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Proceedings of Symposium on Ultrasonic Electronics, Vol. 36 (2015)
5-7 November, 2015

Multi-element transducer module for ultrasound therapy
モジュール型超音波治療素子の開発

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1. Introduction

High-intensity focused ultrasound (HIFU) is widely used for therapeutic applications because it is an attractive and non-invasive tool by which to provide thermal therapy [1]. The sound pressure at the focal point reaches hundreds of megapascals, resulting in an increase in temperature, which necrotizes cells. Although HIFU treatment has been applied to limited regions. It is difficult to treat targets that lie behind bone (e.g., brain tumors) or that lie deep inside the body (e.g., liver tumors), because the ultrasound beam is reflected, refracted, and attenuated by the intervening tissue and/or bone [2-3]. In order to resolve this problem, phased array HIFU has been developed [4]. Focus position control of HIFU by multi-elements phase control is very popular in clinical application. However, multi-elements driving amplifier are very large size like a large refrigerator. So, we adopted a direct drive amplifier system for the multi-elements transducer. This system has an advantage of reducing the energy loss of the connecting cable between the transducer element and the amplifier[5]. So, we make the very compact multi-elements transducer system combined with multi-elements amplifier and multi-channel phase delay generator system[6]. Figure 1 shows the schematic view of the module system. Figure 2 shows the first prototype multi-elements module transducer.

2. Method

In this study, we evaluated the first prototype module transducer. The ultrasound wave formed a focal point by the phase control. We measured the acoustic pressure distribution near the focal point. We measured the relationship between the input voltage and the output acoustic pressure.

3. Results

Fig.3 to Fig.6 showed the measurement results of the output acoustic pressure from the

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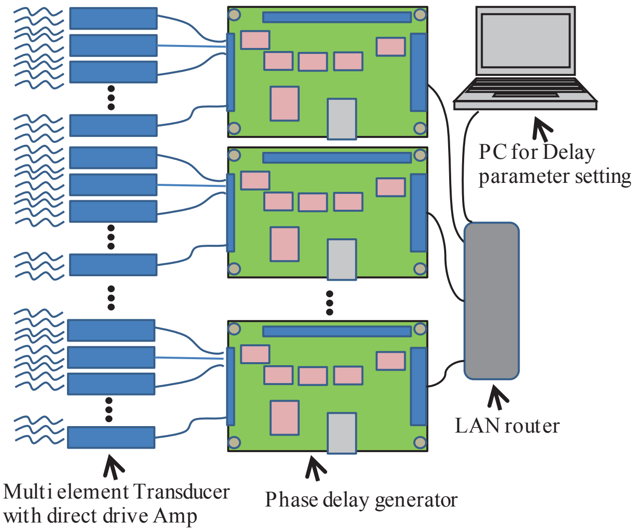

Fig.1 Schematic view of the module system

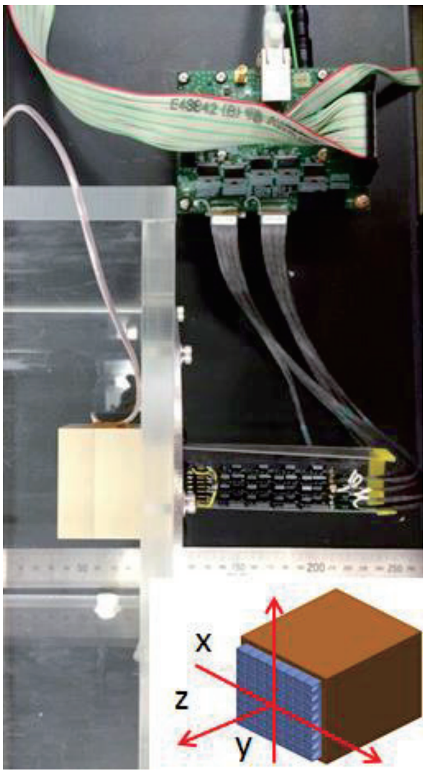

Fig.2 The first prototype module transducer

prototype module transducer. Those measurement parameters ware as follows.
-focal point(x,y,z): (0,0,40) in Fig.3 to Fig.5
(5,0,40) in Fig.6
-Input voltage: 3V in Fig.4 to Fig.6

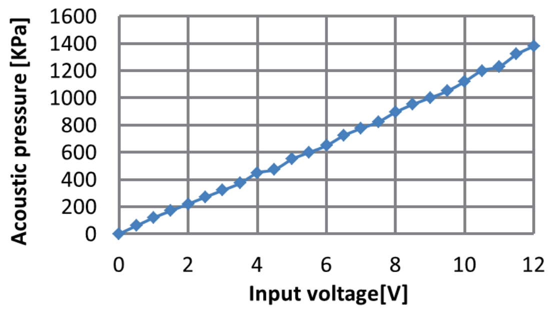

Fig.3 Input voltage Vs. Acoustic pressure

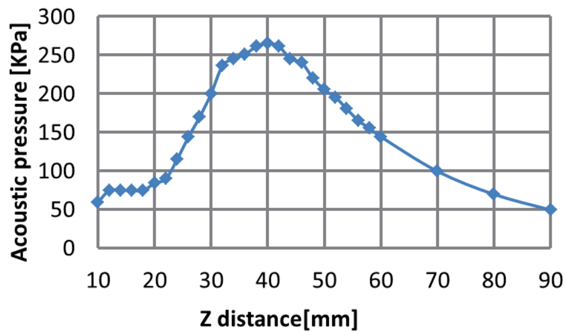

Fig.4 Z distance Vs. Acoustic pressure

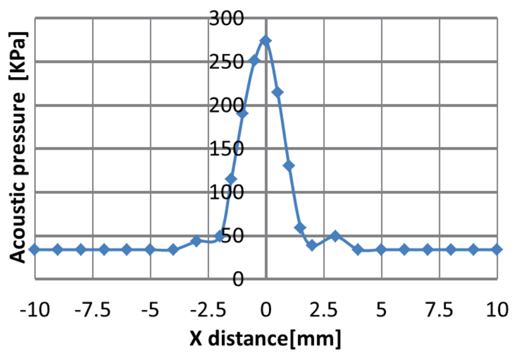

Fig.5 X distance Vs. Acoustic pressure
(focal point(0,0,40))

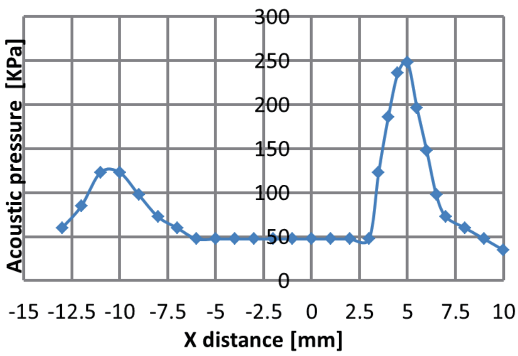

Fig.6 X distance Vs. Acoustic pressure
(focal point(5,0,40))

Fig.3 showed the acoustic pressure rises linearly to change in the input voltage, and the acoustic pressure was 1400KPa (input voltage 12V). Fig.4 and Fig.5 showed the ultrasound wave formed a focal point by the phase control. Fig.6 showed that focal position was moved to right direction (moves to right side 5mm.), and there was the second peek at -10.5mm. This second peek position was the same as the numerical simulation.

4. Conclusion

In this study, we evaluate the first prototype module transducer. This prototype module transducer can make focal point by phased control and acoustic pressure controlled by the input voltage.

Acknowledgment
The present study was partially supported by a Grant for Translational Systems Biology and Medicine Initiative (TSBMI) and Scientific Research (A) 2012, 24246035 from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

References
1. G. T. Clement (2004) Perspectives in clinical uses of high-intensity focused ultrasound. Ultrasonics 42: 1087-1093.
2. K. Kajiyama, K. Yoshinaka, S Takagi, Y Matsumoto (2010) Microbubble enhanced HIFU. Physics Procedia, Vol. 3,1:305-314.
3. K.yoshinaka, K. Kajiyama, et al.(2011) Heating location control of gas exchanged microbubble enhanced HIFU, Proceedings of Symposium on Ultrasonic Electronics, 32, pp.549-550
4. Ryuta Narumi, Kosuke Matsuki, Shigeru Mitarai, Takashi Azuma, Kohei Okita, Akira Sasaki, Kiyoshi Yoshinaka, Shu Takagi, and Yoichiro Matsumoto. Focus Control Aided by Numerical Simulation in Heterogeneous Media for High-Intensity Focused Ultrasound Treatment. Jpn. J. Appl. Phys. 52 (2013) 07HF01pp.1-9
5. Tzu-Yin Wang, Zhen Xu, Timothy L. Hall, J. Brian Fowlkes, William W. Roberts, and Charles A. Cain,Active Focal Zone Sharpening for High-Precision Treatment Using Histotripsy. IEEE Trans. UFFC ,vol.58, No.2 (2011), pp305-315
6. S.Toyoda, K.Yoshinaka, et al.(2014) アンプ内蔵超小型集束超音波治療モジュールの開発，Mechanical Engineering Congress Japan, J2410104, pp.1-4