2P-53

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 395-396
6-8 December, 2010

Development of Imaging Method Utilizing the Acoustic Characteristics of High-Density-Microbubble.
高濃度マイクロバブルによる信号を用いた画像化手法の開発

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1. Introduction

Current ultrasound angiography is utilizing the higher harmonics of the microbubble contrast agents (CAs) in order to improve the signal to noise (SN) ratio. And other approaches for further improvement of the SN ratio such as pulse inversion method, emitting two types of ultrasound to negate the fundamental harmonics of the reflected signals, and subharmonic imaging, to utilize the subharmonics that are unique in the signal of the microbubble, are developed. But it is difficult to get the sufficient SN ratio by the method using the higher harmonics.

In our previous study, we found a low frequency signal of the CAs flowing inside the vessel-mimicking gel, emitted under the condition of high CA concentration and high peak negative pressure of the driving pulse [3]. In this study, we developed the imaging method using this signal and compared the image to those which were acquired by applying the same processing to other frequency signals. This imaging method would be useful when partially high concentration is made, such as detection of cavitations.

2. Materials and Methods

Fig.1 shows the experiment setup for the imaging method. We used the channel in polyacrylamid gel as the vessel-mimicking phantom. The diameter of the channel was 3 mm, and the channel was positioned on the focal point of the ultrasound transducer. The transducer emitted three-wavelength sinusoidal ultrasound toward its focal point. The frequency was 3.5 MHz. The CAs inside the channel were excited by the ultrasound and generated secondary wave. This wave was detected by the focused hydrophone fixed in front of the transducer. The peak negative pressure of the driving pulse was 0.8 MPa.

We collected the data by stepping the phantom from –2.5 to 2.5 mm by 0.1 mm in transverse direction to make an image of the channel.

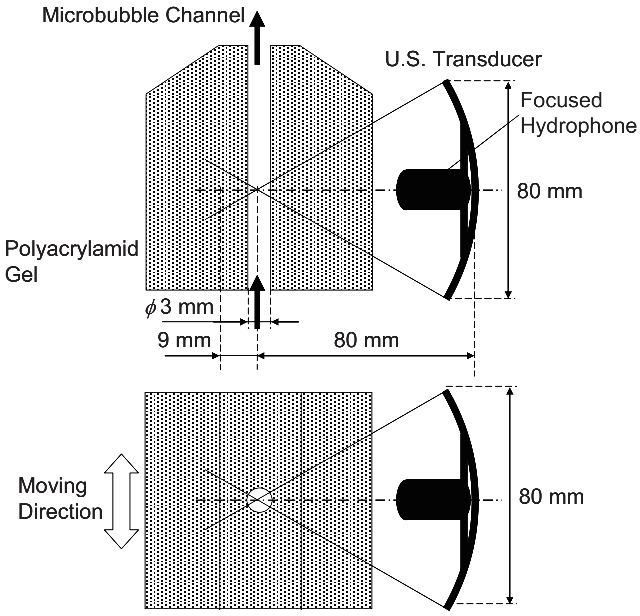

Fig. 1 Experiment Setup for the measurement of radiated signal and imaging. Side view (top) and top view (bottom).

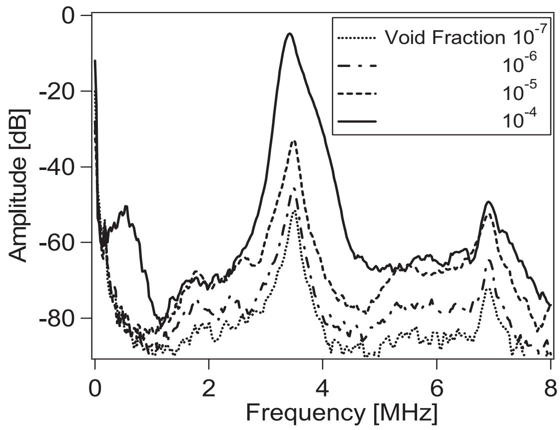

Fig. 2 FFT Analysis of the radiated signals from contrast agents.

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3. Results and Discussions

Fig.2 shows the FFT analysis of the radiated signals from CAs (written in [3]). The peak negative pressure of the driving pulse was 0.8 MPa. We can see the low frequency signal (lower than 1 MHz) in void fraction 10^{-4}. We used this frequency signal for imaging.

Fig.3 shows the raw signal from CAs and the signal after 500±250 kHz band-pass filter. The low frequency signal can be seen during the pulse.

After band-pass filter and envelope detection, we made the image by choosing the parameters as below: horizontal axis as the propagated time of the ultrasound, longitudinal axis as slided length of the channel and the brightness as the intensity of the signal.

Fundamental signal and the second harmonic signal were filtered in the same (3.5 MHz or 7.0 MHz ±250 kHz band-pass filter and envesope detection) and imaged. The three images are shown in **Fig.4**.

The boundary of the front of the channel in the image with low frequency signal is clear compared with other-frequency-images. And the contrast is improved.

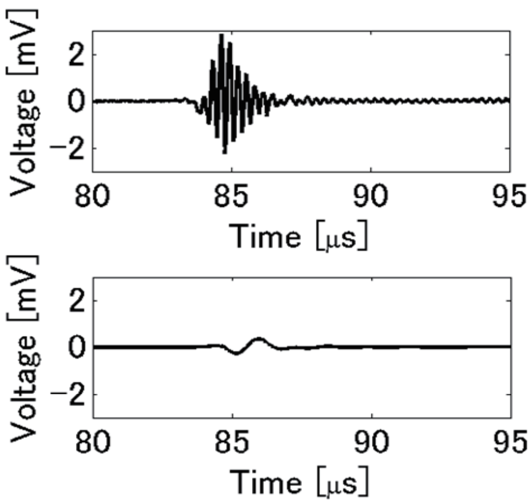

Fig. 3 Raw signal from contrast agents (top) and the signal after 500 ± 250 kHz band-passed

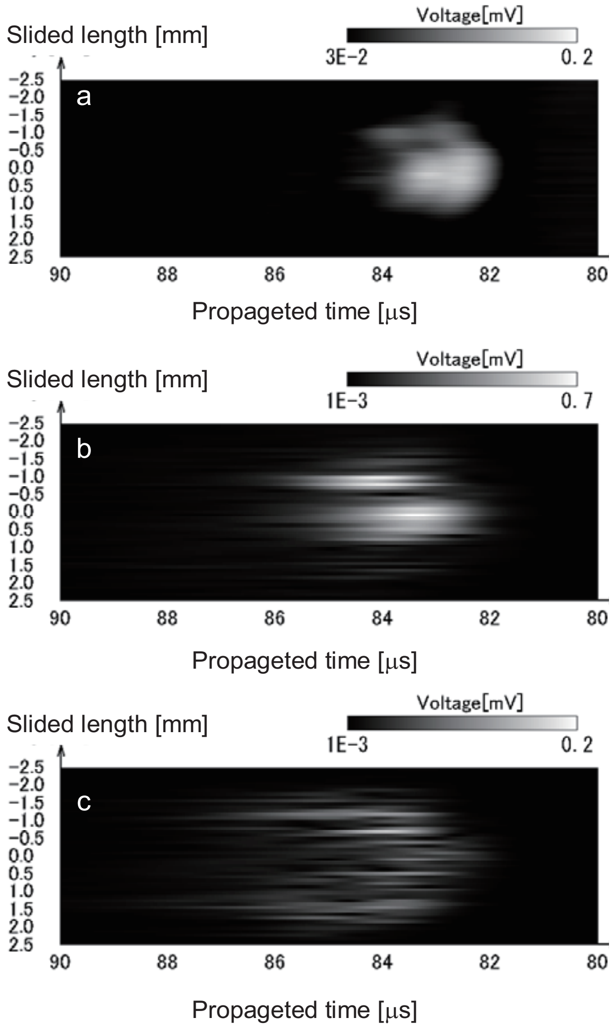

Fig. 4 Ultrasound imaging of the channel utilizing: a.500 kHz low frequency signal, b.fundamental harmonics, and c.second harmonics.

4. Conclusion

In this study, we investigated the imaging method using a low frequency signal which appeared in high CA concentration and high peak negative pressure. With band-pass filter and the envelope detection, the front boundary of the channel was imaged well compared with images utilizing other frequency signals. But the whole shape of the channel was still in vague.

Acknowledgement

This work was supported by the Translational Systems Biology and Medicine Initiative (TSBMI) of the Ministry of Education, Culture, Sports, Science and Technology of Japan.

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