Development of on-chip electrical measurement method for single cell physical properties using femtosecond laser-induced impact force

所属：奈良先端科学技術大学院大学　博士後期課程 2 年（助成時）
同上　博士後期課程 3 年（現　在）

氏名：TANG　TAO

■ 要約

Single-cell analysis is crucial in the study of population heterogeneity, the identification of minorities, and discovering unique characteristics of individual cells. To gain more efficient access to cell properties through microfluidic devices, in this research, we proposed, designed, and developed an impedance cytometry system integrated with a femtosecond laser to characterize the physical properties of single cells. At present stage, we have succeeded in measuring a few characteristics (such as size, shape, the mass and distribution of intracellular components) of a few types of individual cells. By further improving the system, more different characteristics of cell could be achieved.

■ 結果と考察

The entire research could be separated into different parts due to its basic functions:

1. <u>Label-free shape quantification for single cells</u>

First of the work, we developed the impedance cytometry with the FPGA board, which has the capability of measuring single cells with a throughput of thousands of cells in a second, as shown in Fig. 1. We found that there is a relationship between the cell shape and the tilting level of impedance pulses. Therefore, we proposed a new metric, namely tilt index to quantify the shape of single cells without optical devices.

2. <u>Label-free detection for cell interior</u>

Based on the previous work, we did further research into the high-frequency detection of impedance cytometry. And we found that the high-frequency impedance

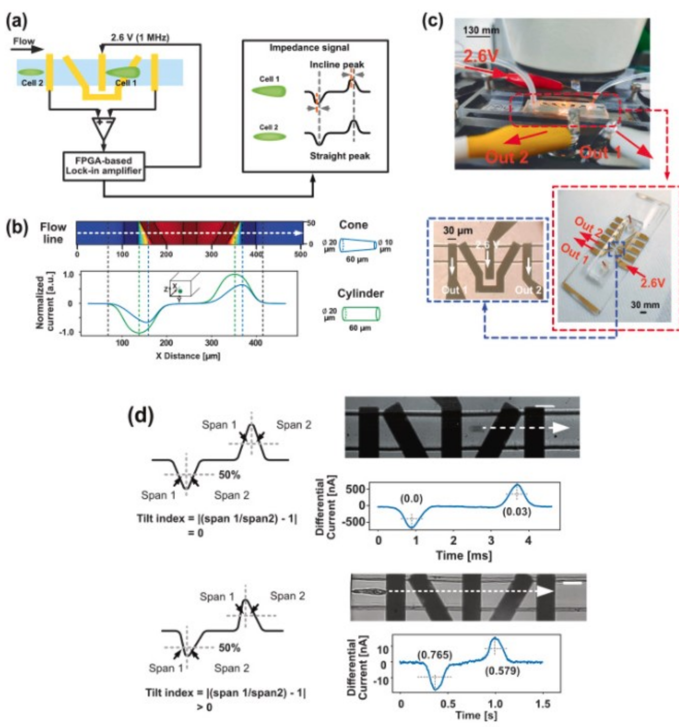

Fig. 1: Microscopic impedance cytometry for quantifying single-cell shape research

detection could be used to analyze the intracellular distribution. Besides, we proposed that the low-frequency impedance detection can be employed to characterize the cell volume and shape (e.g., 0.5 MHz in this work)., and high-frequency detection can be used for interior characterization and quantification. Intracellular uneven distribution is related to the tilting level of high-frequency impedance pulses (e.g., 6 MHz in this work). This work has been selected as the back cover of the Lab on a Chip, as shown in Fig. 2.

As the high-frequency current can cross the cell membrane, we also reported that the electric opacity is positively associated with the intracellular density. The loss of intracellular components is induced using certain methods. Electrical opacity decreases as intracellular density decreases.

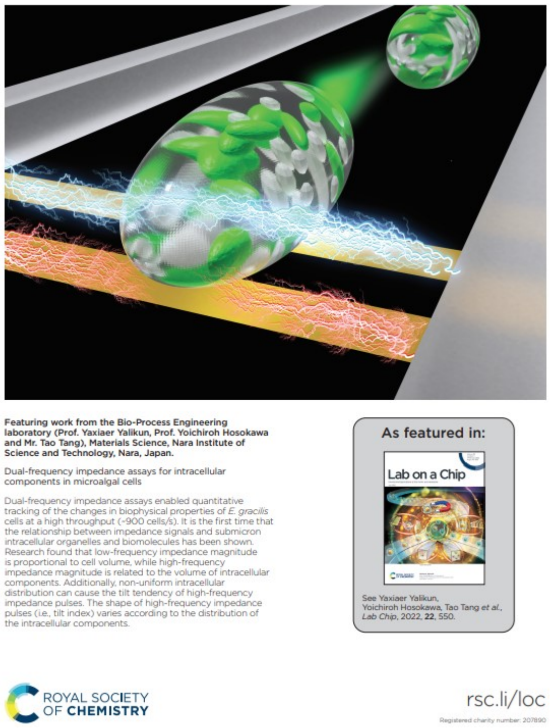

Fig2: Cover page of Lab on a Chip

3. <u>Femtosecond laser-based single cell manuscript</u>

Aimed at the control of the femtosecond laser pulses, we developed a control system based on a FPGA board (ALINX, AXU9EG), as shown in Fig. 3. Through the developed system, we can determine the number of femtosecond laser pulses based on the amplitude of trigger system. This system can be integrated with several types of detection system for the single cell manipulation in the microchannel, like the forementioned impedance detection system or the fluorescence detection system. With the capability of controlling the femtosecond laser pulses, the force acting on the single cells is also controllable for us, which enabled us to characterize the properties of single cells in a more efficient way.

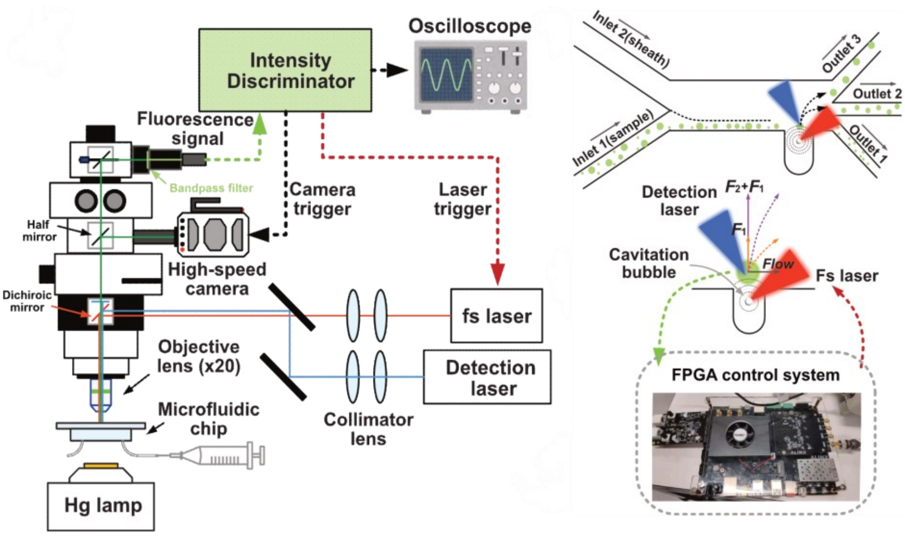

Fig3: FPGA-based control system for femtosecond laser pulses

■ 研究成果

(1) Tang et al. *Sensors and Actuators B: Chemical*, 358, 131514. (2022). *(IF: 7.46)*

(2) Tang et al. *Lab on a Chip*, 22, 550-559. (2022). *(IF: 6.799)*

(3) Tang et al. *Biosensors and Bioelectronics* 193, 113521. (2021). *(IF: 10.618)*