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Application News

No.V23

High-Speed Video Camera

Observation of Microbubbles and Cell Behavior Due to Exposure to Ultrasonic Waves

Introduction

One type of drug delivery system (DDS) dosing method involves injecting pharmaceuticals into cells by filling microbubbles with pharmaceuticals, and then collapsing them after making them adhere to cells. In this method, it is important that the drug is injected by penetrating the cell wall, but without killing the cell, as a result of the jet when the microbubble collapses. Accordingly, it is important to observe the behavior of the cell when the bubble collapses. Bubbles are made to collapse by resonance with ultrasonic waves. Resonant frequencies are 1 MHz or higher, so high-speed imaging must be performed at 1 million frames/sec or faster. This article introduces observations of the behavior of cells and microbubbles due to exposure to ultrasonic waves, using the HPV-X2 high-speed video camera.

Measurement System

The HPV-X2 high-speed video camera was used for this experiment. Fig. 1 shows the imaging system, Fig. 2 shows the sample and ultrasonic horn, and Fig. 3 shows a schematic diagram of the imaging system. As in Fig. 2, cancer cells and PVC microcapsules (approximately 5 µm in diameter) are placed in a sample cell filled with physiological saline, which is then placed at the bottom of a water tank. The focus of the ultrasonic horn was aligned with the sample cell, the sample cell was exposed to 1 MHz ultrasonic waves for a total of 3 seconds, and the results were observed with the HPV-X2. The instruments used are indicated in Table 1.

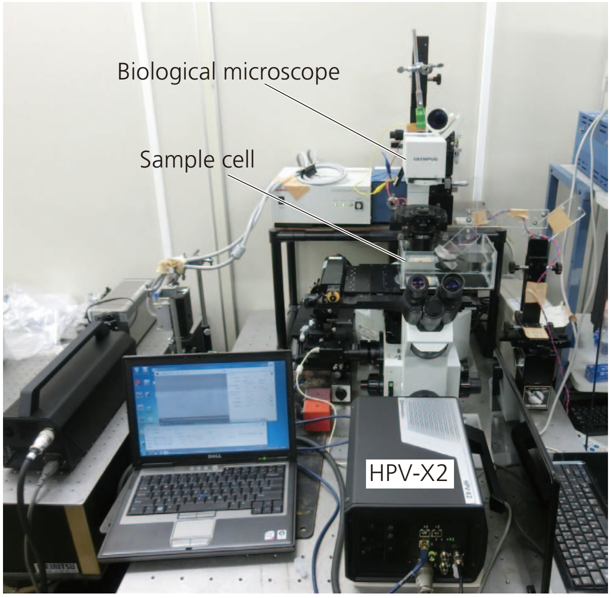

Fig. 1 Imaging System

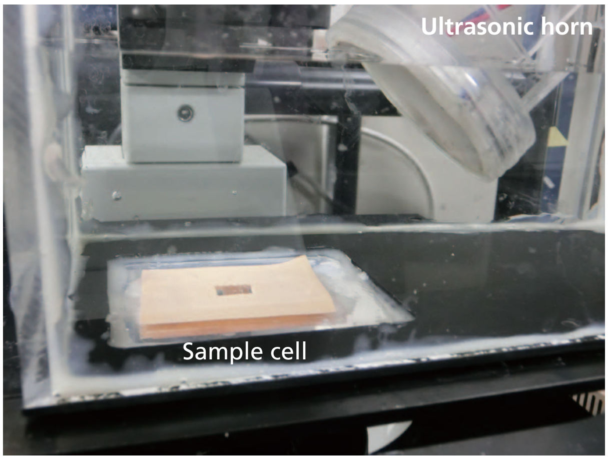

Fig. 2 Sample and Ultrasonic Horn

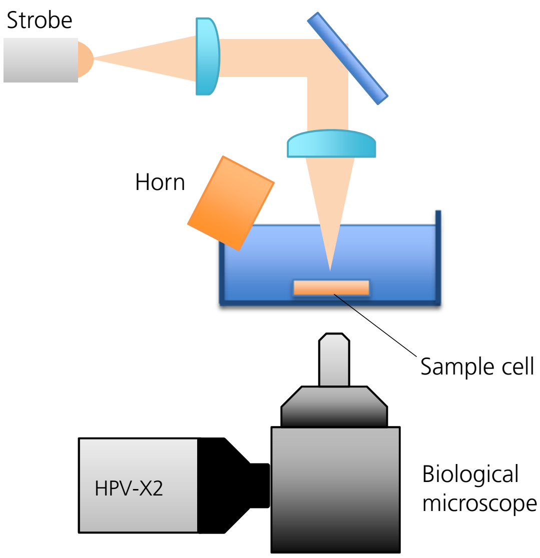

Fig. 3 Schematic Diagram of the Imaging System

Table 1 Imaging Equipment

High-speed video camera	: HPV-X2
Microscope	: IX70 Biological Microscope
Illumination	: Strobe

Measurement Results

Imaging was performed at a speed of 10 million frames/sec. Fig. 4 shows the imaging results. In Image 2 in Fig. 4, the sample is exposed to ultrasonic waves, and the microbubbles within the microcapsules are expanding. The two microbubbles shown by the arrows in Image 3 have made contact with the cell due to the expansion process and a load is being applied. The expansion of the microbubbles continues until Image 4, after which they contract until Image 11. The cell has become deformed at the two locations shown by the arrows in Image 11, and it can be confirmed that it is damaged.

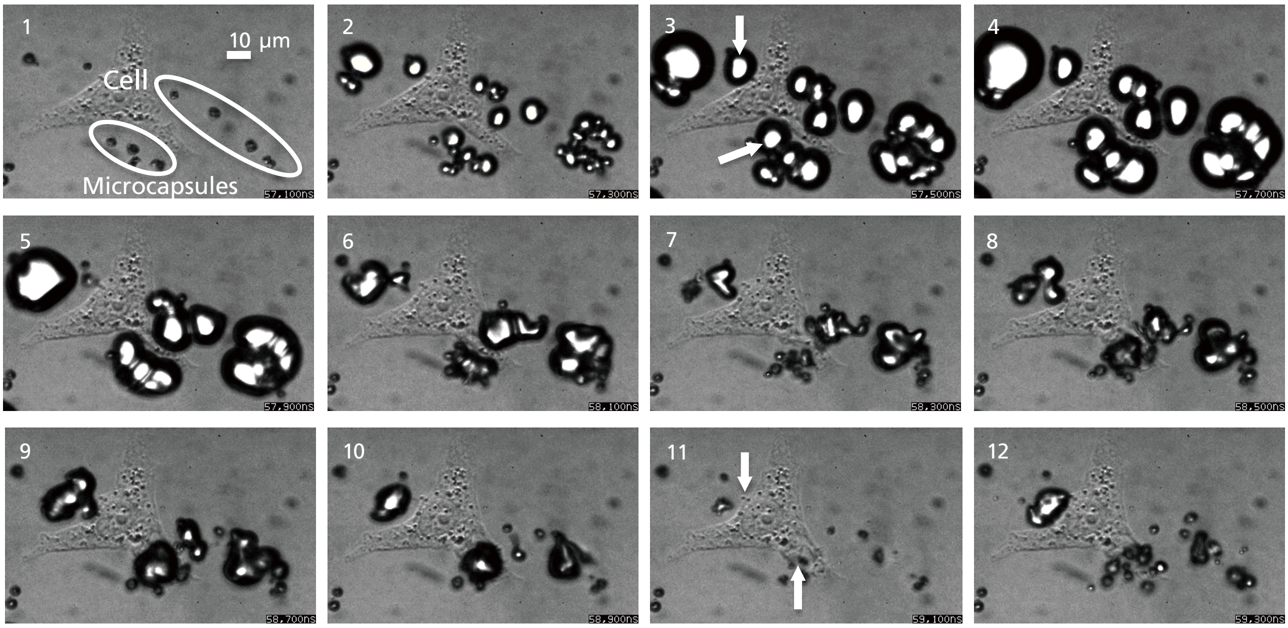

Fig. 4 High Speed Imaging Results (Interval Between Images is 200 ns)

Data provided by the Laboratory of Biomedical Engineering at Hokkaido University

Conclusion

The behavior of cells and microbubbles due to exposure to ultrasonic waves were observed using the HPV-X2 high-speed video camera. Samples were exposed to 1 MHz ultrasonic waves, so an imaging speed of at least 1 million frames/sec was required. Because a microscope was used for imaging, camera sensitivity was very important for these measurements. The newly developed HPV-X2 has at least six times the sensitivity of the conventional HPV-X, so favorable imaging was obtained, even using a microscope, at an imaging speed of 10 million frames/sec. Using the HPV-2 in this way will contribute to DDS development.

Note: Drug Delivery Systems

A drug delivery system (DDS) is a system for administering pharmaceuticals. It is a general term for a form of pharmaceutical administration designed to further enhance the effectiveness of medicinal agents, aiming to optimize the pharmaceutical administration route. In other words, the objective is to provide the required pharmaceuticals to the required location at the required time. When medicine is swallowed, only a tiny portion of the amount actually arrives at the affected area to have the intended effect. Some medicinal components are degraded within the body, while others cause side effects by acting at sites where they are not needed. Using a DDS enables more effective administration, which can be expected to reduce both the dosage of medicinal agents and their side effects, thereby improving the quality of life (QOL) for patients. In addition, expense reductions can be expected due to reductions in the number of times pharmaceuticals are administered.

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