Design Optimization of Piezoelectric Micro-machined Modal Gyroscope

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Introduction: MEMS gyroscope has transformed the way we interact with gadgets by providing rotational motion sensing. In this study a new design is proposed for better sensing capability using Piezoelectric crystal.

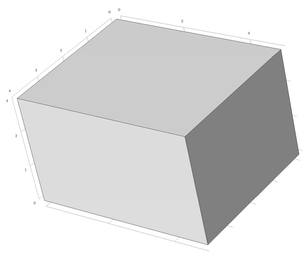

Figure 1. Simple cuboidal Piezoelectric crystal

Working principal of PMMG: Crystal is kept in natural frequency vibration suitable for gyroscopic action. When the angular velocity along an axis is input, the Coriolis force is generated according to movement of the mass elements resulting in compressive and tensile stresses depending on the position which induces piezoelectric voltage on surfaces which is proportional to the input angular rate.

Modal Analysis: The mode suitable for gyroscopic action is 9th mode which was vibrating at 352.217KHz.

Harmonic Analysis: voltage of same frequency was applied to verify the response of crystal.

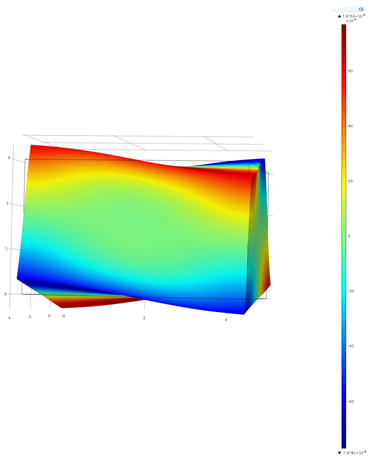

Figure 2. Response of crystal for Harmonic analysis

Design Modification: The new structure is found to be vibrating at 3.064 kHz. Also the modified structure has two distinct vibratory modes which are symmetric making it ideal for dual axis sensing. Having lower modal frequency and larger vibratory amplitude causes increase in sensitivity of the gyroscope.

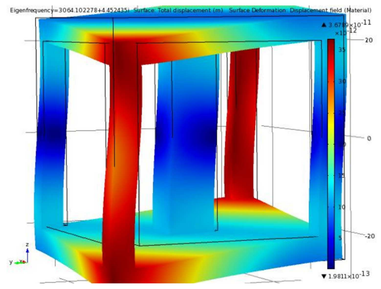

Figure 3. 7th Mode

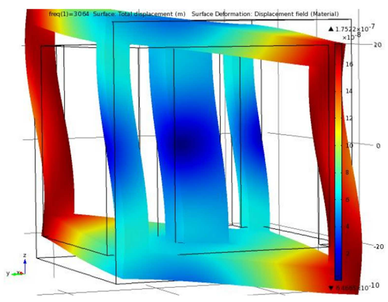

Figure 4. 8th mode

Conclusions: The new design is successful in increasing sensitivity by lowering the working frequency of crystal which makes it easy to displace from its vibrating locus at the same time consume less power due to lower frequency. Also the symmetric vibrating modes makes it suitable for dual axis sensing. Future research would be to manufacture and test this design.

References:

1. Xiaosheng Wu , Wenyuan Chen, Weiping Zhang et al ., Yipeng Lu et al ., Feng Cui et al .,Modeling Analysis of Piezoelectric Micro machined Modal Gyroscope (PMMG), The 12th International Conference on Sol i d St at e Sensors, Actuators and Micro systems, Boston, June 8-12 pp. 1726-1729(2003)

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