2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

# Dielectrophoretic Movement of Cell in Micro Machined Flow Channel

Shigehiro Hashimoto, *Member, IEEE*

***Abstract*— Asymmetric surface electrodes were manufactured in a flow-channel by micromachining technique to analyze dielectrophoretic movement of biological cells for the micro-invasive sorting. A micro flow-channel with a pair of titanium-coated (200 nm thick) surface electrodes (a triangular electrode and a rectangular reference electrode) was made by photolithography technique. The suspension of myoblasts (C2C12: mouse myoblast cell line) was injected into the channel, and the movement of each flowing cell was analyzed at the microscopic movie image. The experimental results show that the movement of each cell depends on several parameters: the alternating electric field (wave form, frequency, and amplitude), the diameter of cell, the deformation ratio, and the direction of the major axis.**

***Clinical Relevance*— Cell sorting technology has a lot of application. Detection of target cells leads to diagnostic techniques. Collection of target cells can be applied to regenerative medicine by tissue engineering.**

## I. INTRODUCTION

Minimally invasive cell sorting technology has a lot of application. Microfluidics is one of technologies to be applied for cell sorting [1]. In several devices, the micromachining technology has been applied [1]. The movement of cells floating in the medium is governed by several factors: movement of the medium, gravity, electric force, van der Waals force, and surface affinity. The movement of each charged particle depends on the electric field. This effect is applied to electrophoresis. A force also acts on the uncharged particle exposed to a non-uniform electric field, because polarization is generated within the particle. This phenomenon is called dielectrophoresis. The force of dielectrophoresis depends on several parameters: the electrical properties of the particle, the shape and size of the particle, the electrical properties of the medium, and the electric field (amplitude and frequency). The dielectrophoretic force is generated by the nonuniform electric field. In this study, a flow channel with asymmetric surface electrodes was designed by applying photolithography technique, aiming at cell selection by dielectrophoretic movement.

## II. METHODS

Titanium film coating was used for the surface electrodes. One of the surface electrodes was a triangle with a tip angle of 0.35 rad. The edge of the other reference electrode was flat. The shortest connecting line (0.1 mm) between the electrodes was perpendicular to the direction of the main flow. The pattern of electrodes with the flow channel was drawn on a photomask using a laser drawing system. The pattern was made by the photolithography process: photoresist material coating, lighting, developing, and etching. The flow channel (0.5 mm wide, 18 mm long, and 0.04 mm deep) was also made using a photomask. The electric field with alternating square cyclic waves was applied perpendicular to the main flow of the medium. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was used in the test. D-MEM (Dulbecco's Modified Eagle Medium) was used as the medium. Prior to the flow test, the inner surface of the flow channel was hydrophilized by the oxygen plasma ashing. The flow channel was prefilled with bovine serum albumin solution. The suspension of cells was poured into the inlet of the flow channel. The flow was made by the pressure difference between the inlet and outlet, maintained by the head difference (< 5 mm) of the medium. Each cell passing between the electrodes was observed with an inverted phase-contrast microscope. The contour of each cell was approximated to an ellipse. On the ellipse, the length of both the major and minor axes was measured. The movement of the centroid of each cell was tracked at the video images.

*S. Hashimoto is with Kogakuin University, Tokyo, 1920015 Japan, phone: 81-42-6284494; e-mail: at13351@g.kogakuin.jp

## III. RESULTS & DISCUSSION

Each cell rotated and deformed as it moved with the medium. Each cell made a stepwise movement around the tip of the electrode. The stepwise movement was larger at 4 MHz than at 3 MHz. The step tended to decrease with the increase of the deformation of the cell. The absolute value of the acceleration in the direction perpendicular to the main flow was small at the higher deformation of the cell. The stepwise movement tends to be accelerated when the cell elongated to the flow direction. The value of the acceleration tends to fluctuate as the direction of the major axis of the cell tilted. Turbulence does not occur in a flow because of Reynolds number smaller than 1. The flow depends on viscosity than inertia.

## ACKNOWLEDGMENT

The author thanks Mr. Daisuke Hasegawa and Mr. Takeru Noji for the assistance of the experiment.

## REFERENCES

[1] P. N. Carlsen, *Polydimethylsiloxane: Structure and Applications*. Nova Science Publishers, 2020, pp. 29–94.

[2] S. Hashimoto and K. Yoshinaka, "Is dielectrophoretic movement through micro channel with asymmetric surface electrodes fabricated by photolithography technique effective to sort flowing cell?" *Proc. 20th IEEE International Conference on BioInformatics and BioEngineering*. 2020, pp. 1–6.