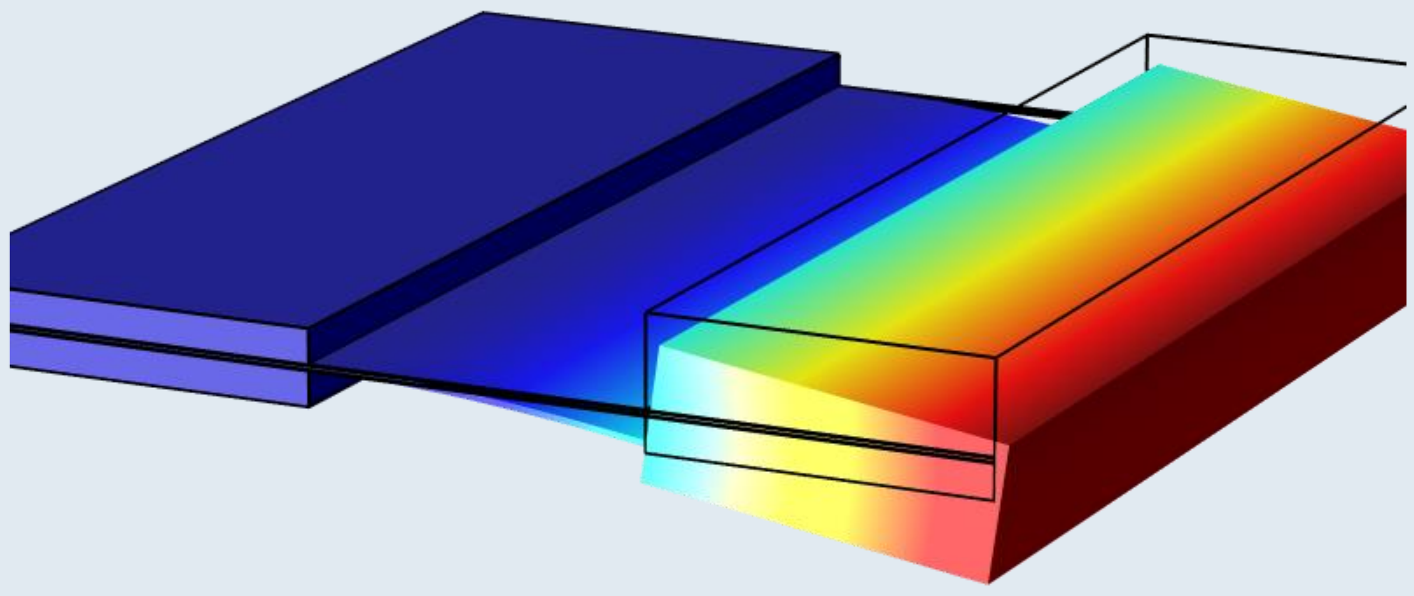

THERMAL ANALYSIS OF A PIEZOELECTRIC ENERGY HARVESTER

Simulation and experimental investigation of the temperature dependence of cantilever-type PVDF-based piezoelectric energy harvesting device

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Introduction and Goals

During usage, storage, and transportation, electronic products often become affected by a few unwanted adverse effects of the surrounding environment that compromise their working performance, reliability, and device life. There is evidence that environmental effects cause 52% of such electronic devices to fail.

Therefore, a study is conducted to investigate the effect of temperature [-20 °C; 50 °C] on the energy generation capacity of a piezoelectric energy harvester cantilever having a power density of $3.77\mu W/\mathrm{g}/\mathrm{mm}^3$ at room temperature. Temperature tests are performed experimentally on prepared real prototypes of energy harvesters and compared with simulated results

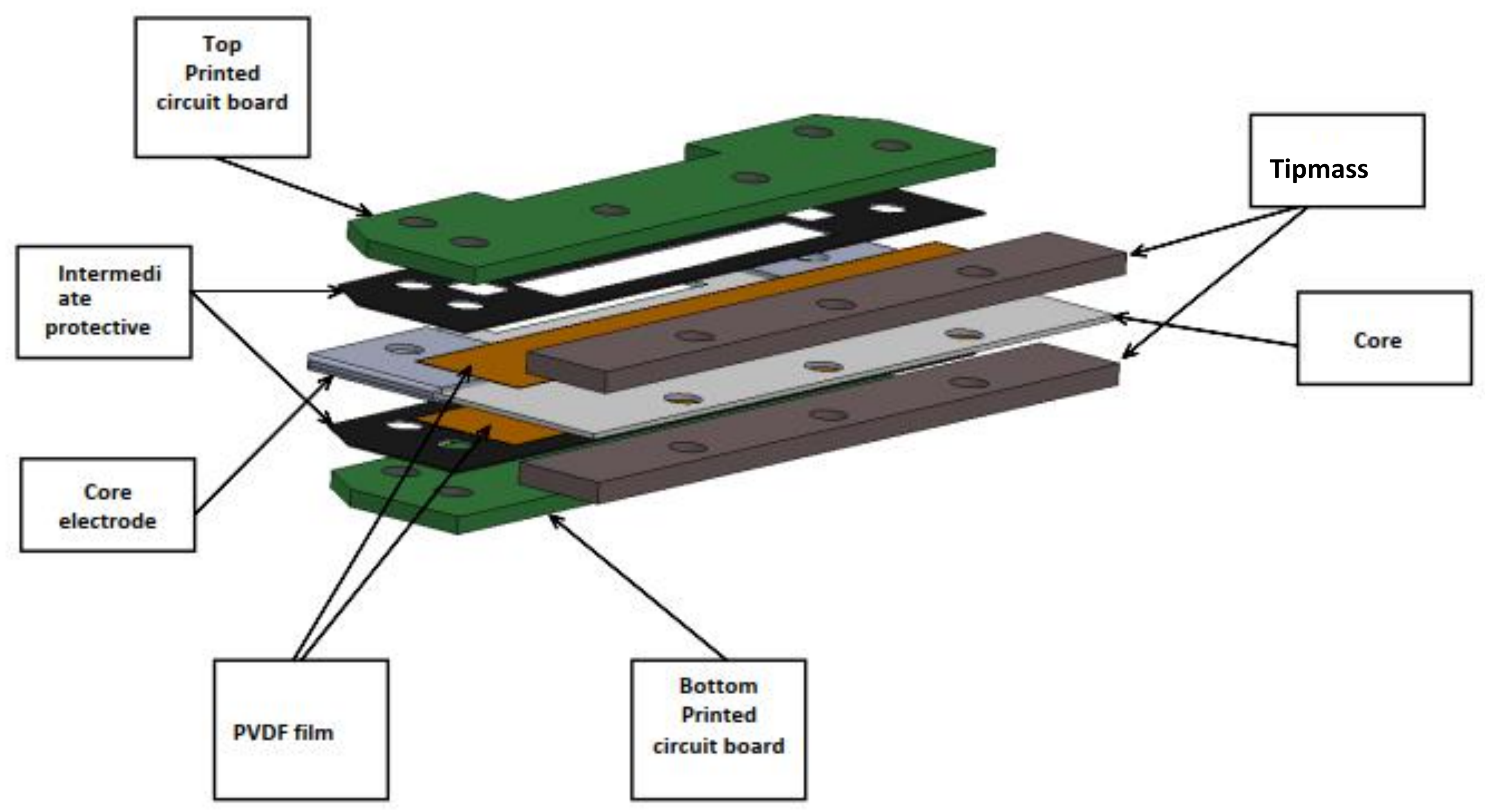


Figure 1. Structural composition of the developed energy harvester[1]

Methodology

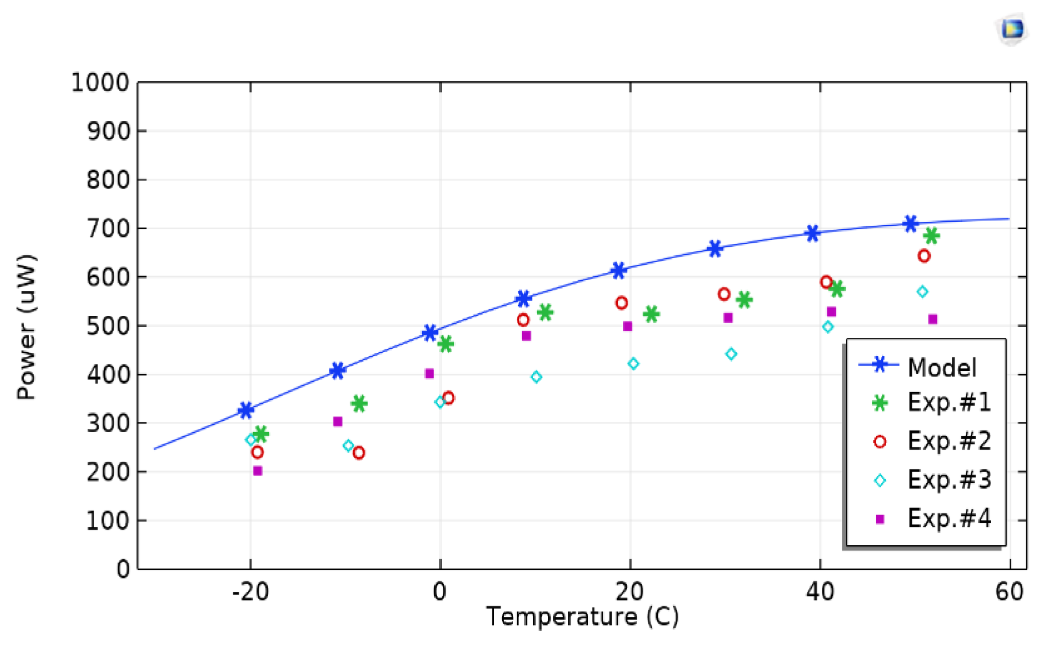
The lumped parameter mathematical model adopted in our study is from ref [2],

$$v(t) = -\frac{-jR\theta m_e \omega^3 Y_0 e^{j\omega t}}{({\omega_{nL}}^2 - \omega^2 + j2\zeta m_e \omega) \times (m_e + jm_e R C_p \omega) + jR\theta^2 \omega}$$

Where $v(t)$ is the generated output voltage, θ is the electromechanical coupling factor, R is the load resistance, m_e is the effective mass of the beam, m_e is the effective mass of the beam, ζ is the mechanical damping ratio , C_p is the equivalent capacitance, L is the length of the beam, ω_{nL} is the natural frequency

Results

- Well-fitted model and temperature test simulation is built using defined Rayleigh coefficients. The simulation results are in agreement with the practical results with sufficient error(up to 10%)
- The energy harvester in simulation generates power of 329 μW, 642 μW and 710 μW at a uniform 0.5g acceleration in temperatures $-20^0C, 25^0C$ and 50^0C respectively, with a rate of increase of $5\mu W/^0C$ and the resonant frequency remains almost stable at all temperatures.
- The results help to anticipate the maximum safe operating temperature range, the service life, the storage conditions, and this also leads to more efficient use of existing materials and fewer device failures



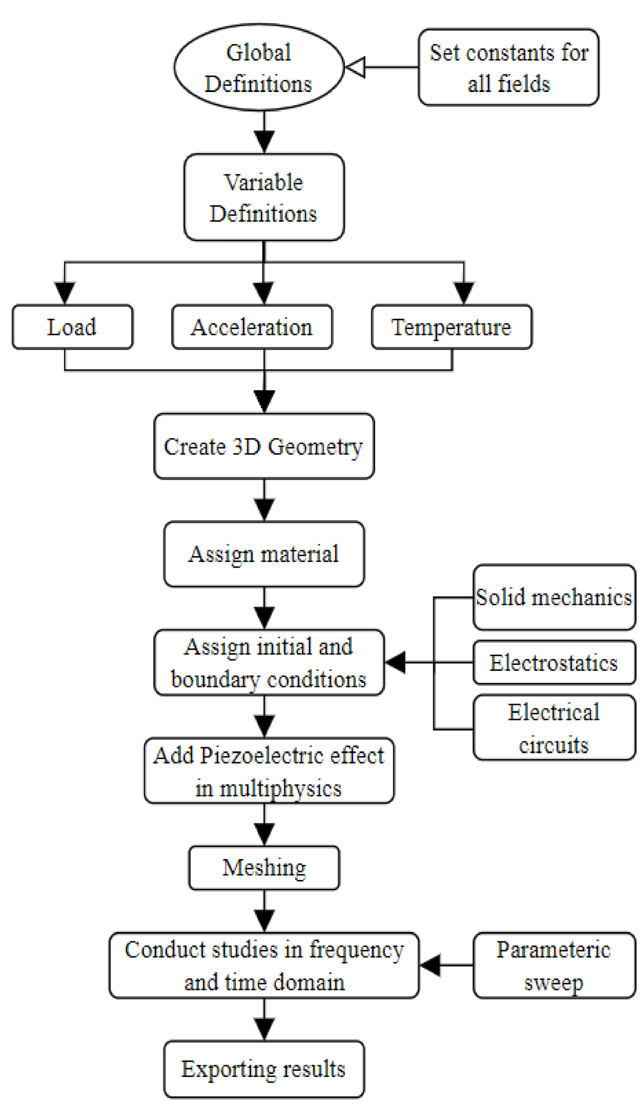


Figure 2. (a) Power generated versus Temperature change both experiment and simulation results
(b) Implementation of the temperature test procedure in COMSOL

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