DEVELOPMENT OF MICROFLUIDIC DEVICE WITH MOVABLE ELECTRODE FOR ELECTRICAL IMPEDANCE MEASUREMENT ON THE ACTIVELY COMPRESSED SINGLE CELL

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ABSTRACT

We develop a microfluidic device which can measure the electrical properties of the actively compressed cell. When compared with the previous passive cell compression device, the proposed microfluidic device can provide the active cell compression via the movable(sliding) electrode. Cell's direct contact with the electrodes can reduce the noise and produce the pure physiological information of cell. In this paper, we have performed the mechanical and electrical characterization of three cell types(WBC, SW620, A549) using the proposed microfluidic device and showed this can be used in practical cell experiments.

KEYWORDS: Impedance, Cancer cell, Movable electrode, Cell compression

INTRODUCTION

In this study, we develop a microfluidic device with movable electrode which can give an active compression on a single cell. Our device differs from other's work by the two plate sliding structure. Upper plate has a relative sliding motion to lower plate and the electrode in upper plate becomes movable by driving the upper plate with external precision actuator. In the previous work, a single cell was deformed by the aspiration, taper structure and pneumatic pressure. The movable electrode can offer an active compression on single cell and make direct contacts with electrodes. Therefore our device has a higher sensitivity than the noncontact method. The gap between electrodes is easily clogged when the large cell enters. However, the clogged cell can be readily swept away by moving the electrode to widen the gap. Our device can provide the (label-free) impedance based cellular analysis in every compressed state of a single cell at wide frequency range. The monitoring of the electrical impedance coupled with the compression of a single cell is more useful to analyze a rare cell such as circulating tumor cell since the electrical properties of cell are strongly related with its physiological state (type, size, malignancy, etc).

DEVICE FABRICATION AND EXPERIMENTAL SETUP

The concept of our device is shown in Fig. 1. Our device is composed of two matching plates which have a relative sliding motion. The electrode in upper plate follows the upper plate's motion. Lower plate has the electrode and the sealing structure which makes flow channel. Upper plate was flipped and assembled to lower plate. Electrodes were fabricated by Cu electroplating (thickness 25 μm). After CMP of electrode and removal of electroplating mold, Au was electrolessplated and photoresist (THB151N, JSR) was patterned to make sealing structure. In the upper plate, drilling was done to make hole (dia. 0.7 mm) (Fig. 2, 3). Experimental setup is composed of device holder, microscope (AE31, Motic), external precision actuator, LCR meter (E4980A, Agilent) and syringe pump (KDS-200, KDScientific)

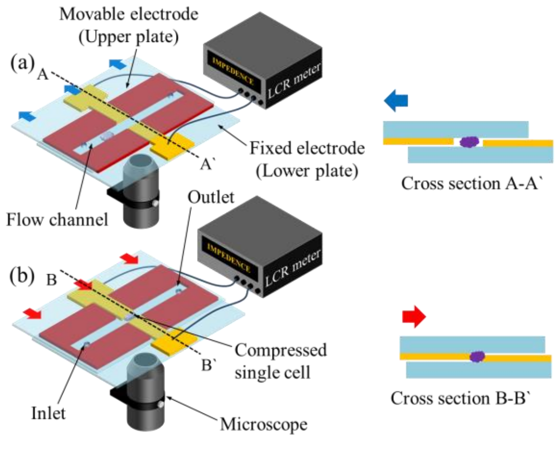

Figure 1: Concept of a microfluidic device with movable electrode: (a) before compression, (b) after compression.

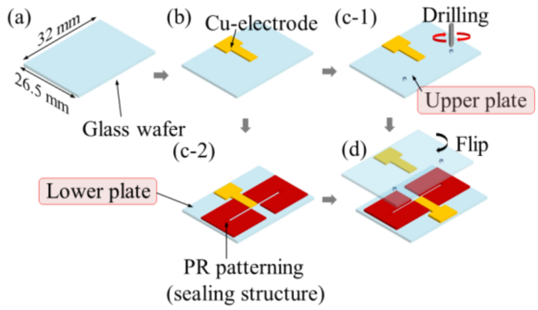

Figure 2: Fabrication process of the proposed microfluidic device with movable electrode.

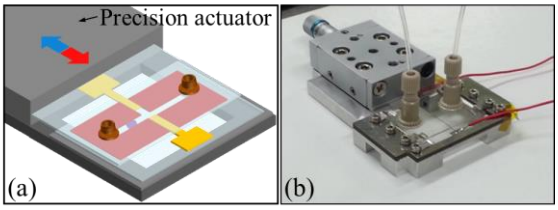

Figure 3: Full assembly of the microfluidic device with movable electrode; (a) concept diagram, (b) photo of the fabricated device.

EXPERIMENTAL RESULTS

In the experiment, the impedance of white blood cell (WBC), colon cancer cell (SW620) and lung cancer cell (A549) were measured along the cell compression.(Fig. 4, 5) It is easier to distinguish WBC, SW620 and A549 with the phase result instead of the magnitude. In the low frequency range, the phase of WBC is between A549 and SW620. In the high frequency range, the phase of SW620 and A549 are much higher than that of WBC. When the cell is compressed, the magnitude of impedance decreases and the phase increases. (Fig. 6)

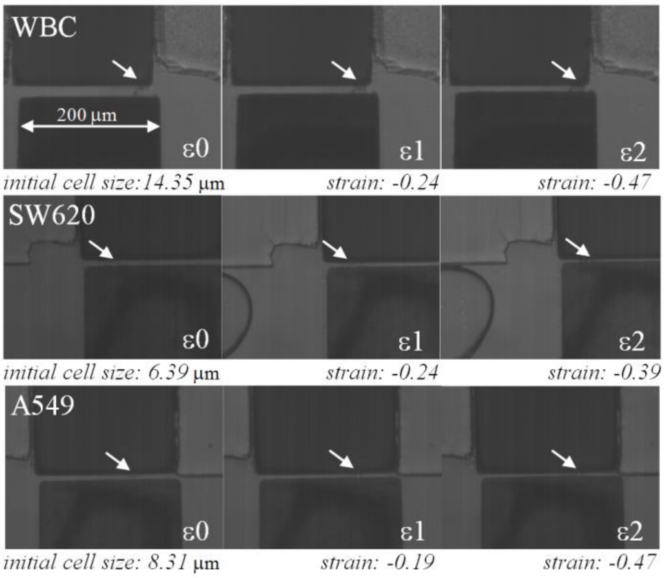

Figure 4: Single cell under compression via movable electrode (WBC, SW620 and A549).

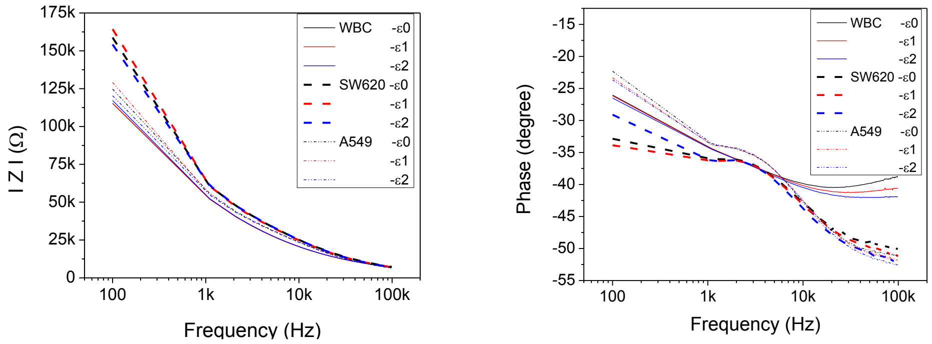

Figure 5: Results of impedance on a compressed single cell; a) magnitude, (b) phase.

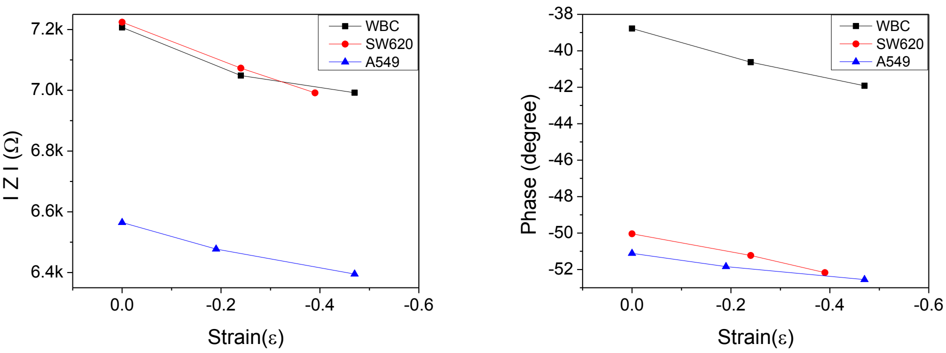

Figure 6: Results of impedance along compressive strain on a single cell at 100kHz ; a) magnitude, (b) phase.

CONCLUSION

We have developed and tested new device with movable electrode that can give the active manipulation on a single cell without clogging. The device can be used for the differentiation of cell type and metastasis level. In future work, more simple fabrication, fluorescence test and fatigue test on cell will be included

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