TRANSLATIONAL VELOCITY MEASUREMENT FOR TRACKING OF SINGLE FLOATING CELLS

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Abstract: We propose the optical spatial filtering method, as translational velocity measurement to observe morphological changes of single floating cells in long stretches. This measurement derives the arbitrary component of the spatial frequency from the random refracted index distribution as the periodic light intensity distribution.

Keywords: spatial filtering, refracted index distribution, periodic light intensity.

1. INTRODUCTION

Currently, diagnosis of cancer is performed by biopsy, whereby medical doctors observe a removed specimen, focusing their attention on morphological changes in the cell sequence and cell nuclei. Based on medical knowledge, it is presumed that an extremely small amount of a specific protein may be contained in a cell nucleus. Therefore, we have proposed spectroscopy-tomography of single living cells about 10 μm in diameter to assist in the quantitative diagnosis of early cancer [1]. By this method, we can obtain a 3-dimensional distribution of the cell components with high spatial resolution. We propose a new optical spatial filtering method as the translational velocity measurement. We focus attention on the diffracted light that is generated from the cell. This proposed method derives the arbitrary component of the spatial frequency from the random refraction index distribution. By this method, we can observe morphological changes of single floating cell in long stretches.

In this report, we've tried to examine the proposed new optical spatial filtering method using non-labeled cell. The complex distribution of refraction index is modeled by liquid crystal as the artificial non-labeled cell. We discuss the velocity vector measurement results, and the observation results of a single living human cell.

2. PRINCIPLE OF TRANSLATIONAL VELOCITY MEASUREMENT FOR SIGLE CELL

A cell is a transparent object with low contrast. And, the target value of the frequency response is about 1kHz. The conventional imaging processing technique is not able to realize such a high-frequency response measurement. Hence, we focused our attention on the diffracted light that is generated by organelles. The various kinds of organelles form a complex refraction index distribution. Since nonperiodic light that is diffracted from the random refraction index distribution can't be used for measuring the translational velocity, we proposed the optical spatial filtering method, which can select the specific component of spatial frequency.

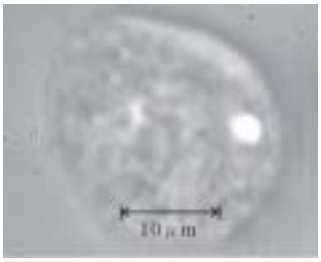

Fig. 1. 1Low-contrast cancerous cell

By this method, periodic light intensity distribution can be observed regardless of the low contrast of the object. The periodic light intensity distribution changes in accordance with the object's movement. Therefore, as shown in Fig. 2, a high-response photo diode can be applied to measure the translational velocity as simple periodic light change through a pinhole.

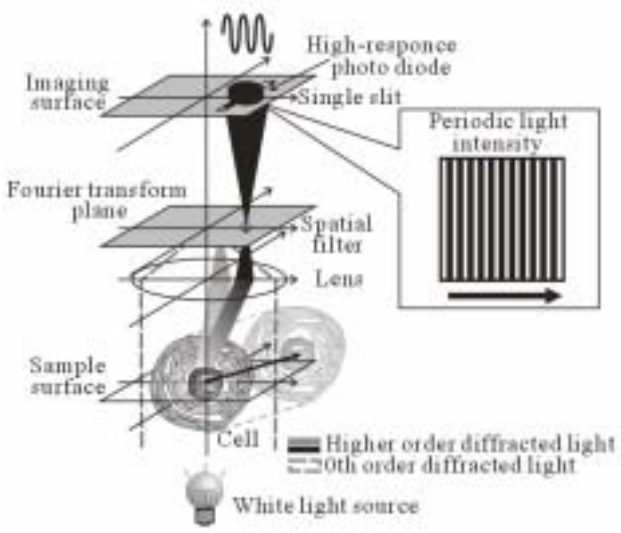

Fig. 2. Principle of the transrational velocity measurement for single cell

3. VELOCITY VECTOR MEASUREMENT EXPERIMENT OF THE NONCONTRAST OBJECT

In this section, we'll verify that the specific component of spatial frequency can be selectively obtained from the low-contrast object as the periodic light intensity distribution. Fig.3 shows the schematic diagram of the experimental optical equipment. As shown in Fig. 4 (a), the liquid crystal display (pixel size: 26μm) on which the random refractive index distribution is formed is used as a

sample.Fig.4 (b) shows the image of the sample surface that is observed by the CCD camera. Fig. 4 (c) shows that only the diffracted light of selected frequency form image. So, by this proposed spatial filtering method, we can confirm that the periodic light intensity distribution (interval between bright lines: 52μm) is derived from the random refraction index distribution.

We've tried to confirm that the translational velocity can be measured by the high-response photo diode (frequency response: 100MHz) from this obtained image. The vector of velocity (v_x, v_y) is changed from (0, v) to (v, 0) in every 15 degrees. As shown in Fig.5, we can measure the x-component value v_x that is almost equal to the theoretical value.

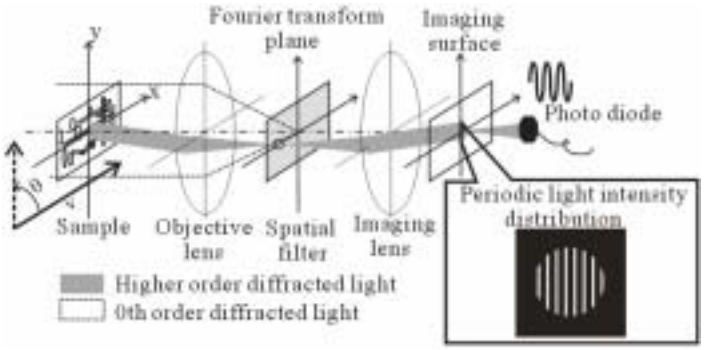

Fig.3 Schematic diagram of the experimental optical equipment

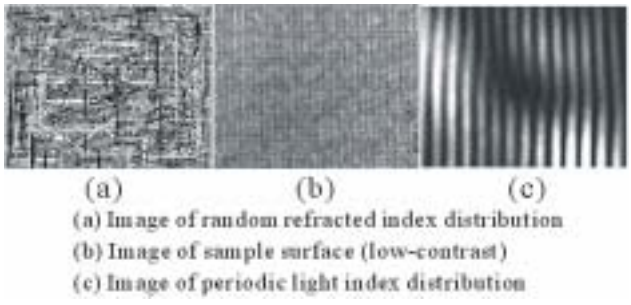

Fig.4 Derivation of the periodic light intensity distribution from the random refracted index distribution

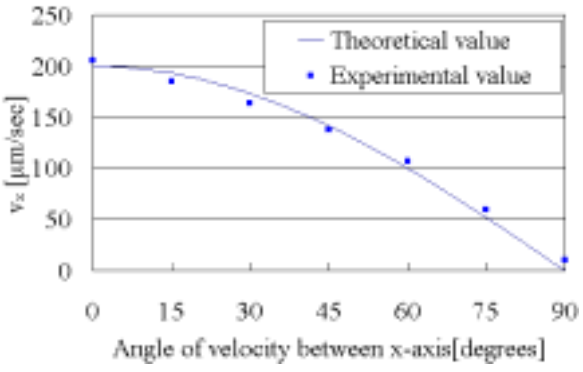

Fig.5 Relationship between angle of velocity and x-component value v_x

4. DERIVATION OF THE PERIODIC LIGHT INTENSITY DISTRIBUTION FROM A SINGLE CELL

We've observed the change of periodic light intensity distribution that moves in accordance with a rotating cancerous cell of human (HLE). As shown in Fig. 6, we introduced a white light of low coherence as the light source. Because, when we use the laser as a light source, the fringe resulting from the interference of stray light affects the desired periodic light intensity.

Fig. 7 (a) shows the image of a low-contrast cell observed by the CCD camera. As shown in Fig. 7 (b), we were able to obtain a periodic light intensity distribution.

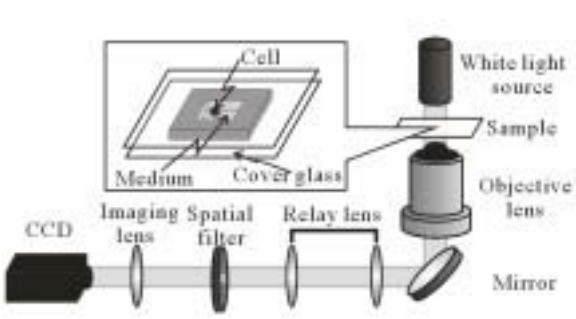

Fig.6 Optical system for using cell

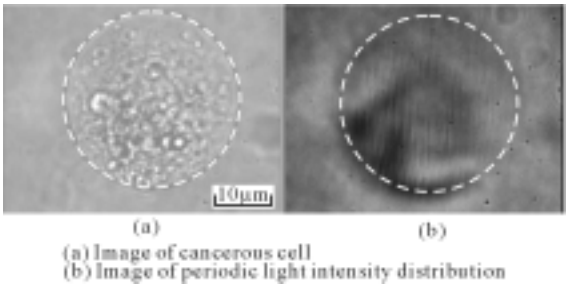

Fig.7 Derivation of the periodic light intensity distribution from cancerous cell

5. CONCLUSION

We propose the optical spatial filtering method as the translational velocity measurement of the low-contrast object. By this method, the periodic intensity distribution is derided from the random refraction index distribution. We verified the velocity measurement using the artificial cell and observed the living single cell of human.

ACKNOWLEDGMENTS

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REFERENCES

[1] T. Yasokawa, I. Ishimaru, F. Oohira, R. Hyodo, H. Kobayashi, A. Hayashi, Y. Inoue, K. Ishizaki, Proposal of spectroscopy-tomography of single-cell, Optomechatronic Micro/Nano Components, Devices, and systems, Proceedings of SPIE, Vol. 5604, pp.108-117(2004).