Capacitive accelerometer characteristics study

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Introduction: To study the effect of the physical dimension and material property on the characteristics of a MEMS capacitive accelerometer such as frequency response, dynamic range, sensitivity and temperature range.

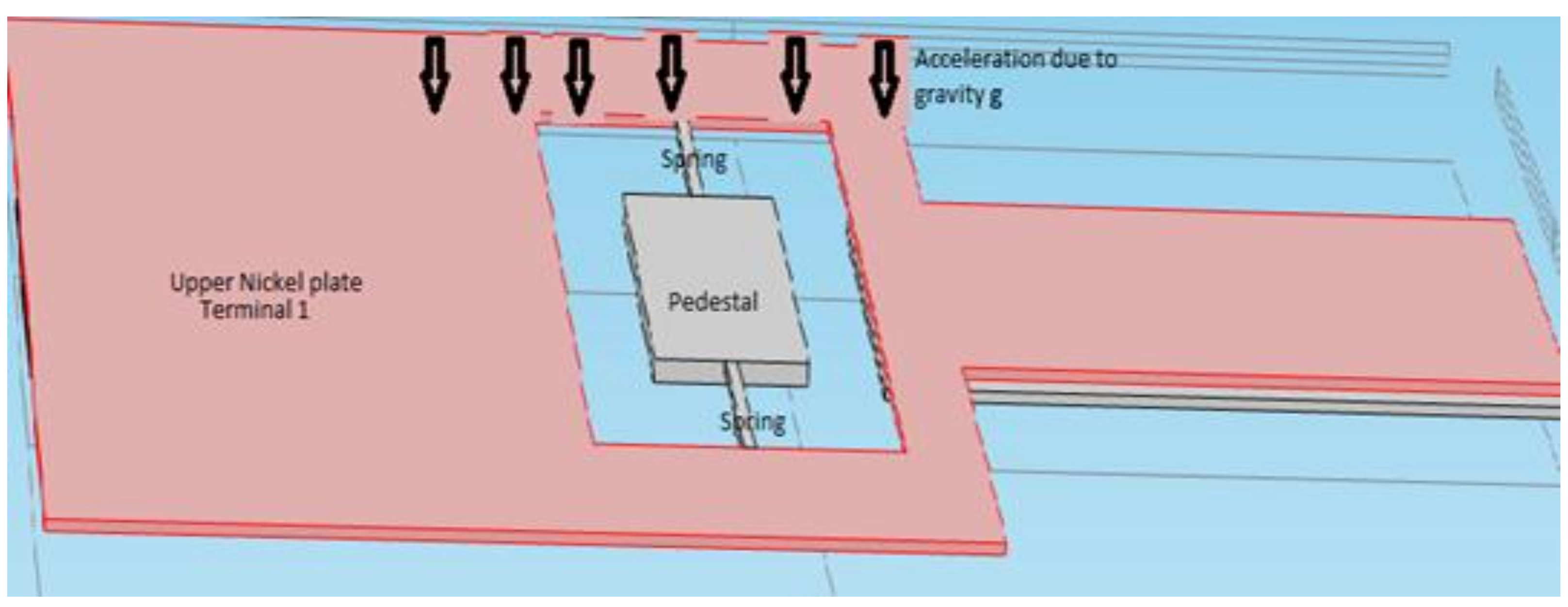

Figure 1: Top view of capacitive accelerometer

Computational Methods:

Acceleration due to gravity g is applied to the top surface of the sense element and simulated. Sensitivity, frequency response, dynamic range and temperature range of the accelerometer is measured. Error in experimental capacitance value with respect to theoretical calculation is measured.

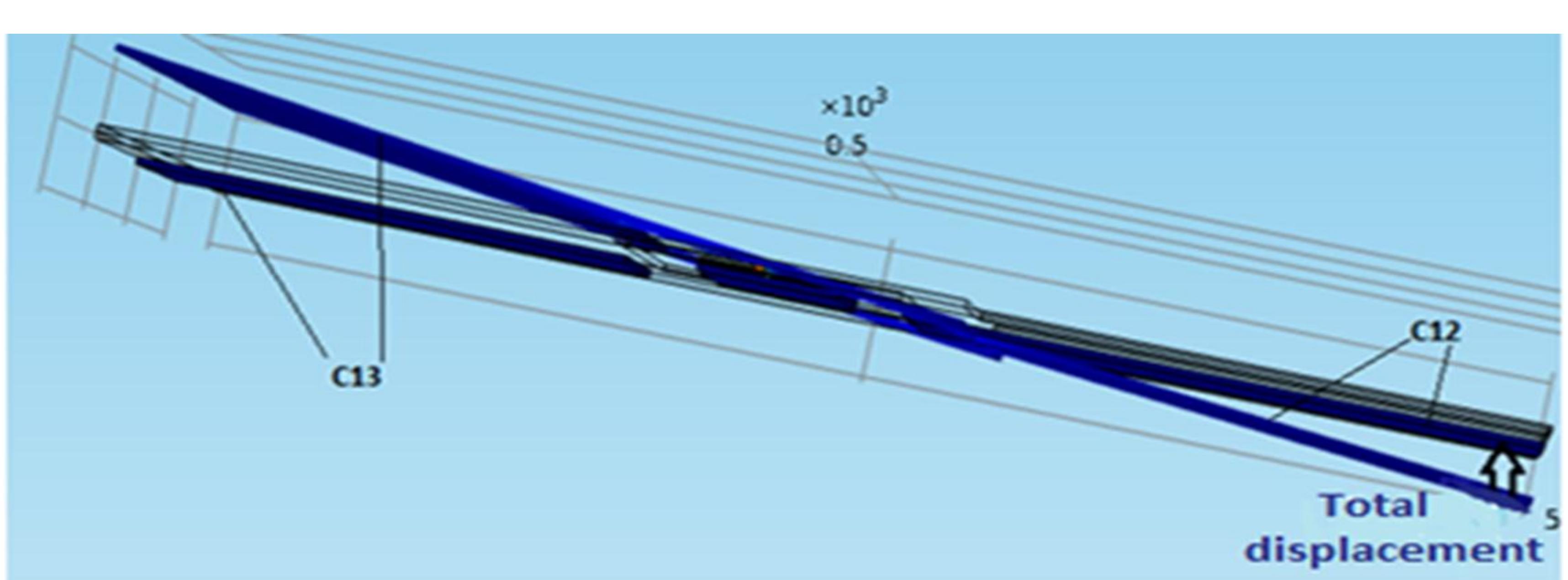

Figure 2: Capacitance measurement

Theoretical analysis

The capacitance is calculated using equations 1 and 2.

$$C12 = \frac{\varepsilon_0 * \varepsilon_r * A}{d+\delta} \qquad (1)$$

$$C13 == \frac{\varepsilon_0 * \varepsilon_r * A}{d-\delta} \qquad (2)$$

Where, δ = Deflection of the beam [m/g].

Sensitivity is given by,

$$Sensitivity = \frac{\Delta C}{g} = \frac{|C12 - C13|}{g}$$

Results: Four different accelerometer dimensions and the materials simulated in this paper are tabulated in table 1.

Plate and Dimensions	Length [μm]	Width [μm]	Thickness [μm]	Material [μm]
Upper plate Design-1,2,3,4	1000,1000, 1000, 1000	600,600, 600,600	5,10, 5,10	Nickel, Ni, Ni,Ni
Springs Design -1,2,3,4	8,10, 8,10	100,150, 100,150	5,10, 5,10	Si, Si, PDMS, PDMS

Table 1: Design dimensions and materials used

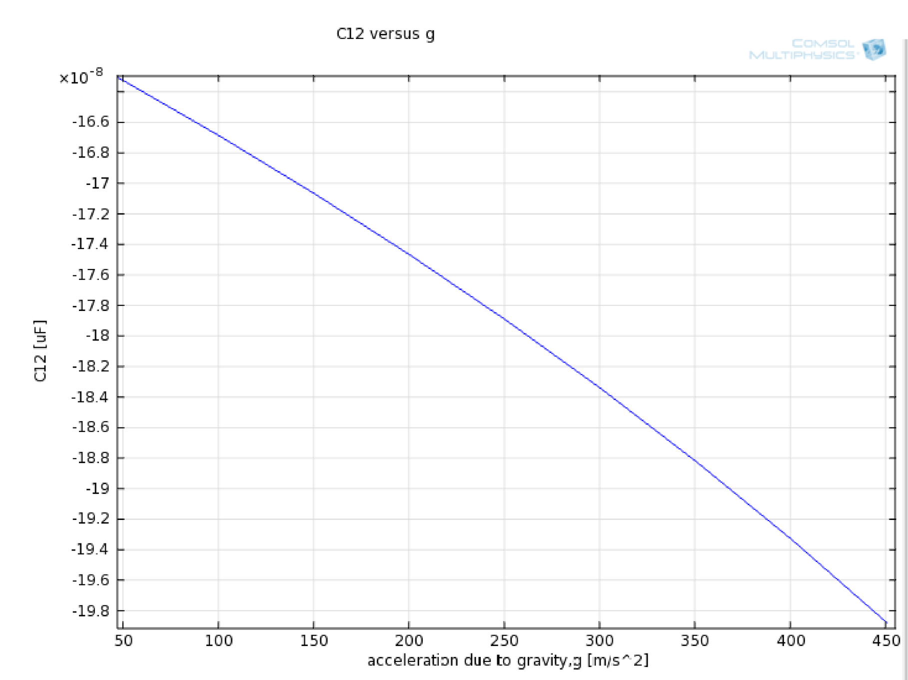

Figure 3: C12 versus g

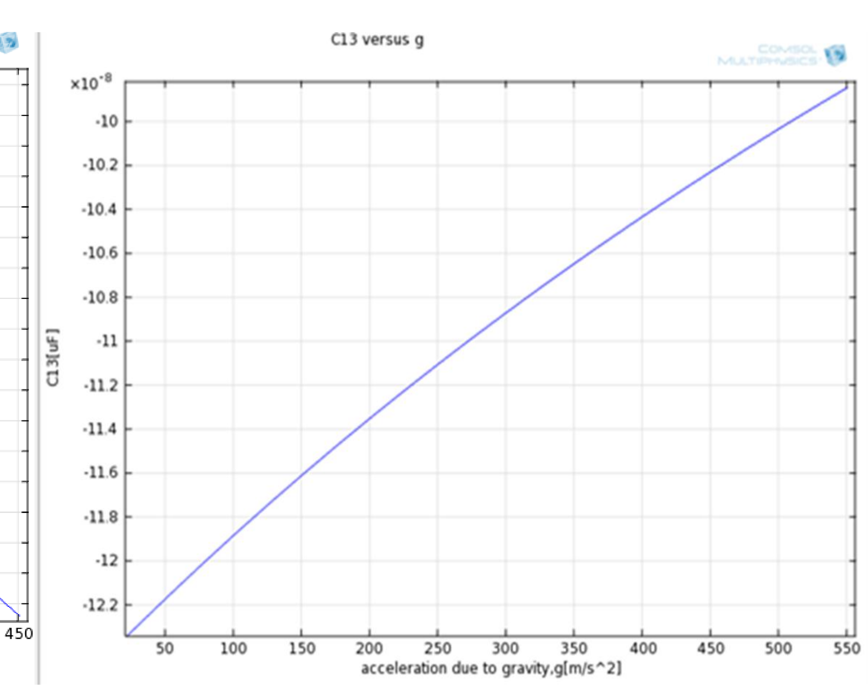

Figure 4: C13 versus g

Design	%error C12	%error C13	Sensitivity [fF/g]	Dynamic range[g]	Bandwidth [Hz]	Temperature range[K]
1	21.66	19.62	0.4764	400	115	200 - 400
2	**0.37**	**0.56**	**35.1**	**5500**	**190**	**95 – 480**
3	4	2.7	373	3E-4	0.7	280 – 305
4	24.9	21.6	47800	5E-3	0.7	275 - 310

Table 2: Design comparison table

Conclusions:

From table 2 we conclude that **Design 2** is the **optimised design** for the basic accelerometer model. This paper has made an attempt to understand the material and physical dimension dependence on accelerometer characteristics.

References:

1.Matej Andrejasic and Marec, "MEMS accelerometer," *Seminar*, University of Ljubljana, 2008.
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