3E5-1

Proceedings of Symposium on Ultrasonic Electronics, Vol. 32 (2011) pp. 443-444
8-10 November, 2011

Development of Multiple Frequency Ultrasonic Imaging System by Using Multi-Resonance Piezoelectric Transducer

多共振型圧電振動子を用いた多周波超音波イメージングシステムの開発

Iwaki Akiyama[1†], Natsuki Yoshizumi[1], Shigemi Saito[2], Yuji Wada[3], Daisuke Koyama[3], Kentaro Nakamura[3] ([1]Shonan Inst. of Tech.; [2]School of Marine Science and Tech., Tokai Univ.; [3] Precision and Intelligence Lab., Tokyo Inst. of Tech.)
秋山 いわき [1†], 吉住 夏輝 [1], 斎藤 繁実 [2], 和田 有司 [3], 小山 大介 [3], 中村 健太郎 [3] ([1] 湘南工大, [2] 東海大海洋学部, [3] 東京工大精研)

1. Introduction

Ultrasonic echography has been widely used in the field of clnical diangosis. It is significant for improvement of image quality to transmit broadband pulsed ultrasound waves. Since ultrasonic attenuation in bilogogical soft tissues is proportional to an exponential function of frequency, the attenuation at higher frequencies is much larger than one at lower frequencies. Therefore it is diffucult for a large organ such as liver to produce the B-mode image from echo signals including higher frequency components. One of the techniques to solve this problem is to transmit the broadband pulse which is divided into a number of narrower bandwidths and imaging at each bandwidth extracted from the echo. This is called as multiple frequency ultrasonic imaging (MFUI). The authors have studied multi-resonance piezoelectric transducers (MRT) for the MFUI[1]. It has been confirmed that a thin piezoelectric transducer bonded with a thick piezoelectric plate works as a MRT. This paper describes the development of the MFUI system by using a mechanical sector scanning ultrasound dianostic equipment. The MRT which was prototyped was embedded in the mechanical sector probe. Tissue mimicking phantoms were used to evaluate the imaging performance of the developped system. As a result, it was effective for the improvement of image quality to superpose the multiple frequecies images based on frequency compound method[2].

2. Multi-Resonance Piezoelectric Transducer

2.1 Structure

A structure of the multi-resonance piezoelectric transducer (MRT) is shown in **Fig. 1**. This transducer was composed of a thin piezoelectric plate with electrodes at both ends bonded with a thick piezoelectric plate. The thin piezoelectric plate is driven by a high voltage electrical signal. A quarter wavelength matching layer is bonded to the thin piezoelectric plate through an electrode. A backing layer is bonded with the thick piezoelectric plate.

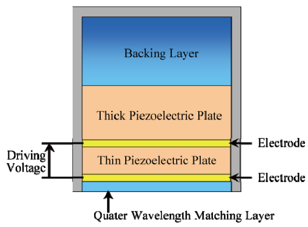

Fig.1 Structure of multi-resonance piezoelectric transducer (MRT).

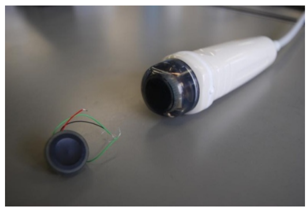

Fig.2 Photograph of the prototyped MRT and the embedding mechanical sector probe.

2.2 Prototyped MRT Embedded in Mechanical Sector Probe

The multi-resonance piezoelectric transducer (MRT, Japan Probe) which was prototyped fabricating 1-3 composite piezoelectric materials was embedded in a mechanical sector probe (ASU-35CWD-2, Aloka) as shown in **Fig. 2**. The fundamental resonance frequencies of the thin and the thick piezoelectric plates were 6 MHz and 2 MHz, respectively. The transmitting surface of the transducer was spherically concave and the focal length was 50mm. The quarter wavelength matching layer which was attached in front of the thin piezoelectric plate was adjusted to the 6 MHz. The backing layer was air. Diameter of the transducer was 15 mm. The transducer was driven by a half cycle of about 6 MHz sinusoidal wave with the peak value of -300 V. The waveform received by a hydrophone (MH23-6, Force Technology) at the focal position is shown in **Fig. 3** (a). The spectrum of the received waveform is shown in Fig.3 (b). The peak frequencies of 3.0, 4.8, and 6.9 MHz are evidently found in the spectrum. Time duration of the pulsed wave is 1.0

akiyama@iwaki.org

μs. The beam profiles at the peak frequencies are shown in **Fig. 4**. Those profiles were measured by scanning of the hydrophone in distilled water.

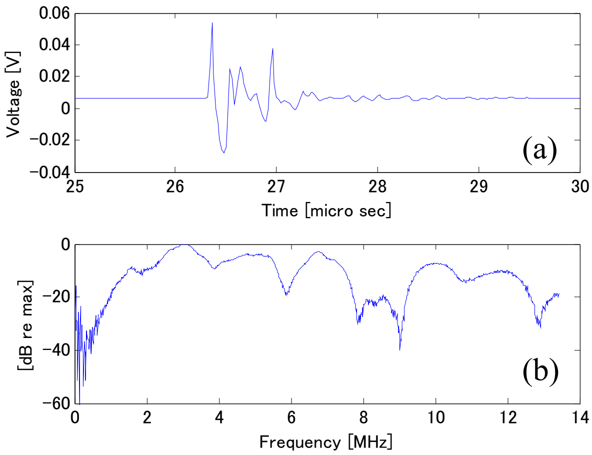

Fig.3 Waveform received by a hydrophone at a focal position (a) and its spectrum (b).

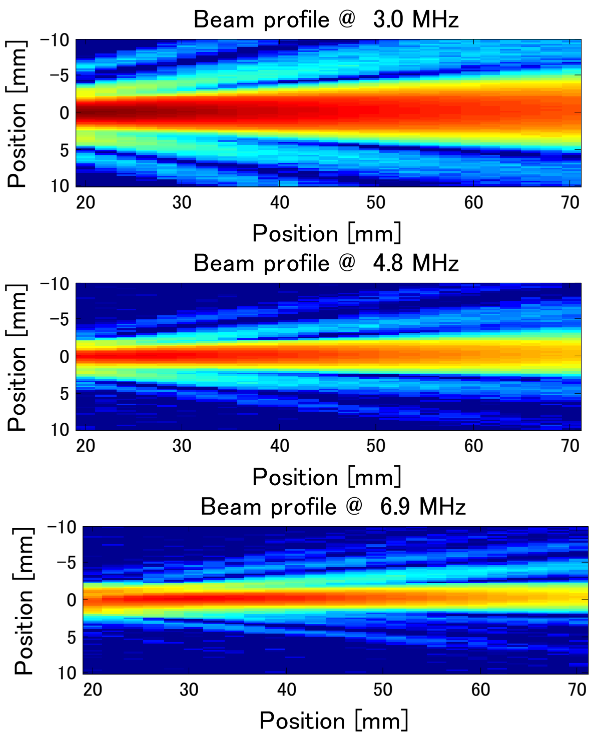

Fig.4 Beam profiles at the peak frequencies of 3.0, 4.8 and 6.9 MHz.

3. Imaging System and Experiments

The MFUI system based on the mechanical sector scanner (SSD1000, Aloka) in which the prototyped MRT was embedded was developed for the performance evaluation. The received echo signals were converted into digital signals of 14bits at a sampling frequency of 100 MHz.

Tissue mimicking phantoms which were used for the evaluation are shown in **Fig. 5**. The B-mode images of the phantoms at 3.0, 4.8, and 6.9 MHz are shown in **Fig. 6** and **7** (a), (b) and (c), respectively. Superposed images of the three B-mode images are shown in Fig.6 and 7 (d). Wire targets are clearly observed and the speckle fluctuation is well reduced in the superposed image.

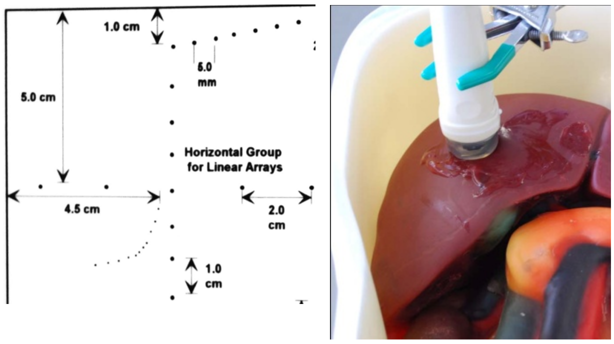

Fig.5 ATS model 539 multipurpose phantom (left) and Kyotokagaku IOSFUN (right).

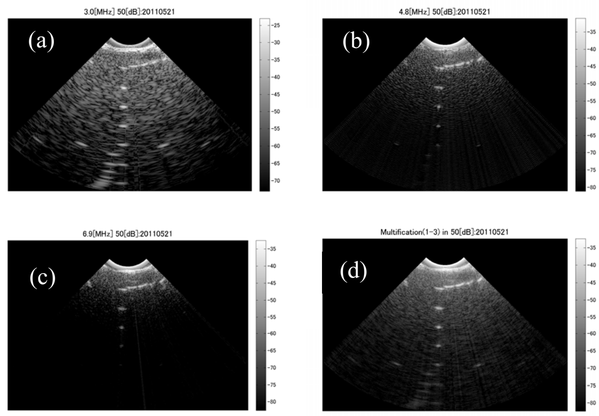

Fig.6 MFUI of ATS 539 and superposed image

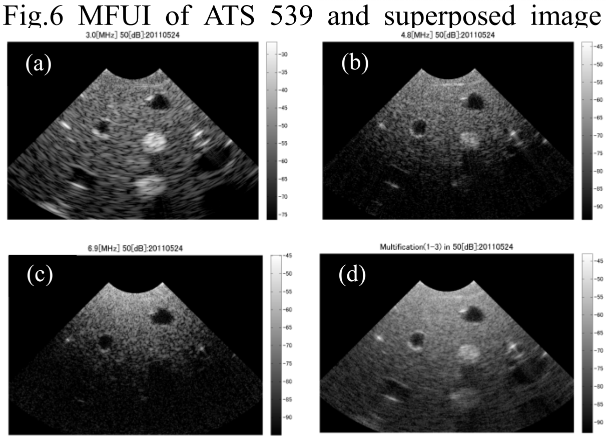

Fig.7 MFUI of IOSFUN and superposed image (d).

Acknowledgment

This work was supported by Grant-in-Aid for Scientific Research (B), (20300181).

References

1. N. Yoshizumi et. al: Proc. Symp. Ultrason. Elec. **30** (2009) 341.
2. P.A. Magnin et. al: Ultrasonic Imaging **4** (1982) 267.