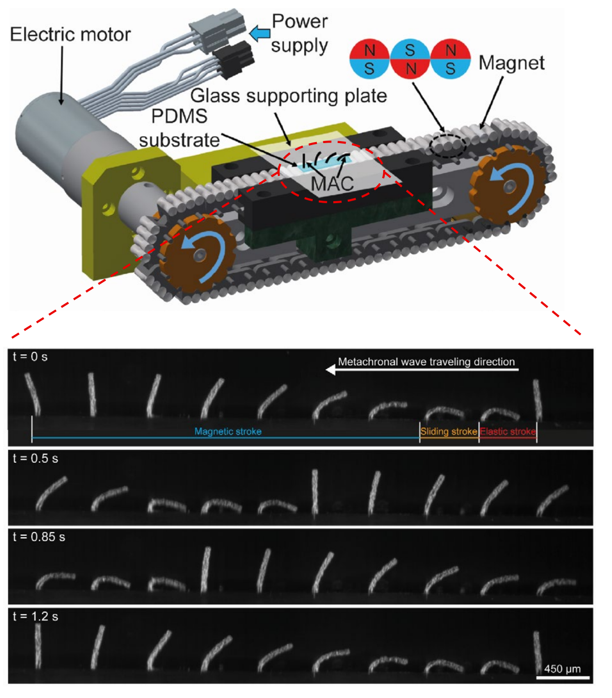


Fig. 2. Schematic of the magnet-belt actuation setup (top), and the side-view metachronal motion of the μMAC array when the magnet-belt rotates counterclockwise (bottom) [3].

References
[1] W. Hu et al, *Nature*, 2018.
[2] M. Sitti and D. S. Wiersma, *Advanced Materials*, 2020.
[3] S. Zhang et al. *Lab Chip*, 2020.

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