# Development and Optimization of a Microfluidic Device for Magnetic Field Induced Cell Separation

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## Abstract

Besides conventional laboratory analysis methods so called lab-on-a-chip devices have gained great interest during the last decades. These devices aim to integrate all laboratory tasks such as the tissue organization, cell selection and analysis on a single microfluidic chip. [1] This work is focussed on the second step, i.e. the selection and separation of samples.

We demonstrate that the movement of organic tissues such as cells can be directed using magnetic beads bound to the biological samples. Therefore, the motion of our magnetically labelled cells becomes sensitive to external magnetic gradient fields. One way of controlling and directing the motion of such particles is the use of Rocking Ratchet structures [2].

From an experimental point of view, such a structure can be realized with a micrometer-sized spatially periodic array of conduction lines beneath a microfluidic channel [3] and an additional external magnetic gradient field. A current within these conduction lines induces a magnetic field and the microfluidic channel provides a suitable environment for the cells. This structure has been applied to Human Embryonic Kidney cells which were labelled with commercially available magnetic beads.

Prior to the experimental realization, parameter optimization studies were carried out using COMSOL Multiphysics®: The limiting values for experimentally accessible field strengths were simulated using the AC/DC Module. We were able to evaluate the field gradients in a three dimensional model despite the challenges due to the restrictions of the predefined base functions. Furthermore, the microfluidic environment and particle interactions have been considered using the Particle Tracing Module. The relevant component of the field gradient is shown in figure 1 using two conduction lines with periodic boundary conditions.

A set of parameters for a successful separation of cells depending on certain biological properties such as the density of surface receptors could be derived from these simulations.

## Reference

[1] El-Ali et al., Cells On Chips, Nature, 442, 7101 (2006)
[2] P. Reimann, Brownian motors: noisy transport far from equilibrium, Physics Reports, 361 57-265 (2002)
[3] A. Auge et al., Magnetic ratchet for biotechnological applications, Appl. Phys. Lett, 94, 183507 (2009)

## Figures used in the abstract

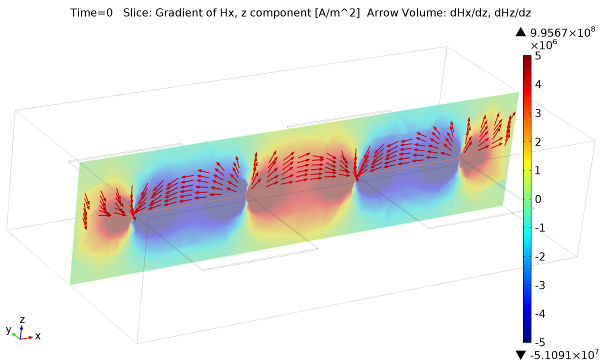


**Figure 1**: The magnetic field gradient [dHx/dz] of rectangular shaped conduction lines is shown in a slice plot. Arrows indicate the direction of the forces acting on magnetically functionalized biological samples