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The Study of the Inductive Coil to the Acoustic Performance of Electromagnetic Driven Microspeaker

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Abstract

Electromagnetic driven MEMS speakers using Polydimethylsiloxane (PDMS) membrane have been investigated to obtain a better sound pressure level (SPL) respond in low frequency regime. The comparison between measure and COMSOL simulation of fabricated microspeakers shows that the copper coil and its electrical feedthrough have a strong effect on the rigidity of the membrane thus on the SPL. Without considering the feedthrough effect, wide bandwidth starting at low frequency can be obtained while the coil is placed in the centre of the membrane, whereas placing the coil close to the membrane border instead will give a better response in low frequency with feedthrough effect

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1. Introduction

One tenth of the world population suffers from hearing loss and 278 million of them cannot have normal conversation without hearing aids that raise the issue of accessibility [1]. In the previous work [2], a micromachined electromagnetic (EM) microspeaker was developed with the lowest power consumption, i.e. 1.76mW for 106dB sound pressure level (SPL)@1kHz in a 2c.c. coupler of Brüel & Kjær as shown in Fig. 1 for hearing aids application. The microspeaker driven by Lorentz force was designed with a PDMS membrane where copper coils are placed. For maximizing the magnetic field in the coil, a NiFe soft magnet ring and a NdFeB hard magnet are placed on the

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border and under the center part of the membrane, respectively. However, it was found that good SPL results in low frequencies are limited with such a miniaturized speaker. In this work, we will investigate the inductive coil in the EM microspeaker and then propose a design scheme for further power reduction resulting from better acoustic performance in low frequency.

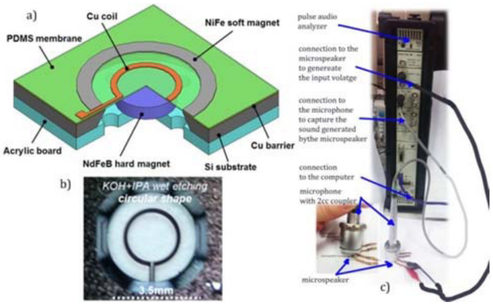

Fig. 1. (a), (b) fabricated microspeaker; (c) Brüel and Kjær measure instruments.

2. Experimental design

In the study, two kinds of microspeakers with different membrane diameter and design are shown in Fig. 2. Two microspeakers were designed with the 3 µm thick membranes, which are 3.5mm in diameter with a 7 turns coil placed at 900 µm from the center and 2.5 mm one with a 5 turn coil placed at 850µm from the center, respectively. The Iron-nickel (NiFe) soft magnet placed on the border of the membrane has a thickness of 10 µm and a width of 400 µm, and the Neodymium (NdFeB) hard magnet has a thickness of 1.5mm and a diameter of 2mm. The speakers were all fabricated using the prior developed process [2].

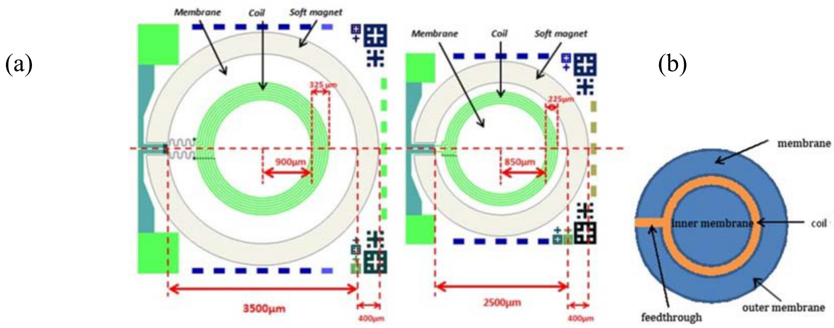

Fig. 2: (a) Details of the two sizes microspeaker, (b) feedthrough, inner and outer part membrane placement

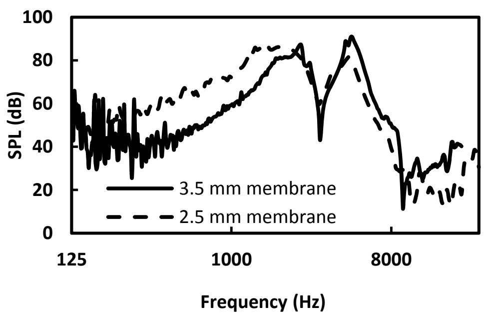

Fig. 3: experimental results for two sizes microspeaker