

Application News

Observation of Expansion/Contraction Process of Bubbles in PVA Gel

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User Benefits

- ◆ The HPV-X3, with a maximum framerate of 20 Mfps, is suitable for observation of high-speed phenomena such as cavitation.
- ◆ The HPV-X3 provides 3 times higher resolution than the conventional device, enabling detailed observation.
- ◆ Since the image sensor of HPV-X3 is burst-type, the HPV-X3 enables image acquisition with constant resolution, regardless of the recording speed.

Introduction

When laser-induced shock waves and cavitation are applied in the medical field, it is important to understand the actual phenomena. Here, a polyvinyl alcohol (PVA) gel was irradiated with a laser, and the condition of the shock wave and cavitation generated upon laser light condensation (LC) was observed. PVA gel has high biocompatibility and is known as a promising biomaterial which is suitable for tissue mimicking. In this experiment, the newly-developed Hyper Vision HPV-X3 high-speed video camera was used to observe bubble expansion/contraction in PVA gel. In comparison with the conventional device, the recording speed (framerate) of the HPV-X3 is 2 times faster. The new HPV-X3 also provides 3 times higher resolution, supporting more detailed observation.

Comparison of HPV-X3 and HPV-X2

Fig. 2 shows images captured by the HPV-X3 and HPV-X2. The images show the condition of the bubble and shock wave after laser irradiation captured at 500 kfps (HP mode of HPV-X2). As can be seen in Fig. 2 (a) and (b), assuming the same device composition, the HPV-X3 can capture a wider field due to its larger sensor size. In Fig. 2 (c), the image has been partially cropped from Fig. 2 (b) to show the same field of view as the HPV-X2. It can be understood that the information in the cropped image is also clearer due to the three-fold improvement of the resolution of the HPV-X3. Thus, when a wide field of view is captured in order to check the phenomena and the image is then cropped to show only the phenomenon of interest, the HPV-X3 is the more suitable device thanks to its excellent resolution.

Sample and Test Devices

PVA gel was used as the test sample. Fig. 1 shows the condition of image acquisition. Although the HPV-X3 was used in this observation, the HPV-X2 (conventional model) was also used for comparison. Table 1 shows the device composition.

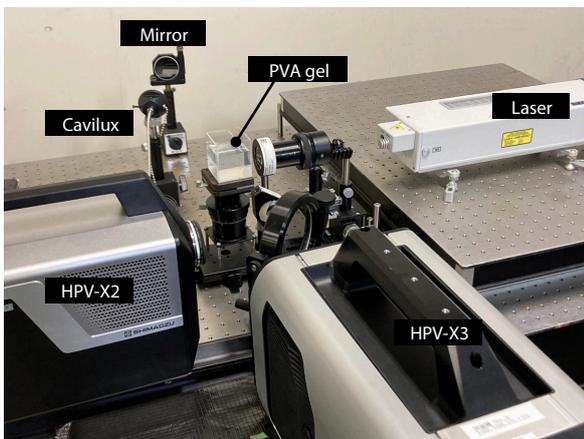


Fig. 1 Condition of Image Acquisition

Table 1 Device Composition

High-speed video camera	: HPV-X3 HPV-X2 (for comparison)
Lighting	: Cavilux

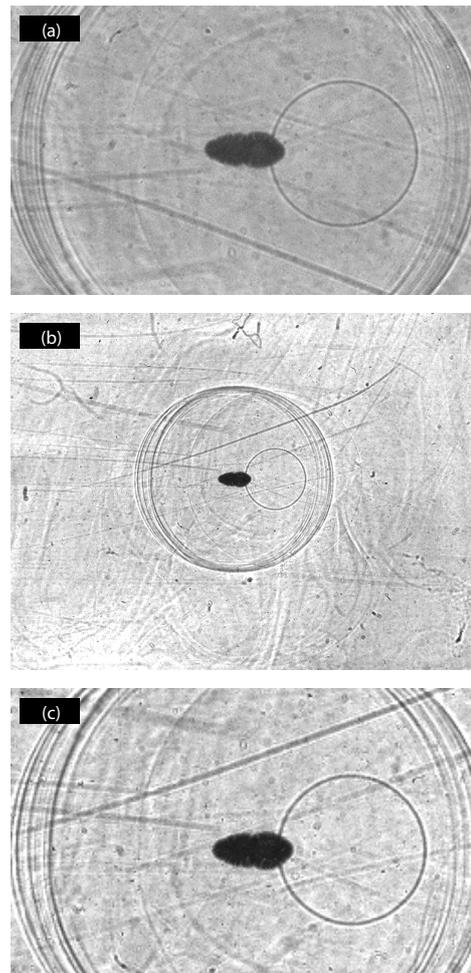


Fig. 2 Comparison of Images Acquired by HPV-X3 and HPV-X2
(a) HPV-X2 image, (b) HPV-X3 image,
(c) Image obtained by partially cropping the image in (b)
to fit the field of view of the HPV-X2

■ Results of Recording

Fig. 3 shows the results of recording the entire phenomenon, captured at a framerate of 500 kfps. In image (1), a bubble appears after laser irradiation, and a shock wave is generated in its surrounding area. In image (2), the shock wave does not appear in the image because it has already propagated outside the field of view. The bubble expands in images (1) to (4), and then contracts in images (5) and (6). Following this contraction, a condition in which the bubble expanded once again could be observed in images (7) and (8).

In the total phenomenon, the condition of shock wave propagation after laser irradiation and the condition of bubble contraction and collapse were recorded at a framerate of 20 Mfps.

Fig. 4 shows the results of observation of the condition of shock wave propagation following laser irradiation at a framerate of 20 Mfps. The propagation of the shock wave could be recorded clearly.

Fig. 5 shows the results of observation of the condition during bubble collapse at the framerate of 20 Mfps. The bubble contracts in the images from (1) to (3) and collapses in image (3). Thereafter, a bubble appears in image (4), and simultaneously with appearance of the bubble, a shock wave is also generated. In images (5) to (8), the propagation of the shock wave could be recorded.

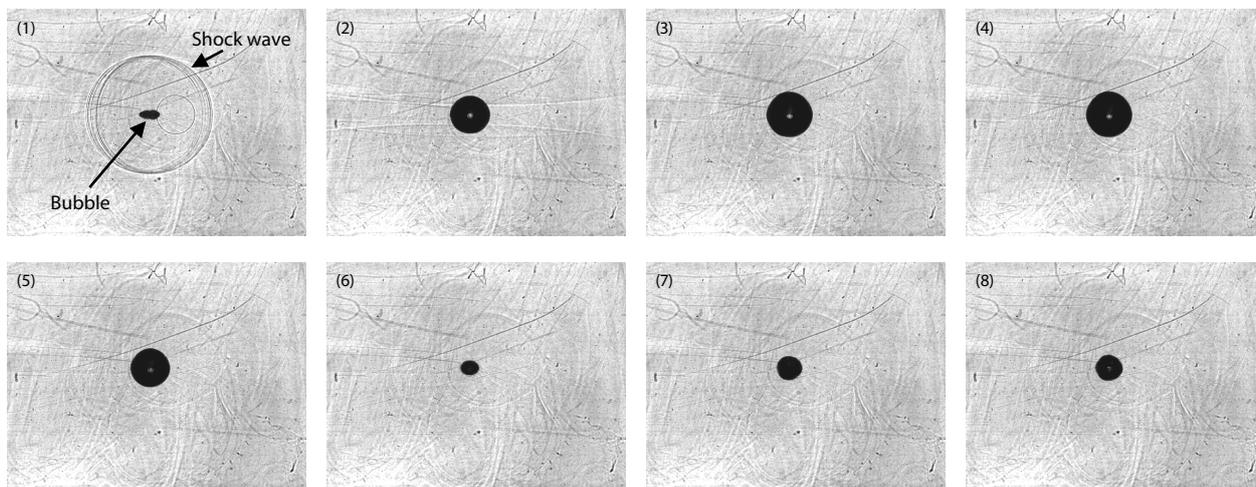


Fig. 3 Results of Recording (Time Interval between Images: 50 μ s, Field of View: Approx. 200 μ m)

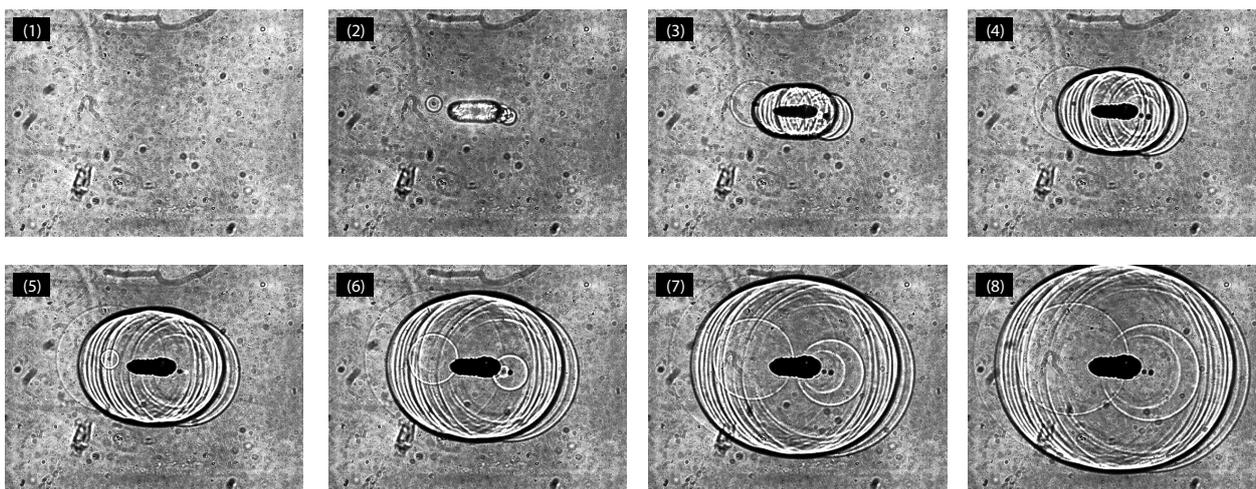


Fig. 4 Results of Recording (Time Interval between Images: 250 ns, Field of View: Approx. 75 μ m)

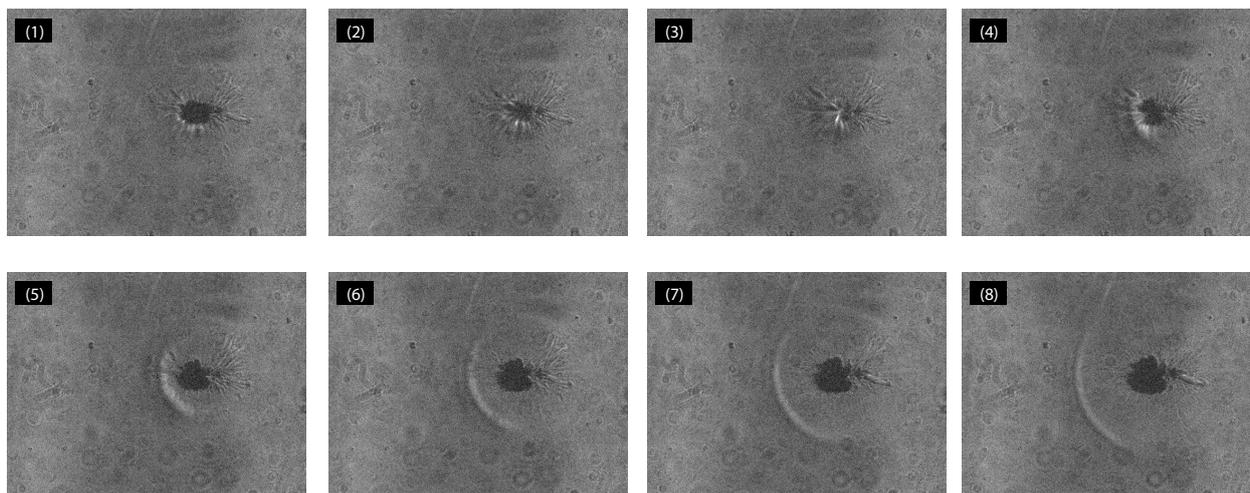


Fig. 5 Results of Recording (Time Interval between Images: 50 ns, Field of View: Approx. 20 mm)

■ Conclusion

Using the new HPV-X3 high-speed video camera, the expansion/contraction of a bubble and shock wave when a laser was irradiated on PVA gel were observed. Because the resolution of the HPV-X3 is 3 times higher than that of the conventional device, resolution is adequate, and it is possible to obtain clear and distinct images, even when a wide angle of view is observed and the image is partially cropped. The HPV-X3 also has a maximum recording speed of 20 Mfps, which enabled detailed observation of the shock wave and the process of bubble collapse.

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