Optimization of MEMS Based Capacitive Accelerometer for Fully Implantable Hearing Aid application

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Introduction: This work describes the design and optimization of three prototypes of MEMS capacitive accelerometer-based middle ear microphone. The microphone is intended for middle ear hearing aids as well as future fully implantable cochlear prosthesis. The accelerometer can be attached to the middle ear bone structure, umbo to convert the bone vibration to an electrical signal representing the original acoustic information

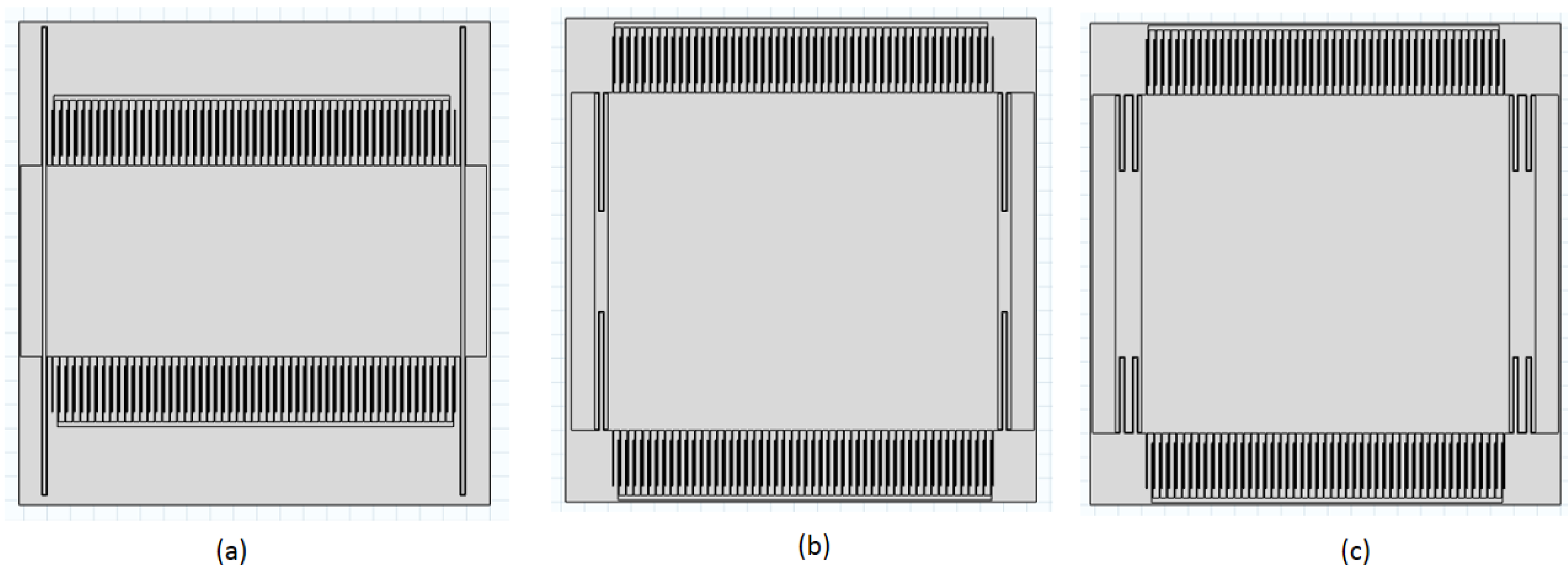

Figure 1. . Different prototypes (a), (b) and (c) of accelerometer based on different spring topologies with gap ratio of 5

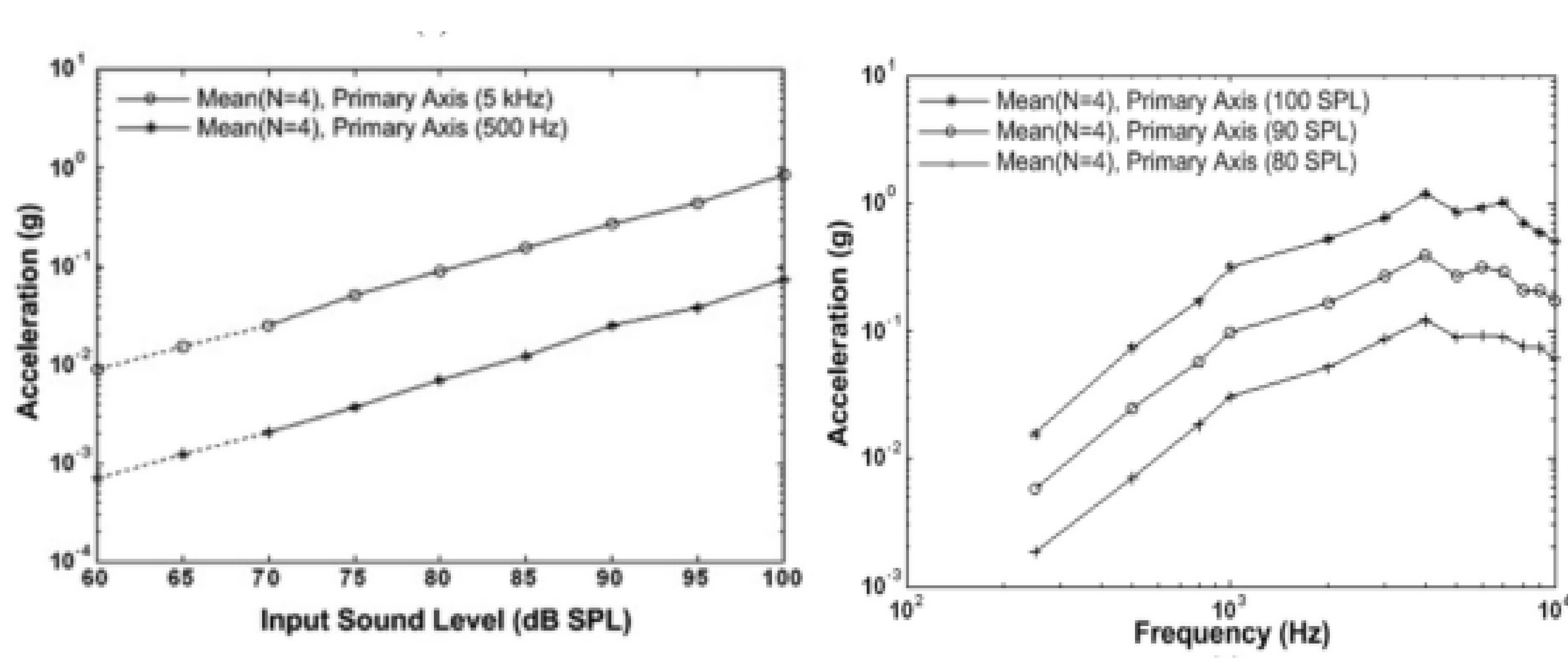

Figure 2. Acceleration response curves of umbo along the primary axis with respect to (a) sound pressure level and (b) frequency of the input signal

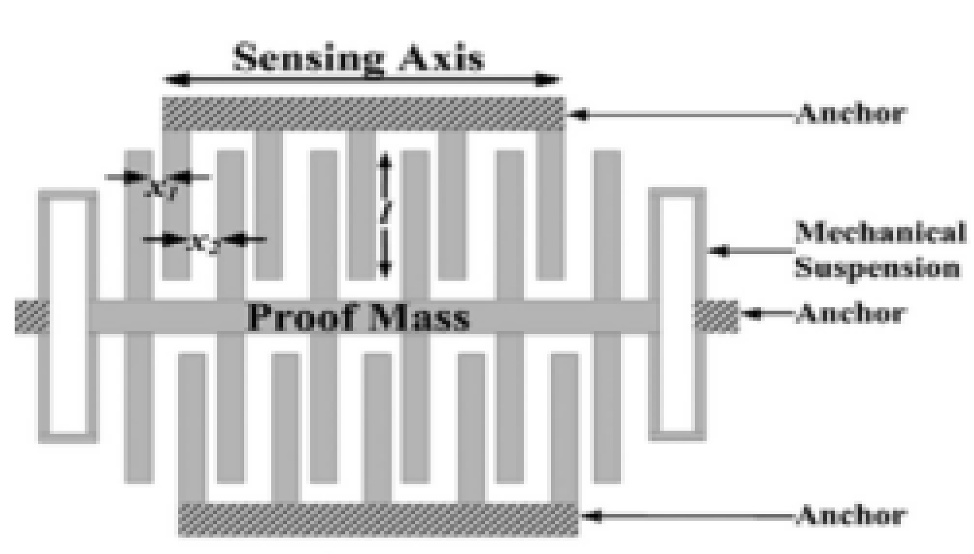

Figure 3. Prototype MEMS accelerometer architecture

Computational Methods: This model is simulated using COMSOL 4.2 in 2D as a plate structure. The physics used includes electrostatics, solid mechanics, and moving mesh. The geometry parameters of the model are given in figure 2. Corresponding to this input voice signal, the acceleration values from 0g to 1g are applied to the designed structures. The structures have been analysed using Silicon as material and dielectric as air. The proof mass along with movable fingers is connected to 1 V supply and the fixed fingers with ground.

$$C_{s+nom} = \left(\frac{\varepsilon_0 lt}{x_1} + \frac{\varepsilon_0 lt}{x_2}\right) \times N = C_{s+1} + C_{s+2}$$

$$\Delta C_{s+} = \left(\frac{\varepsilon_0 lt}{x_1}\frac{\Delta x}{x_1} - \frac{\varepsilon_0 lt}{x_2}\frac{\Delta x}{x_2}\right) \times N$$

Results: The variation of nominal capacitance and capacitive sensitivity with gap ratio (x_2/x_1)) are plotted in figures 3 and 4. The number of fingers and hence the capacitance decreases with increasing gap ratio. But the sensitivity varies randomly.

Geometry Parameters	Values (µm)
Thickness of plate	25
Width of finger	2
Finger overlap length	96
Width of spring beam	2a
Length of finger	116

Table 1. Geometry parameters of the accelerometer model

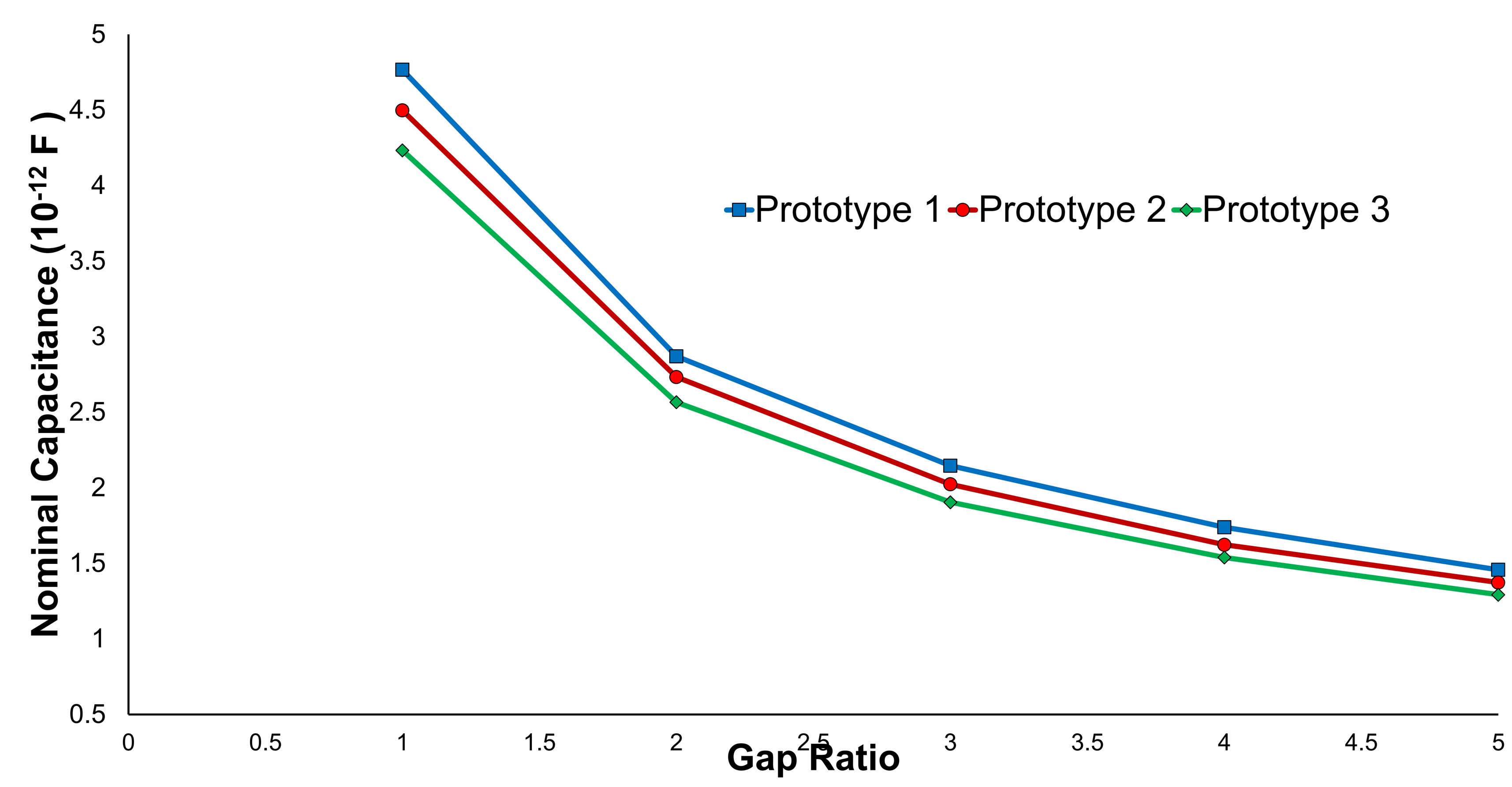

Figure 4. Nominal Capacitance vs gap ratio

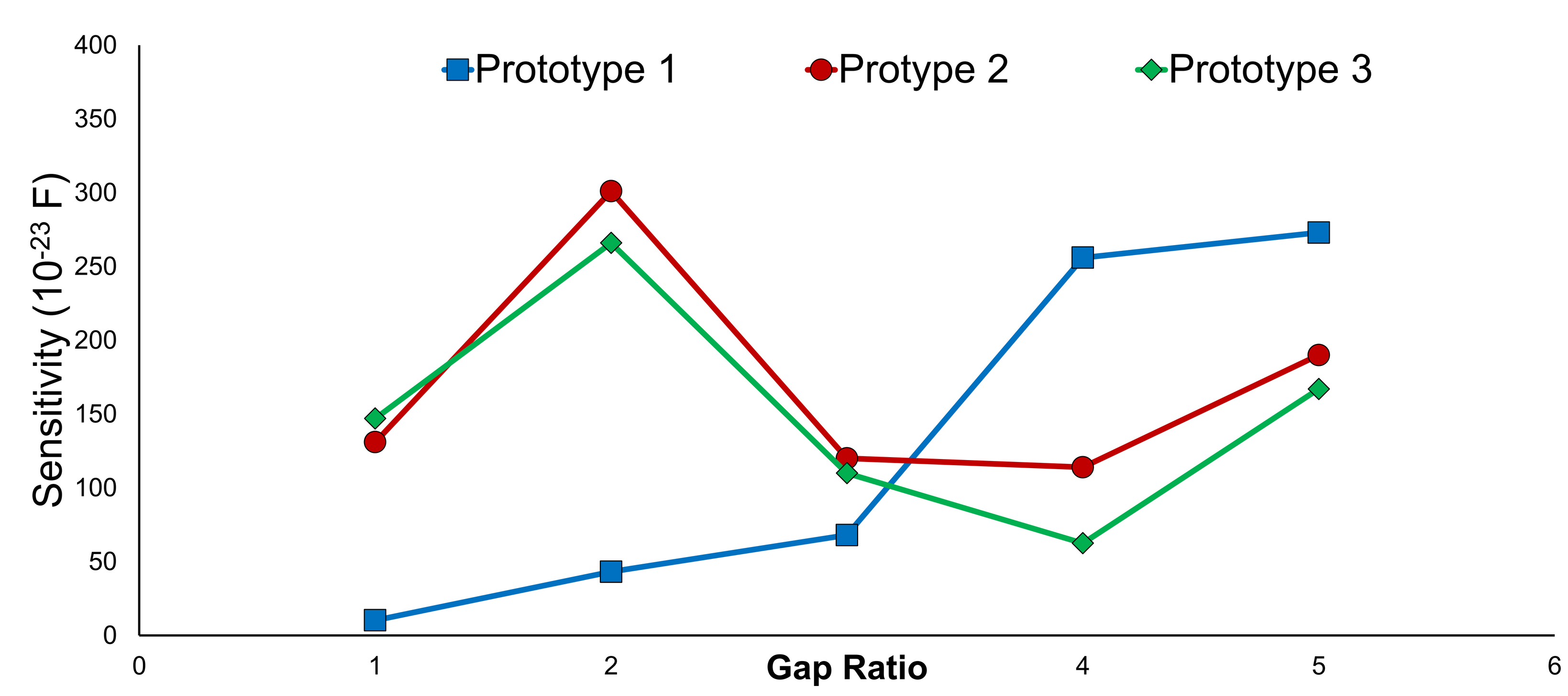

Figure 5. Capacitive sensitivity vs gap ratio

Conclusions: The optimum value of sensitivity is obtained at gap ratio of 2 for prototype 2.The optimised results will be used in selecting the prototype structure for designing high performance MEMS accelerometer for fully implantable hearing aid applications.

References:

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