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Development of Large Displacement SiC Pulser for Subharmonic Ultrasound Measurement

サブハーモニック超音波計測のための大変位 SiC パルサーの開発

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1. Introduction

Recently, nonlinear ultrasound has become an effectual measurment technique of detecting and evaluating closed cracks from the basical study report in three decades ago[1]. Measurement of nonlinear ultrasound is based on the detection of nonlinear components, i.e., superharmonic waves or subharmonic waves generated by the interaction of large amplitude ultrasound with closed cracks. The Subharmonic Phased Array for Crack Evaluation (SPACE) measurement, which is the imaging system of the subharmonic ultrasound generation at crack, have been reported for several years[2]. Although subharmonic waves have a better selectivity for closed cracks than superharmonic waves, the subhrarmonics appear only when the amplitude of incident wave is larger than a certain threshold[3]. Then, higher volatage excitation was needed to produce larger amplitude ultrasound. However, conventional pulser has the limitation of the driving to larger amplitude at higher voltage excitation because electric current can't be carry enough at high voltage due to the condenser in pulser.

In this study, we developed a new pulser using SiC transistor for larger current available to generate high amplitude ultrasound. Here we report a efficacy of the novel pulser excitation using three different elements of transducers.

2. Experimental setup

Three kinds of piezoelectric materials are investigated, M6, C6, and C9 which are commercially available from Fuji Ceramics Corporation, Japan, therefore M6, C6, and C9 are piezoceramics based on PZT that are actually used in piezo-actuators standard. We prepared three transducers, which have the elements of PZT materials of M6, C6, C9, respectively. **Table I** shows the piezoelectric properties of the constituent materials that are used in this study. Among these PZT piezoceramics C9 exhibits the maximum piezoelectric charge constants d_{33} while M6 exhibits the minimum d_{33}. However, in terms of dielectric constants $\varepsilon_{33}^{T}/\varepsilon_0$, which is a coefficient relevant to the capacitance of transducer, M6 has the minimum $\varepsilon_{33}^{T}/\varepsilon_0$ and C9 has the maximum $\varepsilon_{33}^{T}/\varepsilon_0$.

Table I　Piezoelectric properties of materials

	M6	***C6***	***C9***
d_{33} [x10^{-12} m/V]	71.0	472	718
$\varepsilon_{33}^{T}/\varepsilon_0$	215	2130	6640

These three elements of the transducers have same properties in terms of shape (square), size (20 x 20 mm^2), and thickness (0.55 mm). The central frequency of these elements is 4 MHz. **Fig.1** shows the design of the transducers. The components are face plate, element, outer case, and BNC cable which are connected by using soldering technique. The case was packed with sealing plastic.

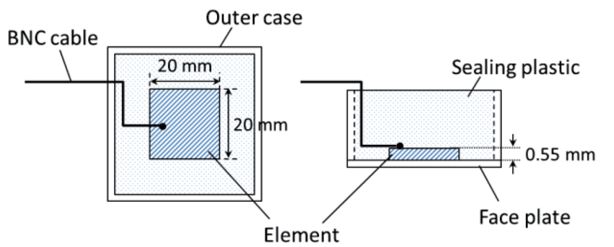

Fig. 1 The design of the transducer.

To drive these transducers at higher voltage, we prepared two types of pulsers. One is a conventional pulser (Pulser I, Japan Probe), which set the maximum setting voltage of 600 V and the output impedance of 50 Ω. The other is new SiC transistor pulser (Pulser II, ISL), which set the maximum setting voltage of 1200 V and the output impedance of 0.5 Ω.

To measure accurate displacement waveform of the transducers for the evaluation of generated ultrasound depend on pulsers, we constructed an experimental set up as shown in **Fig.2**. Displacement of the face plate of transducer was

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measured by using a laser vibrometer (Polytec, OFV-505). A 1000:1 probe was connected to oscilloscope from pulser to measure excitation voltage at the transducer.

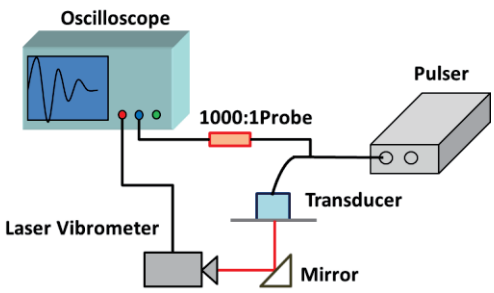

Fig. 2 Experimental set up to measure displacement of transducers by using a laser vibrometer.

3. Result and discussion

Fig.3 is a view showing a frame format of excitation voltage and ultrasound waveforms generated from transducer. Here the wave number *N* was set 5-cycle and the tone burst of 4MHz longitudinal waves was input. The displacement amplitude on the face plate was calculated from receiving signal of peak-to-peak (p–p) measured by a laser vibrometer.

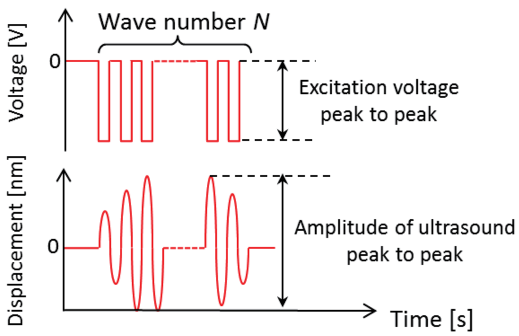

Fig. 3 Ultrasound waveform generated from transducers and the excitation voltage.

Figs. 4 and **5** show measuring results of displacement vs. excitation voltage applied to the transducers. In **Fig.4**, the transducers were driven with a conventional pulser, Pulser I. The setting voltages were set from 100 to 600 Vp-p. Although M6 and C6 have a linearity relation between displacement and excitation voltage, C9 was not enough driven due to the much capacitance of the element. In **Fig.5**, the transducers were driven with the new pulser, Pulser II. The setting voltages were set from 100 to 1200 Vp-p. The displacements of all transducers increase according to excitation voltage. Furthermore, the slopes expressed Displacement / Excitation Voltage of each materials showed same magnitude relationship of d_{33} i.e., C9 > C6 > M6, though voltage drops were observed.

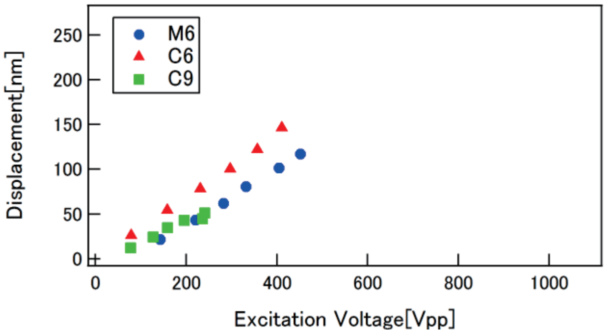

Fig. 4 Displacement of ultrasound vs. excitation voltage driven by Pulser I.

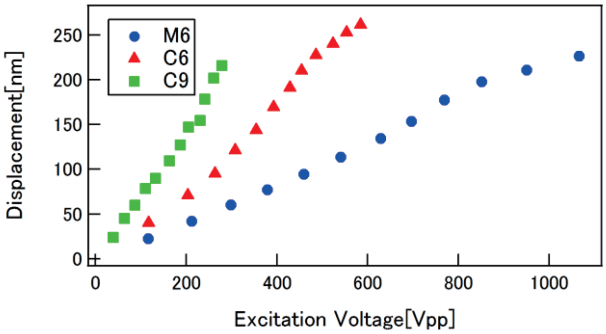

Fig. 5 Displacement of ultrasound vs. excitation voltage driven by Pulser II.

4. Conclusions

In this study, we proposed a new pulser using SiC transistor for larger current available to generate high amplitude ultrasound. Since we observed increasing displacement according to excitation voltage by using new pulser even if C9 transducer, developed concept will be available. Further confirmation of developed pulser must be required using impedance matching technique between transducer and pulser not to drop applied voltage at transducer.

Acknowledgment

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References

1. O. Buck, W. L. Morris, and J. M. Richardson: Appl. Phys. Lett. 33 (1978) 371.
2. T. Mihara, T. Kamimura, Y. Miura and H. Tashiro: Proc. of IWPMA (2012) 61.
3. T. Mihara and H. Ishida: J. Phys. Conf. Ser. 520 (2014) 012010.