1Pb-61

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 263-264
6-8 December, 2010

Study of Transmission Method for 100 MHz Range Ultrasonic Wave using Thin Acoustic Wave Guide

細径ファイバーを用いた 100MH z 帯超音波伝送の検討

Takasuke Irie[1,2†], Norio Tagawa[1], Masakazu Sato[2], Tadashi Moriya[3], Masasumi Yoshizawa[4,] Takashi Iijima[5], Kouichi Itoh[6], Taku Yokoyama[7], Kei Konno[8], and Nobuyuki Taniguchi [8] ([1]Tokyo Metropolitan Univ., Tokyo; [2]Microsonic Co. Ltd., Tokyo, [3]Tokyo Metropolitan Univ., Tokyo, [4]Tokyo Metropolitan College of Industrial Technology, Tokyo, [5]National Institute of Advanced Industrial Science and Technology, Ibaraki, [6,7]Hitachi-Omiya Saiseikai Hospital, Ibaraki, [8]Jichi Medical Univ.,) 入江喬介 [1,2‡], 田川憲男 [1], 佐藤正和 [2], 守屋正 [3], 吉澤昌純 [4], 飯島高志 [5], 伊東紘一 [6], 横山卓 [7], 紺野啓 [8], 谷口信行 [8] ([1] 首都大学東京, [2] マイクロソニック㈱, [3] 首都大学東京名誉教授, [4] 東京都立産業高等専門学校, [5] 産業技術総合研究所, [6,7] 常陸大宮済生会病院, [8] 自治医科大学)

1. Introduction

The tissue diagnosis in the current pathological examination takes time because it requires a tissue sample obtained by the biopsy and the observation using an optical microscope, and gives burden on the patient. The purpose of the study is to enable an operator to observe directly microscopic images of the tissue without taking out the tissue sample from patient. To achieve the purpose, we are developing a needle-type ultrasonic probe that uses a thin fiber [1]. Previously, it was reported that a fused quartz fiber was used as the guided line using the L(0,1) and L(0,3) mode of the Pocchammer-Chree Wave in the 20 MHz range [2]. And we also reported that the ultrasonic pulse wave generated by a 50 MHz transducer was transmitted in the transmission line and reflected at the end face [3]. However, to obtain a high resolution of the order of 100 μm, it is necessary to use an ultrasonic wave with a frequency higher than 100 MHz. In this paper, we describe experimental results of the propagation in the 100 MHz range using sapphire fibers.

2. Experimental system and measurements

Figure 1 shows a block diagram of the experimental system. Burst waves generated by the function generator are amplified by the power amplifier (40 dB) and applied to the transmitting (T_x) transducer (PZT on the sapphire board). The frequency-band width and the diameter of the transducer are approximately 100 ~ 200 MHz and 1mm in diameter, respectively. The burst waves transmitted from the transducer propagate through the sapphire fiber and are sent to the receiving (R_x) transducer with the frequency-band width of approximately 100 ~ 280 MHz. The ultrasonic waves received by the transducer are amplified in the pre-amplifier (30dB), and sent to the oscilloscope (Tektronix TDS5104B). The

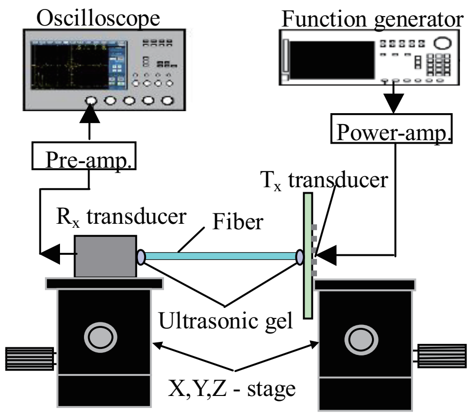


Fig.1 Block diagram of the experimental system

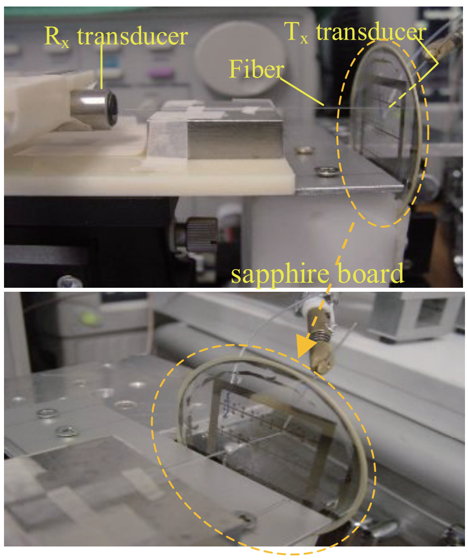


Fig.2 Overview of the transducers and fiber

irie@microsonic.co.jp

amplitude of the signal as a function of frequency is measured using the oscilloscope. By changing the frequency of the burst waves from 100 MHz to 200 MHz continuously, the measurements are performed repeatedly. As the results, the frequency characteristics of the fibers can be obtained.

3. Results and discussions

The results of the measurements are shown in Fig. 3 and 4.

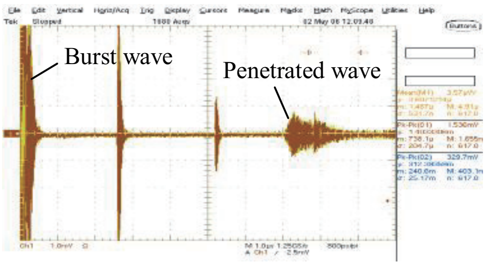
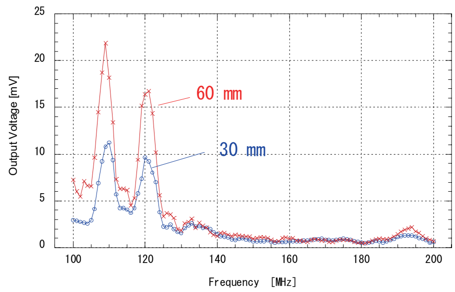
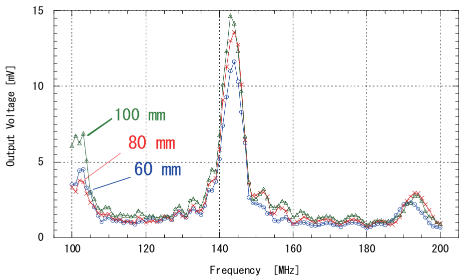


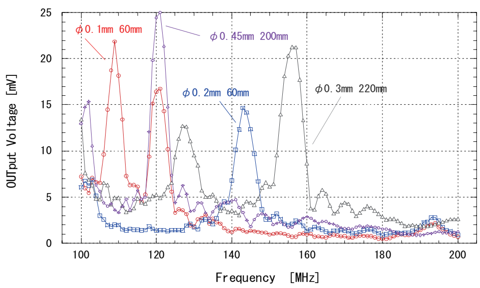
Fig.3 Penetrated wave through the fiber



(a) ϕ 0.1 mm in diameter



(b) ϕ 0.2 mm in diameter



(c) ϕ 0.1 ~ 0.45 mm in diameter

Fig.4 Frequency characteristics of transmitted waves in sapphire fibers

Figure 3 shows a transmitted wave through the fiber with 0.1 mm in diameter. Figure 4 (a), (b), and (c) show the frequency characteristics of the fibers with each different diameter of 0.1, 0.2 and 0.1 ~ 0.45 mm. The results of the measurements for the frequency characteristics of the fibers with 30 and 60 mm in length are shown in Fig. 4(a). In the measurement of the fiber with 0.2 mm in diameter, the measurements for three types of length of 60, 80 and 100 mm were performed for the fibers, the results are shown in Fig. 4(b). Figure 4(c) shows the results for the measurement of the frequency characteristics of the fiber with the diameter of 0.3 and 0.45 mm together with the above two results.

As the results of the measurements, it was found that the high frequency ultrasonic waves over 100 MHz propagated through the thin sappier fiber. However, it seems that the frequency bandwidth of the propagated ultrasonic wave is not so wide as to propagate a short pulse. It is considered that the frequency in which the amplitude of the propagated ultrasonic wave becomes the maximum does not depend on the length of the fiber with the same diameter.

4. Conclusions

As the results of the measurements in this study, we found that the high frequency ultrasonic waves over 100 MHz propagated through the thin sapphire fiber. The maximum frequency of the obtained wave is approximately 155 MHz. The wavelength of the 155 MHz is approximately 10 μm. If the ultrasonic image with the resolution higher than the half of the wavelength could be obtained, it will be expected that the microscopic image of the tissue can be seen directly. Increasing the sensitivity of the system and improving the efficiency of the transmission are the future work.

References

1. M. Yoshizawa, R. Emoto, H. Kawabata, T. Irie, K. Itoh and T. Moriya: JJAP, 48 (2009)
2. T. Moriya, Z. Hu, T. Irie: J Med Ultrasonis, 30 (2003)
3. T. Irie, Z. Hu, N. Tagawa, T. Moriya: Proc. of Symp. on Ultrasonic Electronics, 23 (2002)