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Developing two Dimensional Film Speaker using Piezoelectric Materials

Keehong Um[1*], Dong-Soo Lee[2]

[1*]*Department of Information Technology, Hansei University, Korea*
um@hansei.ac.kr

[2]*R&D Center of Industrial Materials, FILS CO., Ltd, Korea*
dslee@fils.co.kr

Abstract

A speaker is a system which produces sound through electromechanical operations. It transforms electronic signals into audible sound signals. Almost all speakers are three dimensional. These days, many mobile electronic devices such as mobile electronic devices have become smaller and thinner. A problem with this miniaturization, however, is that the volume of speakers has also decreased. In contrast to conventional three dimensional speakers, we have invented a new type of two dimensional flexible speaker by utilizing the reverse piezoelectric effect.

Keywords: *film speaker, audible sound signals, piezoelectric materials, reverse piezoelectric effect*

1. Introduction

The piezoelectric effect is the internal generation of an electrical charge resulting from an applied mechanical force. It is understood to be the electromechanical interaction between the mechanical and the electrically-charged state in crystalline materials. The piezoelectric effect is a reversible process in that materials exhibit the direct piezoelectric effect. We have invented a new type of two dimensional flexible speaker by utilizing the reverse piezoelectric effect on certain piezoelectric materials.

2. Components of Film Speakers

2.1 Piezoelectric Material

Some of piezoelectric materials exhibit the reverse piezoelectric effect, which is the internal generation of a mechanical force resulting from an applied electrical field. The previous prototype speakers we designed were mainly composed of piezoelectric material (called piezo film), coating material. The piezo film is made from polyvinylidene fluoride(PVDF), which is a highly non-reactive and pure thermoplastic fluoropolymer[1,2]. PVDF is a specialized plastic material in the fluoropolymer family. The coating materials we had previously adopted showed several disadvantages. The first coating material, i.e., conductive macromolecular compound, was faulty in several aspects including:

1. The performance was not good enough in some audio frequency ranges (20-20kHz).
2. It is difficult to achieve a uniform thickness when it is coated on the both surfaces of piezo film.

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Corresponding Author: um@hansei.ac.kr
Tel: +82-31-450-5308, Fax: +82-31-450-5172
Dept. of Information Technology, Hansei University, Korea

3. The sound pressure level(SPL) of film speaker was not high enough to generate a high quality of sound.
4. The frequency response showed that the characteristics of the SPL was not useful in the frequency range below 400Hz.

2.2 Indium Tin Oxide(ITO)

The second coating material, i.e, indium tin oxide(ITO), was found to be fragile due to the mechanical pressure due to the small vibrations of the film. To overcome these technical disadvantages of previous coating materials, we have developed a carbon nanotube(CNT) as a new coating material. We have proved that the CNT improves the characteristics of the SPL and it showed a higher quality of audible sound. The coating material, carbon nanotube(CNT), is made from the mixture of CNT solution and CNT dispersant[3]. The CNT solution includes such ingredients as methyl alcohol, ethyl alcohol, isoprophyl alcohol, toluene, ethyl acetate, and a controlled mixing process. The CNT dispersant includes materials such as sodium dodecy sulfate (SDS), triton X, lithium dodecy sulfate, and a controlled mixing process.[4, 5]

3. Fabrication and Results

3.1 Fabrication Prototype

The prototype we designed is composed of the following three parts;
(1) a piece of piezoelectric material, called piezo film,
(2) two pieces of coating material-a conductive macromolecular compound or indium tin oxide(ITO),
(3) and two pieces of electrodes.

3.2 Measured Results

By changing parameters(such as thickness of CNT, density of CNT solution, and density of CNT dispersant), the impedance of coated carbon nanotube(CNT) can be properly chosen.

4. Conclusion

The speaker system we designed showed outstanding advantages, such as flexibility, wide ranges of operating frequencies, and low values impedance values, and stability. We have shown that the proper surface impedance values of CNT was 50-2000 ohms per square. The axial sensitivity (in dB SPL, 1 watt at 1m) of CNT with 50 ohms per square and 1000 ohms per square was shown to 90 and 85, respectively, in range of 1kHz to 18kHz, which is part of audio frequency.

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