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A study on Power Accumulator of Surface Acoustic Wave by using PZT substrate and its Application to Au Foil joining

PZT 基板上に設けた弾性表面波のパワー合成器による金箔の接合

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1. Introduction

We have carried out ultrasonic Au Foil joining by using 2.5MHz of surface acoustic wave (SAW) device by means of $LiNbO_3$ substrate.[1)-2)] The displacement amplitude of SAW was $112nm_{P\text{-}P}$ under the supplied voltage was $200V_{P\text{-}P}$. The aim of this study is applying ultrasonic joining method to "flip chip bonding". The advantage of usage of a SAW device for joining are follows: Damages of joined parts can be avoided and positioning accuracy becomes higher, because displacement of vibration of joining tool can be small at higher frequencies. Therefore, it is thought that it is suitable for Au Foil joining. On the other hand, it is very difficult to get wider area of joining part by using conventionally used longitudinal-mode transducer system at higher frequencies. By using the SAW joining system, however, we can get a wider work area on the SAW device.

On the other, $LiNbO_3$ substrate cracks easily by static load in the SAW joining. Therefore, we tried using PZT substrate, because PZT substrate is very harder than $LiNbO_3$ substrate. We succeeded in plastic joining in the precedent study by SAW power accumulator.[3)] However, joint strength was very low. In order to clarify the reason, we checked the device. First, we found that attenuation of displacement amplitude of SAW of PZT substrate was 15 % (approx.) larger than that of $LiNbO_3$ substrate. Second, the accuracy of inter-digital transducer (IDT) pattern which is made by vacuum deposition was bit of low. Therefore, we redesign of the IDT and reflector. Moreover, patterning of IDT and reflector was changed to photoetching method.

In this study, we describe the design method of the SAW power accumulator in order to obtain the sufficient displacement amplitude to use for flip chip bonding.

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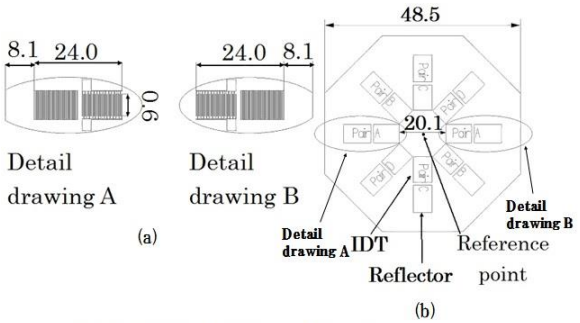
2. Construction of SAW power accumulator

Figure1 illustrates the SAW device that used in this study. The substrate of the SAW device is PZT (Model : C-213 FUJI CERAMICS). The form of substrate is regular octagon. The size of substrate is a width of 84.5 mm and a thickness of 10 mm. By using the substrate, we designed a 2.5 MHz SAW resonator[4)]. The sound velocity of SAW of the substrate is 1988 m/s and a wavelength is 0.8 mm. Material constants are $k_p = 57.9\times10^{-2}$, $d_{15} = 543\times10^{-12}m^2/N$, $\rho = 7.8\times10^3\ kg/m^3$ and $\varepsilon_{33} = 1470$.

Therefore, the width of every electrode finger and the gap width between electrode fingers were both designed as 0.2 mm. Moreover, we arranged IDT and open metal strip array (OMSA) reflector on the substrate as shown in Figs. 1(a) and 1(b). And we used aluminum electrode as IDT by means of photoetching method.



Width of IDT and OMSA reflector : 0.2 mm
Aperture length : 0.6 mm
Bond length : 1.0 mm
IDT : 14 pairs × 8 , OMSA reflector 30 × 8
Substrate : PZT (Model : C-213 FUJI CERAMICS)

Fig.1 Construction of SAW power accumulator (Unit : mm)
(a) Construction of electrode fingers
(b) Detail drawing A and B of electrode fingers

3. Electrical characteristic of SAW power accumulator

Figure 2 shows a frequency characteristics of the SAW power accumulator. We measured the frequency characteristics of each IDT pairs. As the result, all of the pairs has same resonant frequency. The∠Y° of frequency characteristic is not falling to zero, because the damped-capacitance of the PZT substrate is too large. We drove an SAW device by power amplifier. As the result, we obtained 2.58 MHz as the resonant frequency of the SAW accumulator.

Next, we checked electric current flowed into each pair of IDT when the SAW accumulator is driven at 2.58MHz. In this measurement, we measured input current of each pair of IDT under all pairs of IDT is driven in parallel. Figure 3 shows the result. The values of current were 116mA$_{p-p}$ for Pair A, 104mA$_{p-p}$ for Pair B, 120mA$_{p-p}$ for Pair C and 120mA$_{p-p}$ for Pair D under the supplied voltage of 50V$_{p-p}$. As shown in Fig. 3, the values of current for each pair of IDT are almost same. Therefore, we can confirm that each pair of IDT apportioned an acoustic load.

Finally, we obtained 250nm$_{P-P}$ of displacement amplitude at the center of the device under the supplied voltage was 100V$_{P-P}$. This value is sufficient to use for Au joining.

4. Conclusions

The application of the SAW power accumulator system to ultrasonic Au foil joining was studied experimentally. As a result, we obtained sufficient displacement amplitude to use for Au joining by using the SAW power accumulator. Now, we are going to join Au foil and to confirm the accumulator can be used for flip chip bonding.

Acknowledgment

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5. Reference

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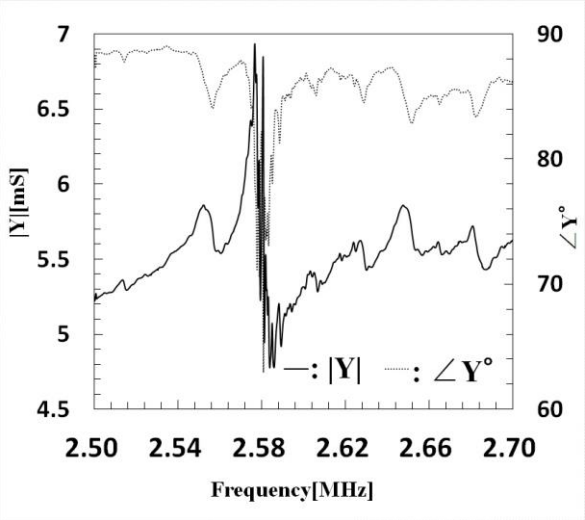
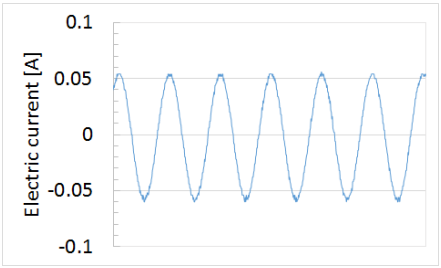
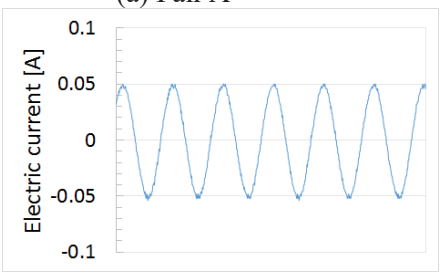


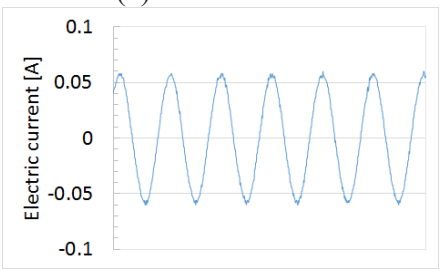
Fig.2 Frequency characteristic of the SAW power accumulator.



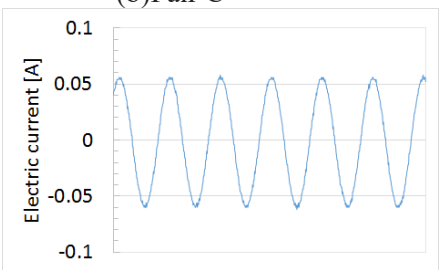
(a) Pair A



(b)Pair B



(b)Pair C



(b)Pair D

Fig.3 Electric current waveform of each pair of IDT (Supplied voltage :50 V$_{p-p}$)