論文の内容の要旨

Abstract of Dissertation

Thesis Title:

MICROMACHINED BROWNIAN MOTORS: UNIDIRECTIONAL ACTUATION OF NANOPARTICLES BY RECTIFIED BROWNIAN MOTION

(マイクロマシンで作るブラウンモータ : ブラウン運動の整流によるナノ粒子の一方向駆動)

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Abstract

We report on energy efficient transportation system for nanoparticles, i.e. nanobeads, which exploits random thermal motion, Brownian motion, as the main actuation source, saving energy compared to a pure electrostatic transport system of the same geometry.

The transportation system employs closed PDMS microfluidic channels to restrict Brownian motion of the nanobeads to only one dimension. A 3-phase dielectrophoretic ratchet rectifies this random motion into unidirectional transport by biasing spacial probability distribution. Applied force is strong enough to control Brownian motion of the nanobead on active electrode but it is not large enough to attract it from inactive electrode. Displacements between electrodes are achieved by Brownian motion and the direction of the transport is determined by 3-phase system.

A theoretical model of the system is developed and used to investigate its performance as a function of different design and actuation parameters, such as size of the nanobeads, driving voltage, electrode spacing and width, fluid viscosity, temperature and switching time. Theoretical calculations on the device have revealed that flows caused by electrohydrodynamic and thermal effects are negligible. A micromachined transport system is fabricated and employed to experimentally validate the model, showing a good agreement.

This study will improve our understanding of effective and efficient actuation (transportation or rotation) of nanoparticles in the artificial systems based on random thermal motion. Nanosystems similar to bio-molecular motors exploiting Brownian motion efficiently can be achieved.