Design of the structure and selection of Multiphysics environment

1.Steps for designing PUEH using COMSOL software in air as medium

Designing a piezoelectric MEMS (Micro-Electro-Mechanical Systems) energy harvester in COMSOL Multiphysics involves several key steps, including material selection, geometry design, physics setup, meshing, solving, and post-processing. Here's the steps for designing energy harvester using COMSOL.

1.1 Geometry and Material Properties

In COMSOL, the geometry of your model determines the structure and shape of your energy harvester. Define the precise dimensions of each geometric element. For MEMS devices, these dimensions are typically in micrometers or millimeters. Build a complex structure by creating multiple parts or components. This can help organize the geometry and allow for reuse of components.

$$f = \frac{1}{2\pi}\sqrt{\frac{D}{p}}\cdot\left(\frac{\pi^2}{a^2}+\frac{\pi^2}{b^2}\right)$$

where f= resonant frequency (HZ),

D= flexural rigidity of diaphragm (n/m2),

a = length of the diaphragm (m),

b= width of diaphragm (m).

h = height of the diaphragm (m),

The flexural rigidity (D) given by

$$D= \frac{Eh^3}{12(1-v^2)}$$

where E= young's modulus of the diaphragm material,

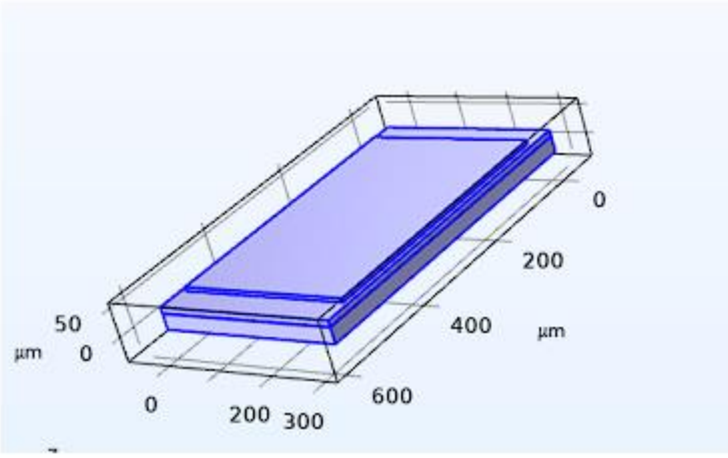
h= thickness of diaphragm ,

v= poison's ratio of diaphragm,

from the above equations with f= 1MHz ,

a= 600 micrometer and b= 241 micrometer

	Length (um)	Width (um)	Height (um)
Silicon bottom	700	300	10
SIO2	700	300	1
Silicon top	700	300	2
PZT	600	241	2
Platinum electrode	600	241	0.2



Characteristics of designed structure under different mediums

1.Eigen frequency study of PUEH

Eigen studies of piezoelectric ultrasonic energy harvesters examine their intrinsic characteristics, such as natural frequencies and mode shapes. These characteristics determine the system's behavior under different conditions, impacting energy harvesting efficiency. Understanding natural frequencies helps design harvesters that resonate at frequencies likely to be encountered, enhancing efficiency. Mode shapes provide insights into deformation patterns, allowing engineers to optimize design and achieve desired performance.

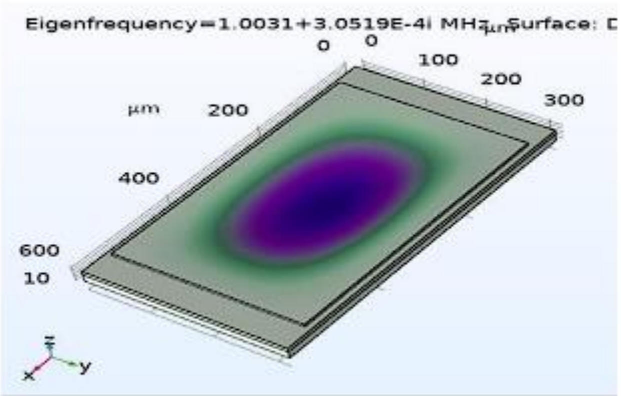


Figure : Eigen frequency study of PUEH

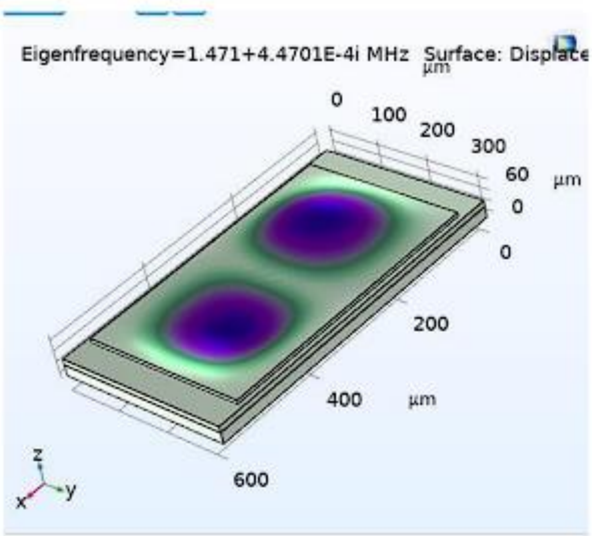


Figure :Eigen frequency study of PUEH in second order Vibration mode

Table : calculation of input pressure in different medium

Medium	Acoustic impedance (kg/m2-s)	Ultrasound pressure (pa)
Bone	5.3×10^6	10677
Water	1.48×10^6	5440
Blood	1.62×10^6	5692

Table 4.2.2 Ultrasound properties in different medium

Medium	Density (kg/m3)	Speed of ultrasound(m/s)	Acoustic impedance(kg/(m2-s))
Air	1.3	343	0.0004×10^6
Water	1000	1480	1.48×10^6
Blood	1060	1580	1.62×10^6
Bone	1400	4080	5.7×10^6

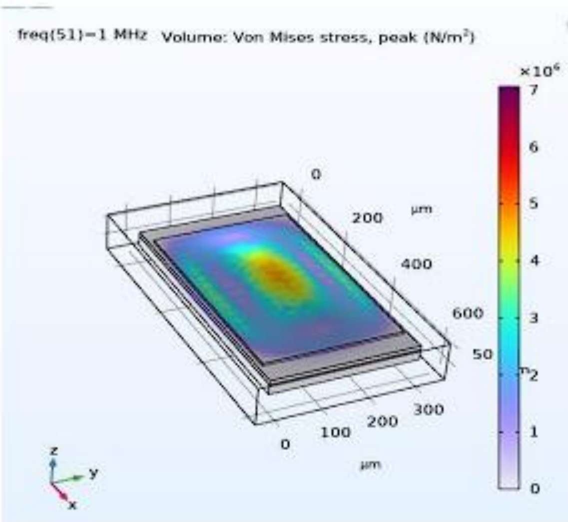


Figure: Stress plot of PUEH