MEMS Electrostatic Acoustic Pixel

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Introduction

The growth of the electronics industry demand better components for the electronic systems. Such components need to be improve to keep up with the evolution of the digital era. The loudspeaker design has not been changed for almost a century [1-5]. The acoustic transducer is the last analogue component needed for a true digital audio system. We want to validate the feasibility of using an electrostatic membrane to develop arrays of membranes to reconstruct the sound, using polyimide as the structural material.

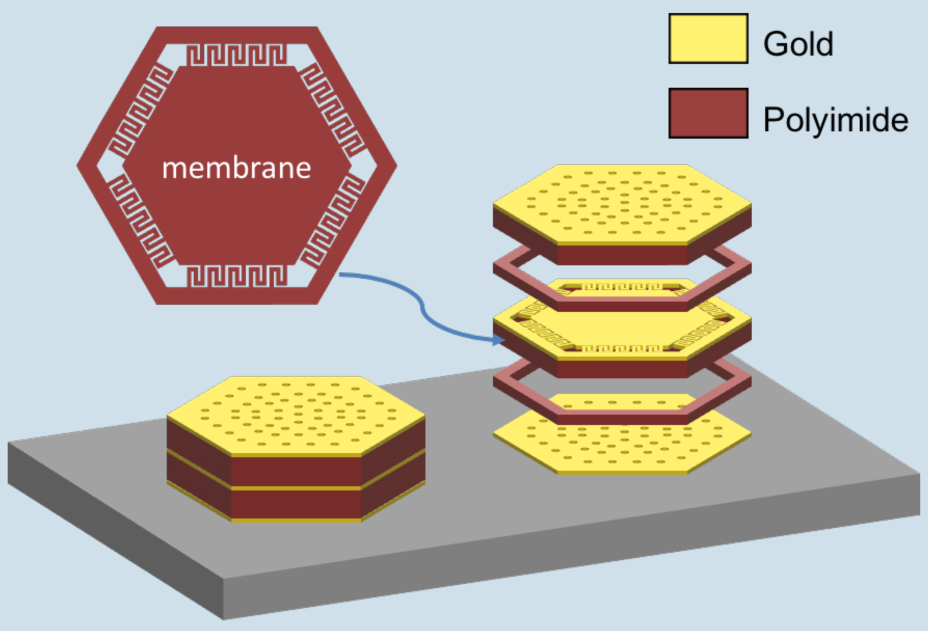

Figure 1 Conceptual view of the proposed electrostatic design.

Computational Methods

COMSOL Multiphysics was used to simulate the behavior of an hexagonal structure with a set of 5 tethers in each side of the hexagonal membrane, shown in Figure 1. The structure is 5µm thick polyimide and has an integrated metal layer on top of it for a bias voltage. The hexagonal plate is separated by an air gap of 3µm from the bottom electrode and 3µm air gap from the top electrode. We set the AC/DC Module to extract the capacitance between the electrodes and the pull-in voltage needed to displace the membrane toward the active electrode. The physics interface solve the following equation:

$$-\nabla \cdot (\varepsilon_0 \nabla V - P) = \rho$$

In this equation, the physical constant, ε0 (SI unit: F/m) is the permittivity of vacuum, **P** (SI unit: C/m2) is the electric polarization vector, and ρ (SI unit: C/m3) is a space charge density. This equation describes the electrostatic field in dielectric materials[6].

The Electrostatic interface assumes a symmetry where the electric potential varies only in the x and y directions and is constant in the z direction.

Results

We use an auxiliary sweep to apply voltages between the electrodes ranging from 10V – 150V in steps of 10V. Figure 2 shows the displacement of the membrane at the maximum applied voltage of 150nm and a total displacement of 3µm.

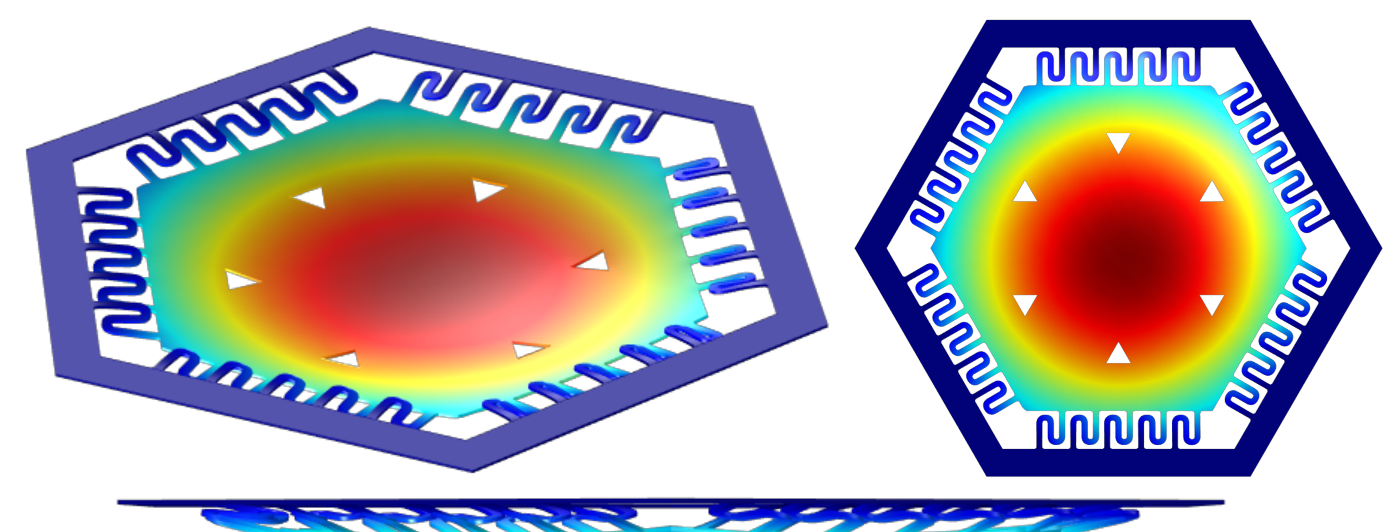

Figure 2 Simulation of the displacement of the membrane with 150V applied. (Top left) Isometric View, (Top Right) Top view and (Bottom) side view.

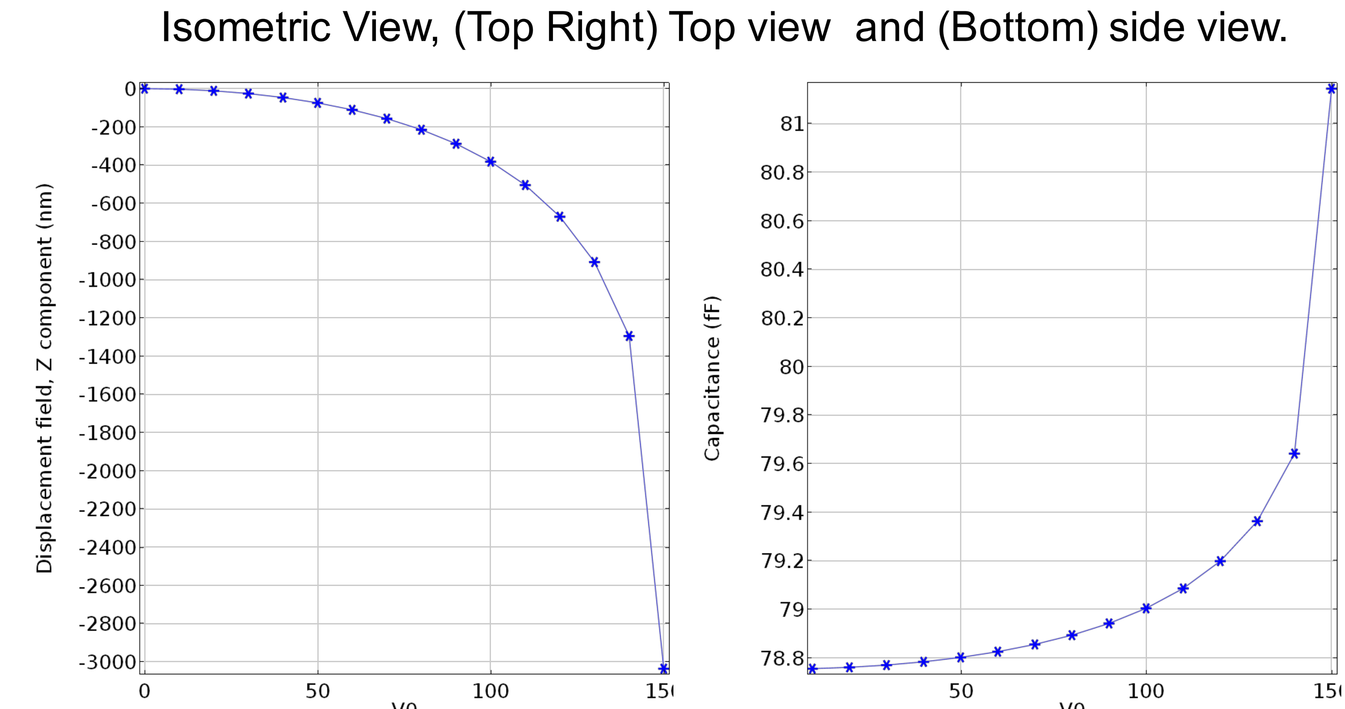

Figure 3 (Left)Displacement vs Voltage graph (Right) Capacitance vs Voltage.

Conclusions

The simulation results showed that the proposed design is suitable for the acoustic transducer element for the final transducer array. The membrane geometry can be adjusted to change the structure resonance frequency, so that the element has optimal acoustic response.

Full arrays have already design and arranged for fabrication. The chips are currently being tested and next steps include the validation of the presented model.

References

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