FEM DESIGN OF INTERFEROMETRIC FBGL ACCELEROMETER FOR UNDERWATER APPLICATIONS

Presented by:

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INTRODUCTION

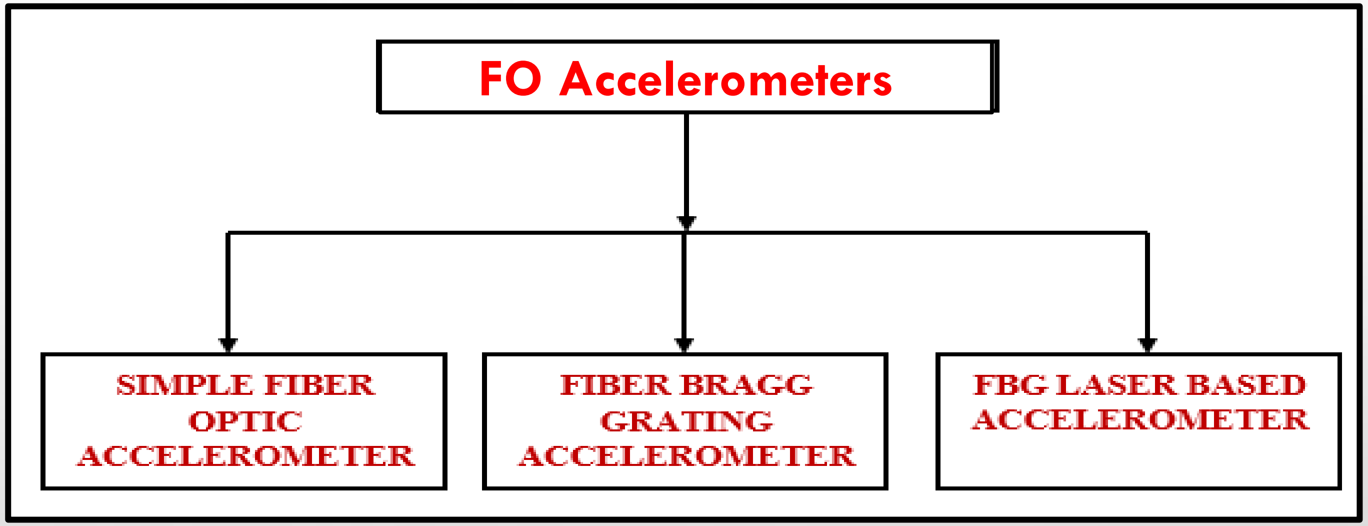


Fig. 1 Accelerometer classification

- FBGL accelerometers offers more sensitivity than FBG accelerometer.
- Wide range of applications: including defence, seismic sensing, structural monitoring etc…

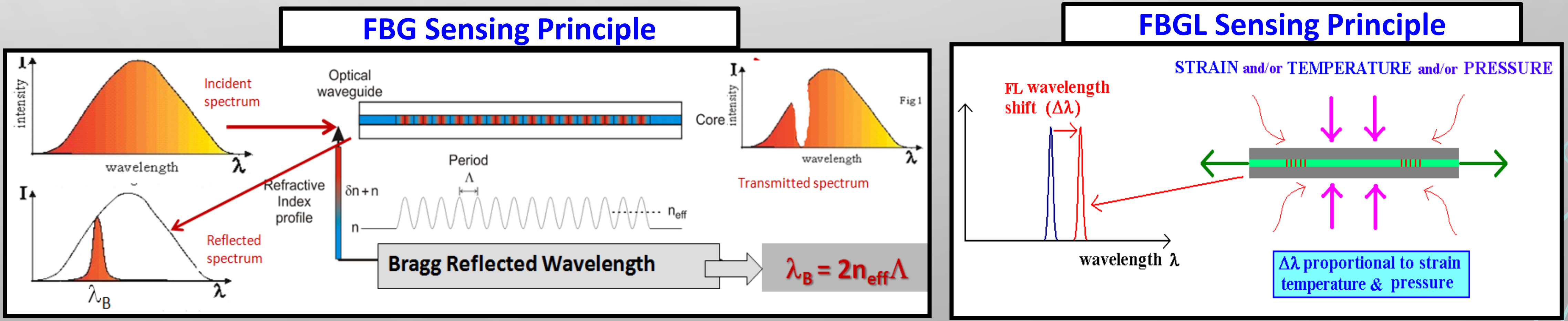


Fig. 2 Shift in Bragg reflected wavelength and Emission wavelength of the laser

ACCELEROMETER DESIGN

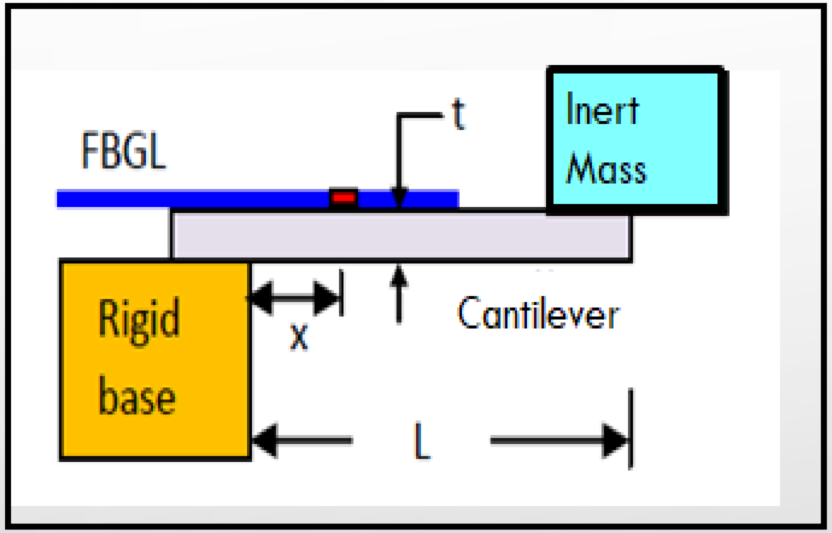


Fig. 3 Proposed Accelerometer Design

Resonant frequency, $\omega_0 = \sqrt{\frac{1}{4}\left(\frac{bt^3E}{ML^3}\right)}$

x - Distance of grating from fixed position.

L - Length of cantilever

t - Thickness of cantilever

L x b x t- Cantilever dimensions

M - Inert mass

E - Young’s modulus

- Bandwidth of the accelerometer is determined by the Resonance frequency
- Thump rule: linearity / flat response in dB is 1/5th of ω_o

Contd…

- Strain experienced by the FBG laser,

$$\varepsilon(x) = \frac{3(0.5d)(L-x)}{(\omega_0^2 - \omega^2)L^3} \times a$$

- Sensitivity of the accelerometer

$$S = \frac{\Delta\lambda}{a} = \frac{1.2 \times \varepsilon_F(x)}{a}$$

- Phase sensitivity

$$\frac{\delta(\Delta\phi)}{\delta\lambda_L(\omega)} = \frac{2\pi}{\lambda_L^2}(n \times \Delta L)$$

Contd…

- FBG laser was used as the sensor instead of simple fiber.

- Along with this system Mach- Zehnder interferometer was used for sensitivity measurement.

- Acceleration of the structure induces dynamic strain along the fiber axis.

- Dynamic strain results in Bragg wavelength shift which is proportional to acceleration.

COMSOL MODELLING

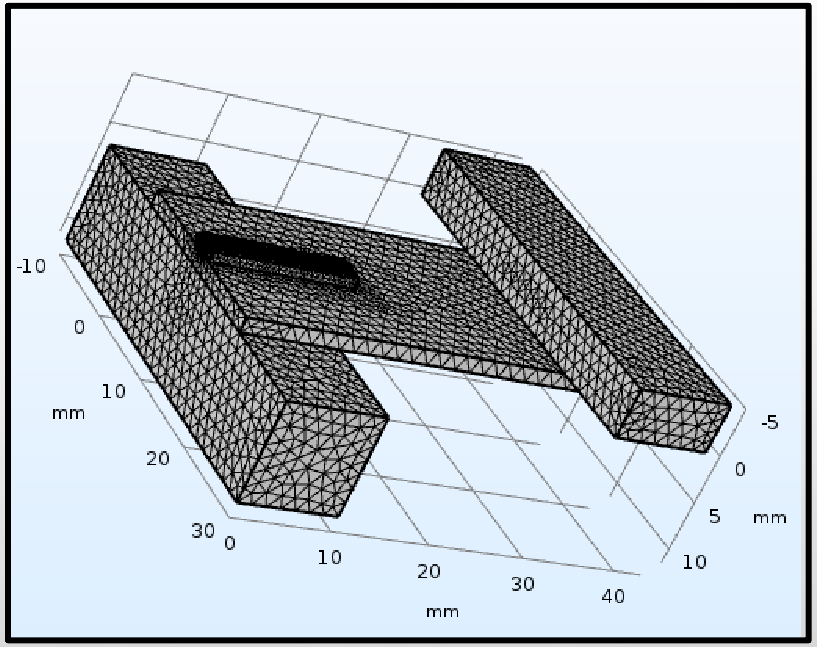


Fig. 4 Meshed configuration of the design

Equations governing the frequency domain study are,

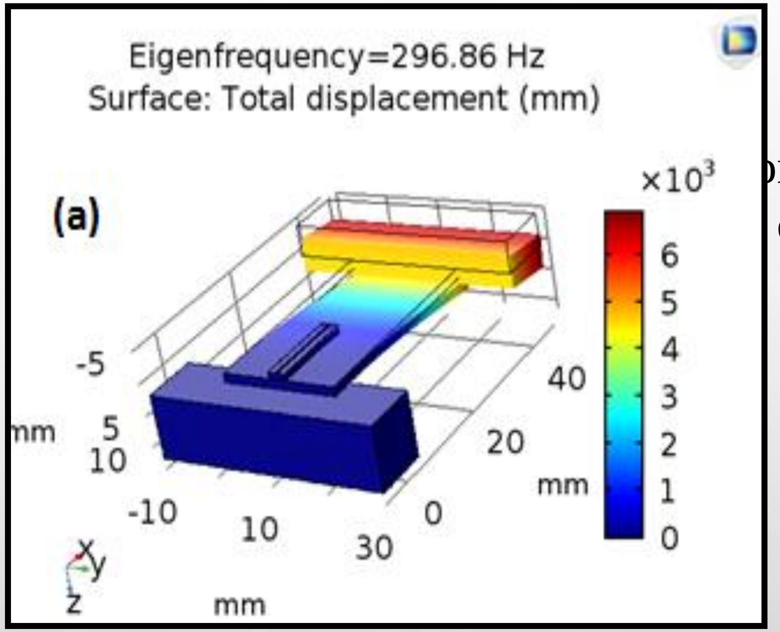
$$-\rho\omega^2 u = \nabla . s + F_v e^{i\emptyset}, -ik_z = \lambda$$

$$s = s_{ad} + c : \epsilon_{el}, \epsilon_{el} = \epsilon - \epsilon_{inel}$$

$$\epsilon = \frac{1}{2}[(\nabla u)^T + \nabla u]$$

s - stress tensor,
ϵ - total strain tensor,
F - force
ω - angular frequency
ρ - density

Contd…



…nant mode movement of the cantilever

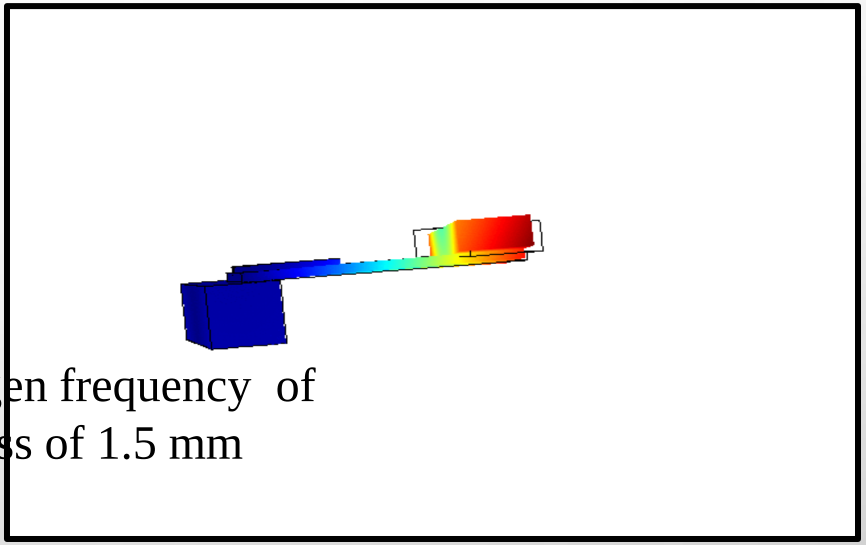


Fig. 5 Results showing Eigen frequency of cantilever with thickness of 1.5 mm

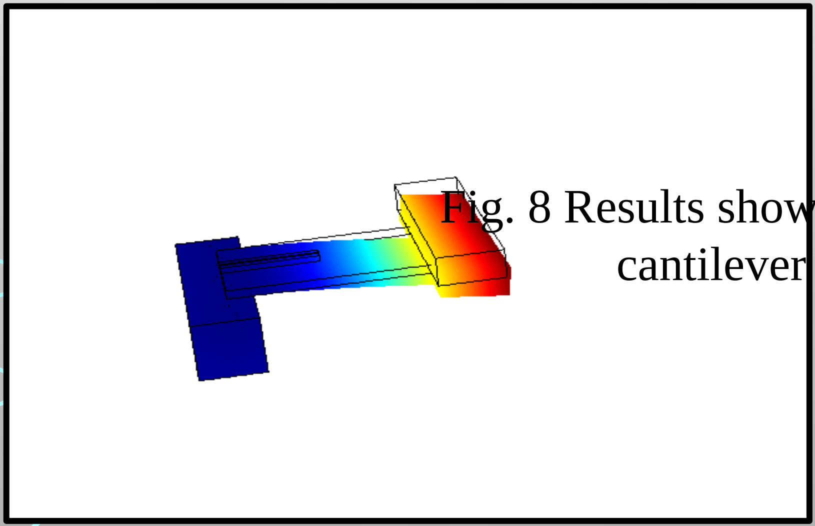
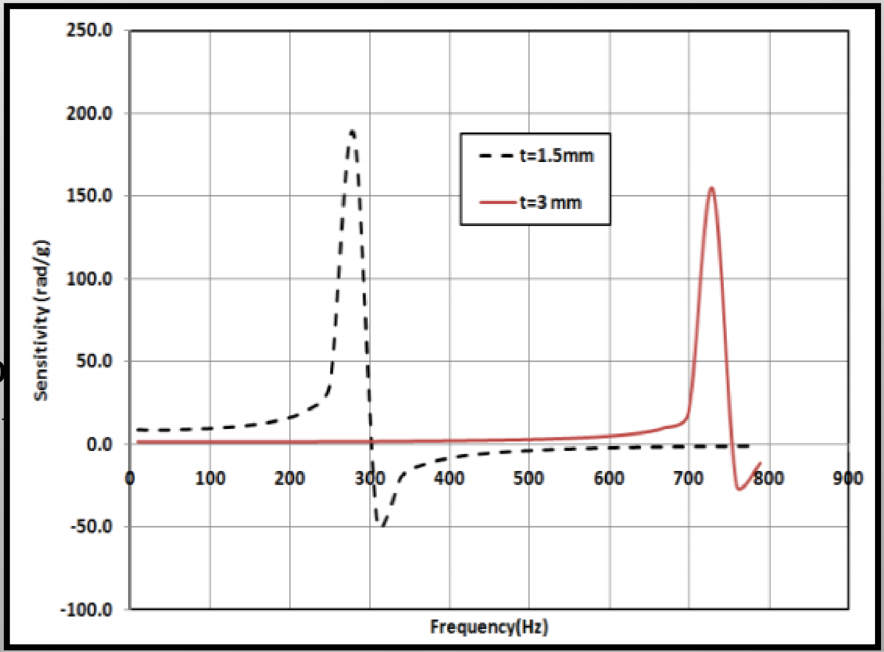


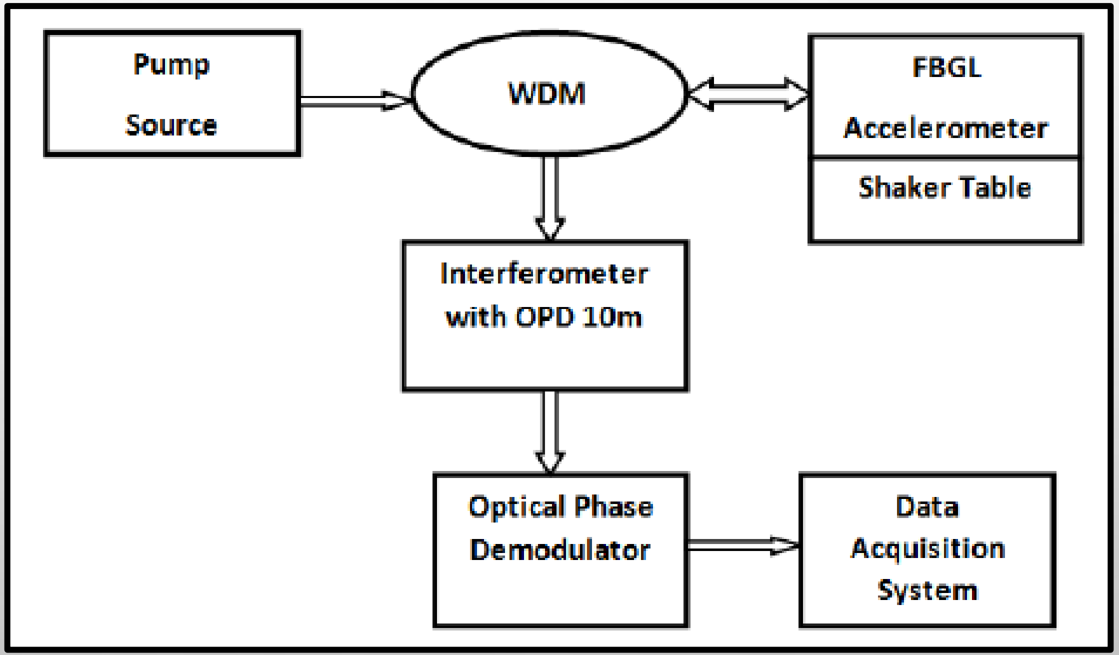
Fig. 8 Results showing dependency of cantilever thickness

Fig. 6 First resonant mo… cantile…



EXPERIMENTAL RESULTS

- Experimental studies were conducted on the prototype developed.



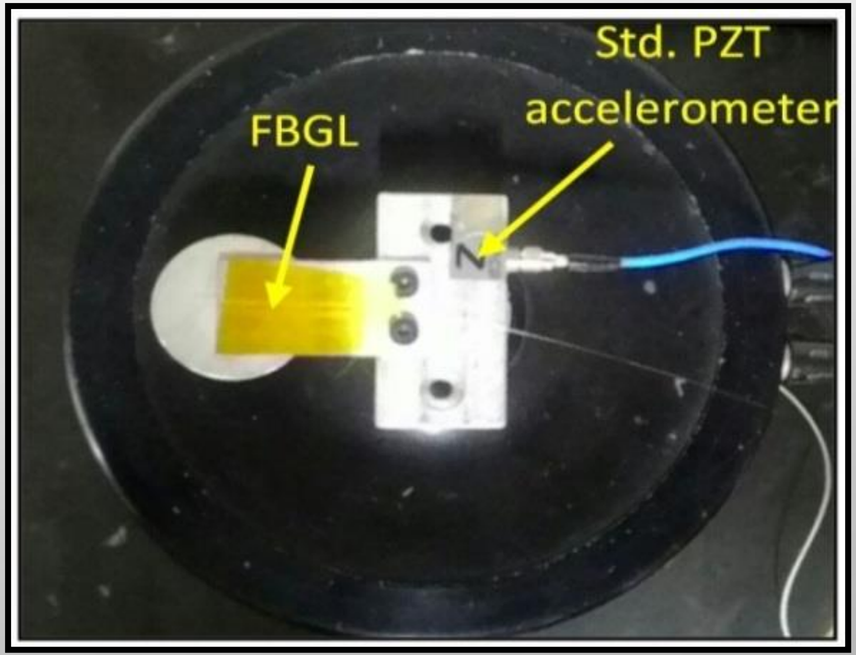


Fig. 9 Experimental setup and block diagram

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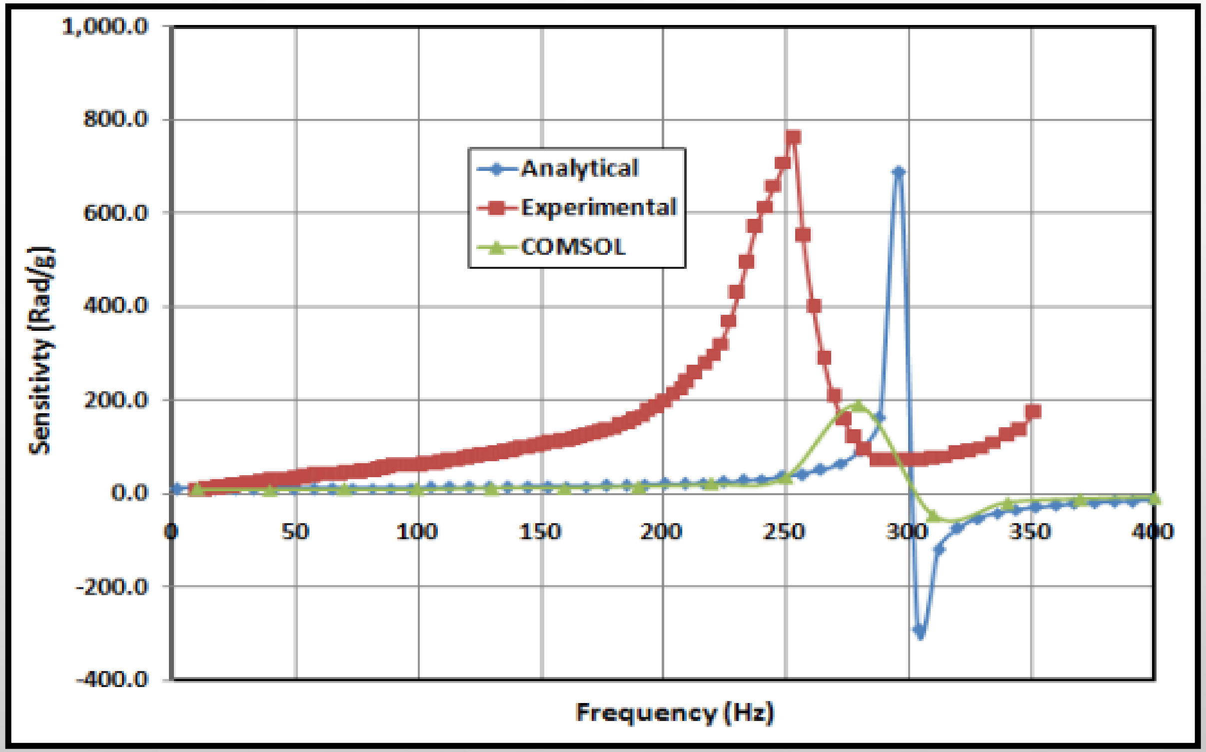

Fig. 10 Comparison between COMSOL, analytical and experimental results.

- Prototype material was selected as stainless steel.
- Dimensions were 40 mm x 20 mm x 1.5 mm.

CONCLUSION

- Designed prototype yielded a sensitivity of 20V/g (or 20 rad/g) and flatness up to 60Hz.

- FEM modelling of FBGL accelerometer design was carried out along with different cantilever dimensions and materials.

- The COMSOL model results are found to be fairly matching with the analytical and experimental results.

COMSOL CONFERENCE 2018 BANGALORE

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THANK YOU