MEMS Acoustic Pixel

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Abstract

The world has evolved to a point where digital media and electronics play an important role in everyday life. The industry of electronics keeps growing with the pass of the months; where more improved components such as speakers, microphones, sensors and cameras among others are in high demand. These components require improved characteristics (i.e. smaller dimensions, low power consumption and better quality) in order to keep up with the technological evolution.

It has been approximately 91 years [1-5] since the appearance of the first loudspeaker drive, which is similar to the current transducer used nowadays. Nevertheless, in a world dominated by digital media and electronics, the sound transducer design remains to be the last analog component in the audio systems.

In 2003, Diamond et al. [6] reported the development of a direct digital method of sound reconstruction using CMOS-MEMS arrays as micro-speakers in a single chip. They previously described the theory behind their sound reconstruction method in 2002 [7], with the development of individual membranes joining 7 chips to create a 3-bit array.

In our work we use COMSOL Multiphysics® models to simulate the behavior of a micro-membrane (Acoustic Pixel) to be used as a potential acoustic transducer. The MEMS and Piezoelectric devices interfaces are used to aid the design process of such transducer. A four-cantilever spring configuration is initially proposed. Each cantilever has a width of 30 µm and are connected to a central circular plate with a radius of 150 µm. A top view of the membrane is shown in Figure 1. Figure 2 shows an actuated piezo cantilever [8].

It is expected that the simulations will reveal important information about the feasibility to generate audible pressure changes with the proposed membrane size. From simple analytical calculations, a single Acoustic Pixel is required to generate approximately 52 dB of acoustic pressure, which could be produced with approximately 5 µm displacement of the proposed membrane area. In Figure 3 we provide the first six frequency modes of the membrane.
A time response graph was obtained from the simulations. The piezo actuated cantilevers had a response time of 34 µs using 17 V between the electrodes. The response time graph of the actuated membrane is shown in Figure 4.

The development and innovation of a Digital Micro-Loudspeaker would directly impact the

electronics industry, by creating new components that utilize less power and space on a circuit board, decreasing its fabrication costs without compromising the sound quality, but rather improving it. The field of Audiology, which studies human hearing, balance, and related disorders, could also potentially benefit from such advancements. The aim of this field is to establish if a person can hear within the normal human audible range, if not, determine the affected frequencies (i.e. high, middle or low) and the degree of the damage. Several corrective actions can be taken depending on the diagnosed results, such as hearing aid apparatus or cochlear implants. These devices could substantially benefit of acoustic MEMS advancements and directly improve a person's quality life.

Reference

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Figures used in the abstract

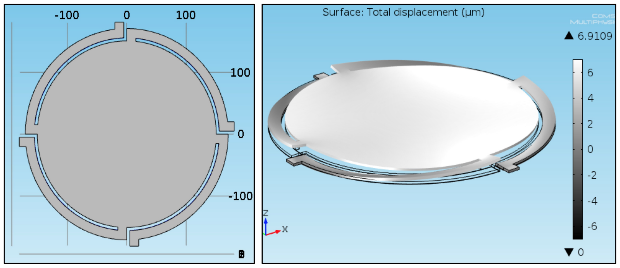

Figure 1: Left: Top view of proposed membrane, Right: Membrane displacement at 17V displacement of ~7µm

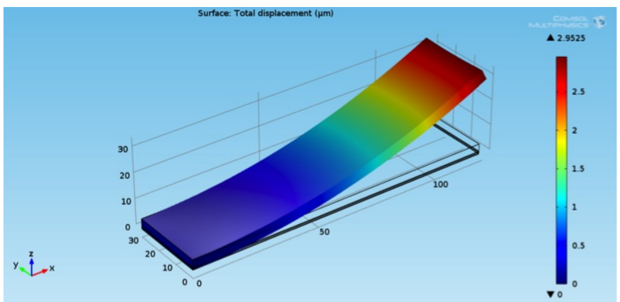

Figure 2: D31 mode simulation (deformation scaled by a factor of 10)

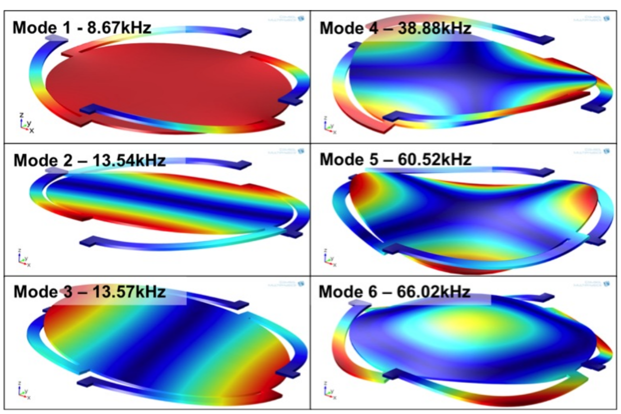

Figure 3: First six frequency modes of the membrane

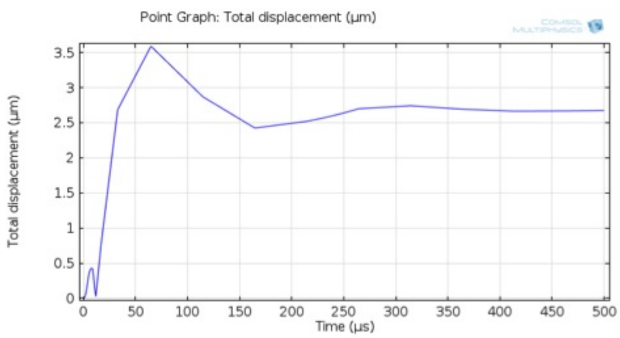

Figure 4: Response time graph of the actuated device [Total displacement vs. Time]