Design and Analysis of MEMS Gyroscope

Preethi. B, Dr. L. Sujatha, V. S. Selvakumar
National MEMS Design Center, Rajalakshmi Engineering College, Thandalam, Chennai,TamilNadu-602105

Introduction: MEMS Gyroscope technology provides cost- effective method for improving directional estimation and overall accuracy in navigation systems. This paper presents a Tuning- fork gyroscope[1] with a perforated proof mass. The perforated proof mass enables the reduction of damping effect. This gyroscope has two modes- drive mode and sense mode. The device is driven at its natural frequency and the response of the device is analyzed. The TFG produced a displacement of 2.6 × 10^{-9} m. The frequency range applied is 0.027 - 0.24 MHz

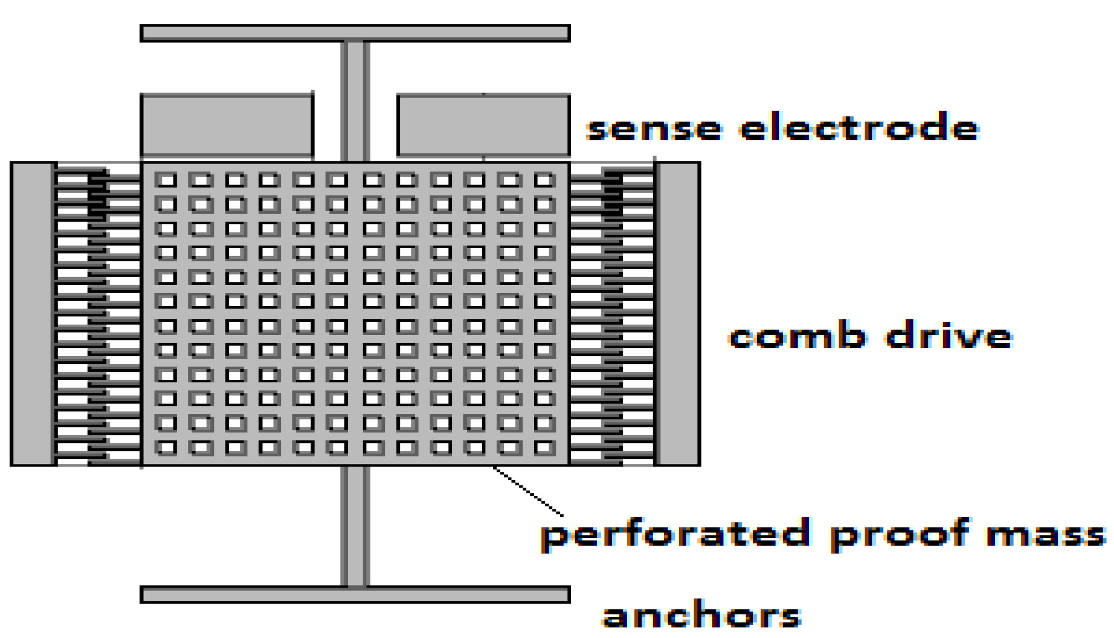

Figure 1. MEMS gyroscope with perforated proof mass

Computational Methods: The structure is fixed at the anchors, while the rest of the structure including the proof mass is free to move. The proof mass is electro statically actuated by applying voltage of 2V to the comb drive. The proof mass vibrates in x- direction which contributes to the drive mode. When coriolis force is applied, the device vibrates in perpendicular direction contributing to the sense mode. The parameters required for the design are listed :

NAME	EXPRESSION
Omega	50*pi [rad/s]
M	Rho*volume
v	2[m/s]
Coriolis	2*m*omega*v
F	1 [1/s]
Rho	2320 [kg/m^3]
volume	2.7 * 10^{-12}[m]

Results: The amount of displacement of the device is proportional to the load applied. The amount of displacement obtained is 2.6 × 10^{-9} m.

Eigen frequency analysis is done to inspect the gyroscope performance in different frequencies. The parametric sweep is chosen, to define the frequency range. The frequency range applied is 0.027 - 0.24 Mhz.

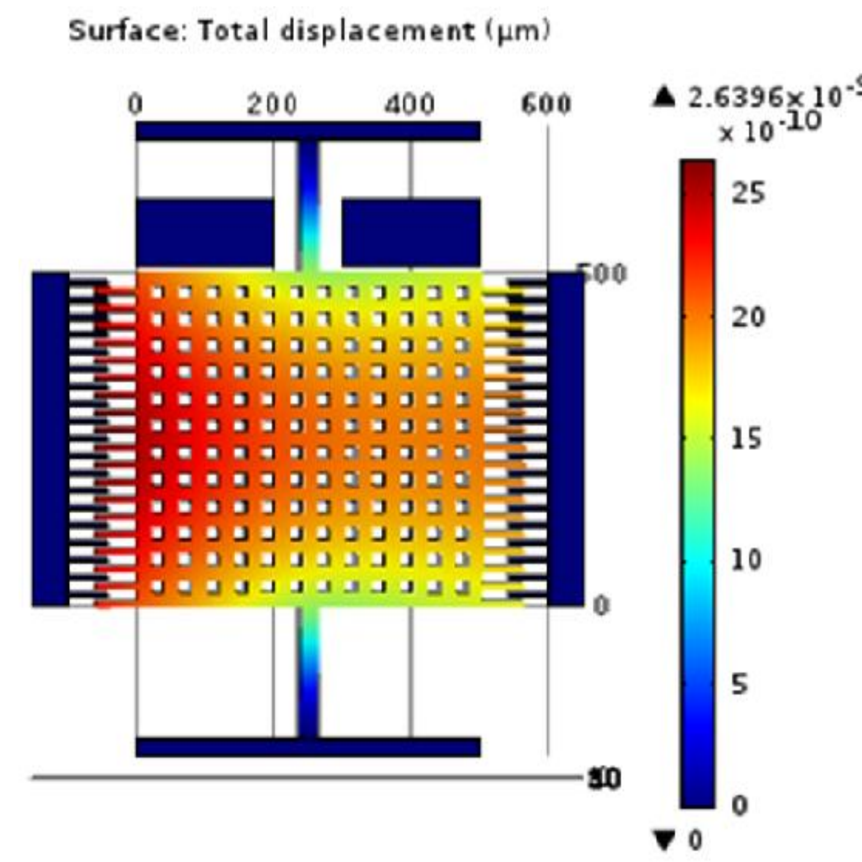

Figure 2. Displacement in stationary study

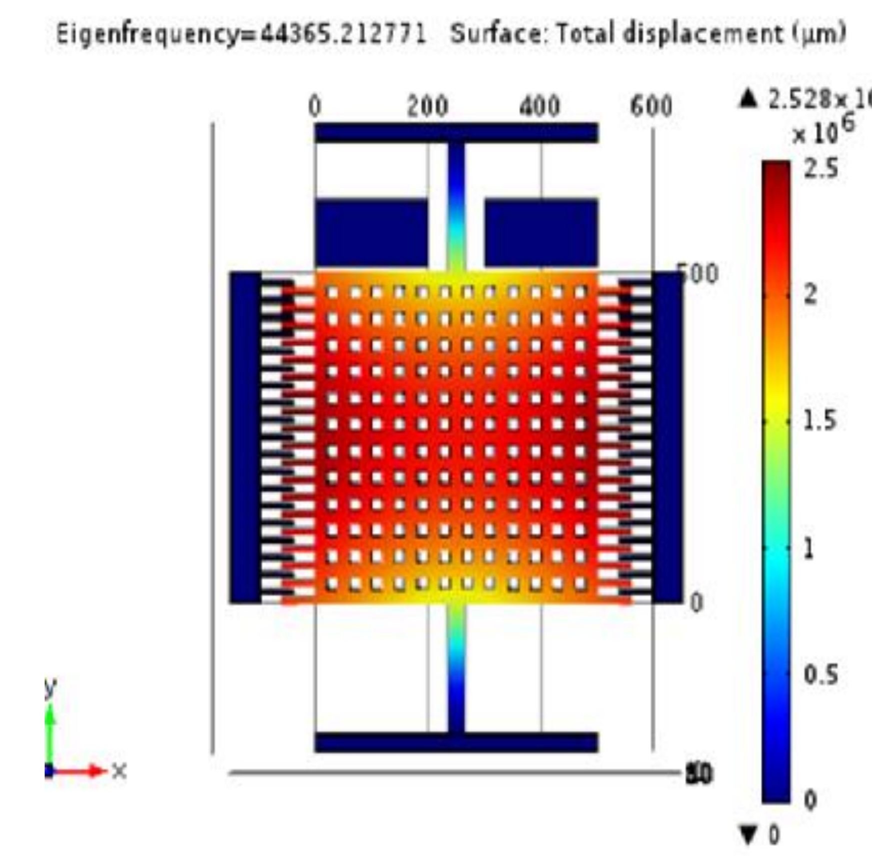

Figure 3. . Eigen frequency displacement

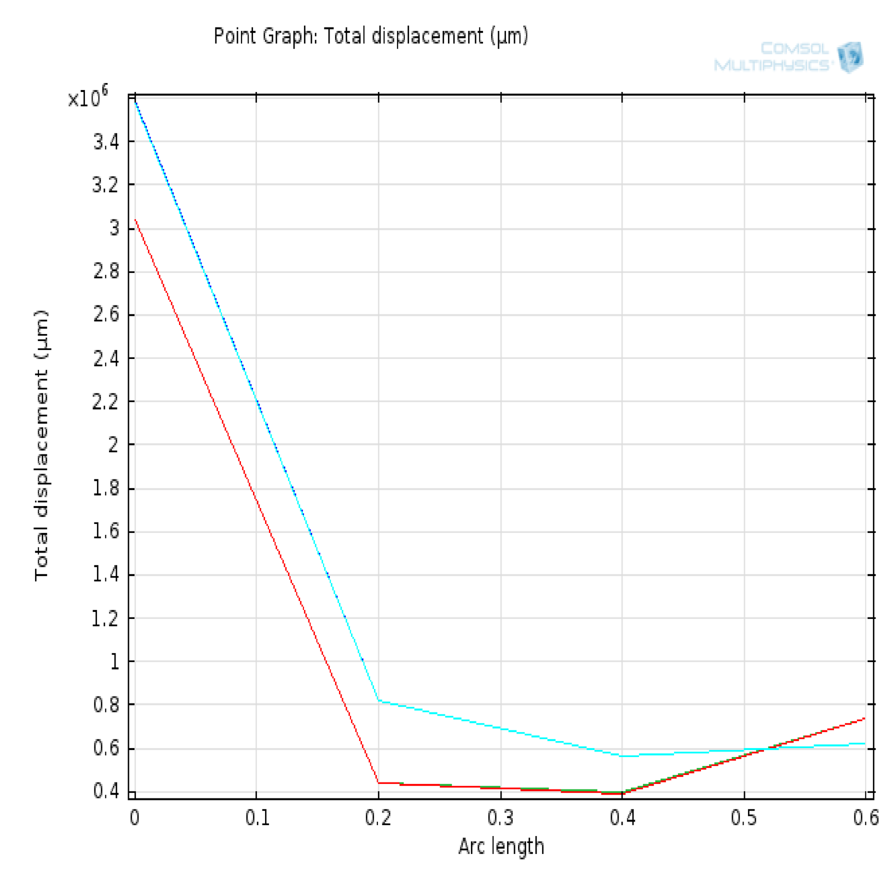

Figure 4. Displacement in frequencies

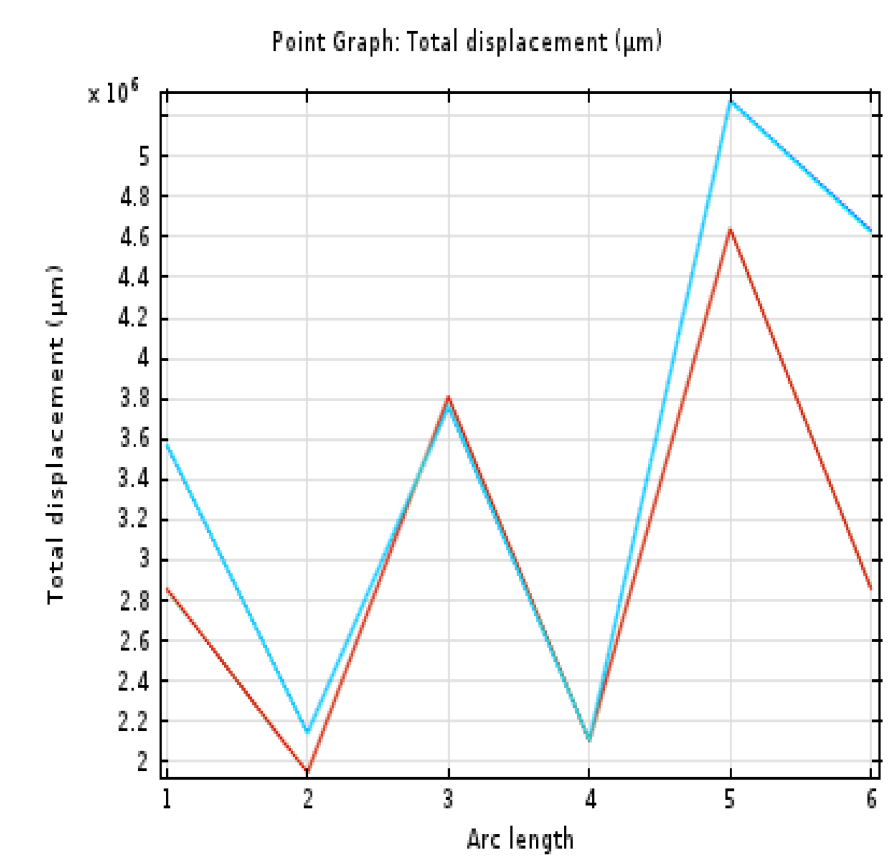

Figure 6. Drive and sense modes

Conclusions: The gyroscope is designed to resonate in its fundamental mode and is exited via external comb drives. The torsional sensing combs help to lower the air damping of the sensing mode. The proof mass area is minimized and the structure is modified as perforated proof mass. The perforated mass design incorporated in the structure, will improve the performance of the gyroscope.

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References:

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2. Braxmaier. M, Geiger. W, Butt. W. U., Gaiber. A, Frech. J, Link. T, Kohne. A, Nommenson. P,Sandmaier. H, Lang. W, "Decoupled Micro Gyros and the Design Principle DAVED", Sense. Actuators A, phys., vol. 95, no. 2/3, pp. 239- 249, (2002).
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