Supplementary Material (ESI) for Lab on a Chip

Electronic Supplementary Information (ESI) for manuscript "*Magnetically controlled rotation and torque of uniaxial microactuators for lab-on-a-chip applications*", by A. Ranzoni et al.

Movies of rotating two-particle microactuators M1-M3

Movie 1: Rotation below the critical frequency

M1.wmv

Rotational behavior of a two-particle microactuator in bulk fluid (PBS buffer). The magnetic field is rotating clockwise at 2.5 Hz and the strength of the field is 1 mT. The magnetic particles (Dynabeads® MyOne™) are 1 μm in diameter and have been chemically coupled with biotinylated BSA. The movie was recorded with high speed video-microscopy in transmission mode.

The microactuator rotation is synchronous with the external field and smooth. The microactuator exhibits a phase lag with respect to the field but the torque available is high enough to overcome the viscous drag.

The playback rate is real time.

Movie 2: Rotation just above the critical frequency

M2.wmv

Rotational behavior of a two-particle microactuator in bulk fluid (PBS buffer). The magnetic field is rotating clockwise at 9 Hz and the strength of the field is 1 mT. The magnetic particles (Dynabeads® MyOne™) are 1 μm in diameter and have been chemically coupled with biotinylated BSA. The movie was recorded with high speed video-microscopy in transmission mode.

The microactuator rotation is not synchronous with the external field and it shows anticlockwise oscillations superimposed to the clockwise rotation in the same direction of the field. The net rotation rate is of 1.3 Hz. The torque available is not sufficient to sustain a rotation synchronous with the external field. Periodically the magnetic field is in advance of the magnetization of the cluster and creates a negative torque, responsible for the "wiggling" behavior.

The playback rate is real time.

Movie 3: Rotation far above the critical frequency

M3.wmv

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Rotational behavior of a two-particle microactuator in mild contact with a surface. The fluid medium is PBS buffer. The magnetic particles (Dynabeads® MyOne™) are 1 μm in diameter and have been chemically coupled with biotinylated BSA. The magnetic field is rotating at 10 KHz and strength of the field is 1.7 mT. The microactuator is trapped in a magnetic potential well generated by two crossed wires, each with a lateral dimension of 3 μm. The movie was recorded with high speed video-microscopy in reflection mode.

The observed rotation is smooth with a net rotation rate of 1.25 Hz in the same direction of the field. The rotation rate of the microactuator is orders of magnitude lower than the rotation rate of the field. The torque is generated by the finite relaxation time of the nanometer-sized grains embedded in the polymer matrix: when it becomes comparable with the period of the external field the magnetization of the each grain lags behind, giving rise to a torque.

The playback rate is real time.