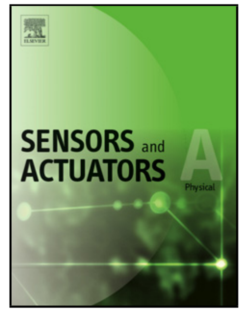

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Helical Microrobot for Force Sensing Inside Microfluidic Chip

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Highlights

- An on-chip protocol for helical microrobot characterization is proposed.
- The force applied by the robot is between 10 and 50 pN with 10% error.
- On-chip selective particle isolation and characterization is demonstrated by the robot.
- A microfluidic design to store the robot while drying the chip is reported.

Abstract

Microfluidic platforms used for biology studies are in need of embedded mobile sensing tools. However, tethered actuators and sensors are almost impossible to use in closed microscopic environments. In this paper we propose a microfluidic platform combined with a helical microrobot control setup to perform such tasks. The microrobot used in this paper is $50\mu m$ long and $5\mu m$ in diameter. It is designed with a helical tail that propels it through rotation. This rotation is induced by a homogenous magnetic field, which is provided by a setup compatible with microscopy techniques. We first propose to use this robot as a force sensor. For this we report a characterization protocol inside the microfluidic chip to link in an open-loop way the robot rotation to the applied force on an object. This approach provided accurate force sensing in the range of 10-40 pN, with measurement error of 12%. Secondly, we demonstrate how this helical microrobot can be used to selectively isolate a particle from a solution and how we can investigate the impact of the particle on the robot propulsion force. Finally, we show that this robot can be stored, ready to use, on a dried microfluidic chip, thus allowing long-term storage and simple transport. This platform opens up the opportunity to develop helical microrobots on various scale that can as untethered sensors and actuators inside microfluidic environment.

Keywords: Microrobot, Microfluidic chip, Force sensing, Particle manipulation.

1 Introduction

In the last decades, the microfluidic chip has been a growing platform for biological manipulation and medical science. On top of the advantages provided by the micrometer scale, this platform offers a closed transparent environment. This prevents contamination and allows for a good interfacing with imaging systems, laser actuator [1] or magnetic actuator [2]. However this closed environment prevents the use of tethered probes for manipulation and sensing. Therefore, microrobots controlled by magnetic field gradients have been proposed for manipulation and cell enucleation [3].

Magnetically controlled microrobots have also been proposed for performing force sensing. To attain force feedback, a deformable cantilever is embedded inside the microrobots. However as the

List of abbreviations:

- RTS: Roll-To-Swimm helical microrobot
- PVD: Physical vapor deposition
- SEM: Scanning Electron Microscope