The compact size piezoelectric transformer to lower an operating voltage of plasma display devices

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Abstract

We suggest a new approach to lower the operating voltage of plasma display devices using a piezoelectric transformer (PT). $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PMNT) was used as a piezoelectric material. The Rosen-type PT, with a compact size of 10 mm × 20 mm × 0.3 mm, was fabricated on a glass substrate. The fabricated PT was operated as a half-wave vibration mode at around 80~90 kHz. The maximum voltage step-up ratio was 3 at 87.8 kHz when the input voltage was 10.32 V (peak-to-peak).

1. Introduction

Micro-plasma has been utilized as a light generation source for plasma display panels (PDPs) and a liquid crystal display (LCD) back light units (BLUs). These micro-plasma displays need a high operating voltage to generate micro-discharge, which is a drawback compared to other display devices [1,2]. In this paper, we suggest a new approach using a piezoelectric transformer (PT) to lower the operating voltage of plasma displays. The PT is a high voltage generator using a conversion between a mechanical force and electrical energy based on a piezoelectric effect [3,4]. PTs are generally used as one of several circuit devices for driving LCD back lights, such as cold cathode fluorescent lamps (CCFLs) [5]. In this work, we developed a compact size PT on a glass substrate; we expect that the proposed PT device can be applied to lowering the operating voltage of plasma displays.

2. Experimental

The structure of the proposed PT is based on the Rosen-type configuration, which is shown in Fig. 1. $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PMNT) was used as a piezoelectric material with a size of 10 mm in length, 2 mm in width, and 0.3 mm in thickness. Cr electrode and Au electrode were used together to form a ground electrode, an input electrode, and an output electrode. In order to adhere the PT to the glass substrate, an Ag electrode was formed on the glass substrate through a screen printing method and substrate was fired with the PT at 560 °C after placing the PT on the Ag electrode.

The PT was poled along the length direction under 500 V for an hour; it was then poled along the thickness direction under 200 V for an hour at room temperature.

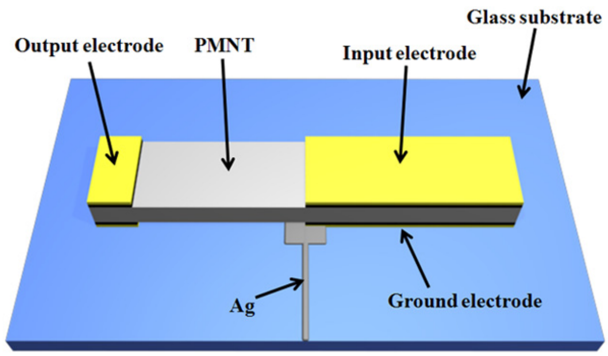

Fig. 1 Structure of the piezoelectric transformer on the glass substrate

3. Results and discussion

Fig. 2 shows the output voltage (peak-to-peak) and voltage step-up ratio as a function of the driving frequency. A sine voltage of 20 V (peak-to-peak) was applied to the input electrode during this measurement. Generally, the voltage step-up ratio of PT is strongly dependent on the driving frequency. The voltage amplification of PT only appears at the specific frequency, resulting in electro-mechanical resonance [3,4]. A similar tendency was observed from our fabricated PT. As shown in Fig. 2, the fabricated PT showed an increased voltage step-up ratio at around

80~90 kHz, at which frequencies the PT was operated as a half-wave vibration mode. The output voltage was not amplified at other frequencies.

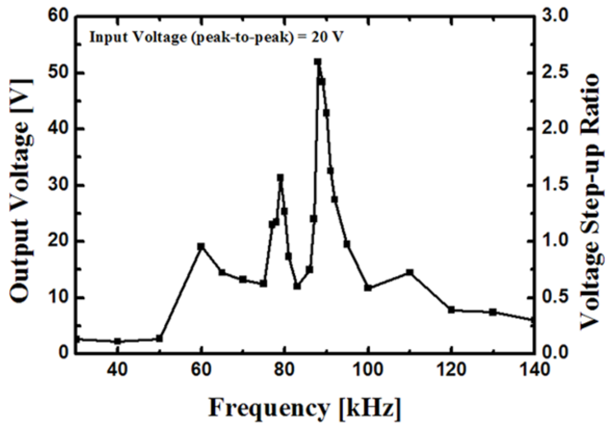

Fig. 2 Output voltage (peak-to-peak) and voltage step-up ratio as a function of the driving frequency when the input voltage (peak-to-peak) was 20 V

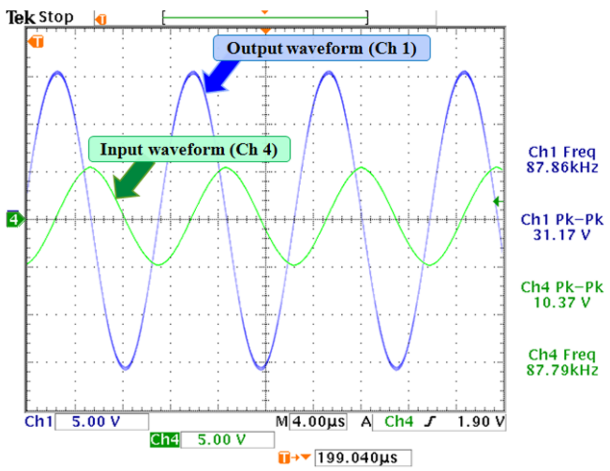

Fig. 3 Input voltage waveform and output voltage waveform at the frequency for which the voltage step-up ratio of the piezoelectric transformer has a maximum value

Fig. 3 shows the oscilloscope data of input voltage waveform and output voltage waveform at the frequency for which the voltage set-up ratio has a maximum value. The output voltage waveform had a clear sinusoidal shape without any noise; the maximum voltage step-up ratio was 3 at 87.8 kHz. The output voltage was 31.17 V (peak-to-peak) when the input voltage of the PT was 10.32 V (peak-to-peak). This voltage step-up ratio of the fabricated PT is a lower value compared with the PTs of other works [4], even if we consider that the compact size of our fabricated PT can act as a disadvantage in regard to the voltage step-up ratio. However, these results have occurred because our fabrication process (such as poling condition) and structure of PT are not yet optimized. We expect that the performance of PT can be further improved if we conduct these optimizations.

4. Summary

In this work, we developed a PT with a compact size of 10 mm in length, 2 mm in width, and 0.3 mm in thickness on a glass substrate. The proposed structure is based on the Rosen-type configuration; PMNT was used as a piezoelectric material. The fabricated PT was operated as a half-wave vibration mode at around 80~90 kHz, at which point electro-mechanical resonance occurred. The maximum voltage step-up ratio of the fabricated PT was 3 at 87.8 kHz, when the input voltage was 10.32 V (peak-to-peak). We plan to apply this technique to plasma display devices, and it is expected that plasma display devices operated at considerably low voltages can be fabricated.

Acknowledgement

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5. References

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