Artificial cilia for microparticle manipulation and anti-fouling

Citation for published version (APA):

Document status and date:
Published: 11/10/2016

Document Version:
Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.
ARTIFICIAL CILIA FOR MICROPARTICLE MANIPULATION AND ANTI-FOULING

Shuaizhong Zhang¹², Ye Wang¹ and Jaap den Toonder²
s.zhang1@tue.nl
¹Eindhoven University of Technology, the Netherlands
²China Scholarship Council, the People’s Republic of China

Motivation and Aim

The (bio-)fouling of surfaces submerged in liquid forms a serious problem for many applications. One inspiration to address this issue is the use of cilia which are oscillating micro-hairs found in nature, and which are very effective in particle manipulation. Thus we aim to develop engineered analogues of cilia – magnetically actuated artificial cilia (MAAC) for particle manipulation and anti-fouling. We have fabricated MAAC using a home-built roll-pulling setup. The MAAC perform a synchronized tilted conical movement when actuated by a rotating magnet underneath, generating substantial fluid flow which is an important first step towards manipulating surrounding particles and creating anti-fouling.

Background

(Bio-)fouling occurs in many applications including biomedical and microfluidic devices, micro- to macroscale sensors and marine devices. It inhibits their normal functioning and leads to enormous economic losses.

Cilia

In nature, cilia are very effective in manipulating surrounding particles [1].

Simulation-base evidence

Since biological cilia are so effective in manipulating particles, researchers propose the use of cilia to create anti-fouling surfaces. Numerical simulations on repelling particles away from ciliated surfaces have been done by the group of Balazs and coworkers [2].

Figure 3: Numerical simulation of microparticle manipulation using cilia: (a) a model of active cilia; (b) a model of passive cilia. [5]

Roll Pulling Process of MAAC

We have fabricated MAAC using a novel out-of-cleanroom, cost-effective and potentially large-scale roll-pulling method. The MAAC made in this way can perform a synchronized tilted conical movement under the actuation of an external rotating magnet. An actuation movie can be found on https://youtu.be/qnqh435wHo8.

Figure 4: (a) Schematic of the roll-pulling setup; (b) Photo of the home-built set-up; (c) Microscopic picture of MAAC made with the roll-pulling setup using micropillars of 150 μm in diameter.

Results

We can produce MAAC with lengths of 250, 200 and 150 μm using micropillars with diameters 150, 125 and 100 μm respectively. The length and aspect ratio can be adjusted by varying the gap between the roll and the substrate, and the diameter of the micropillars. What's more, the geometrical configuration of the MAAC can be set by controlling the arrangement of the roll’s micropillars. Fig. 5d shows the fluid flow generation property of MAAC.

Figure 5: Microscopic pictures of MAAC: (a) MAAC fabricated with micropillars of 100 μm diameter; (b) MAAC fabricated with 125 μm diameter micropillars; (c) MAAC fabricated with 150 μm diameter micropillars; and (d) the fluid flow generation property of MAAC made by pillars of diameter 150 μm.

Outlooks

Characterize the capability of MAAC in manipulating particles, including sticky and non-sticky, soft and hard, passive and active particles.

Acknowledgements

This research is financially supported by the China Scholarship Council. Hossein Eslami Amirabadi and Sheen SahebAli have provided useful suggestions during the experiments. Many thanks to the Chemical and Biological Microsystems Society (CBMS) for offering a travel grant.

References