**Masters Thesis Information Showcase**
**Spring Semester-2026**
**Year 2026**

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| | **Department: Mechanical Engineering**<br>Programme: Masters in Engineering<br>Specialization: Mechatronics |
| **1** | **Title of the Thesis**<br><br>Simulation and Analysis of Micro Thin Film Piezoelectric Energy Harvester |
| **2** | **Abstract** (min 300 to 500 words)<br><br>This thesis investigates the ZnO piezoelectric film's response under different mechanical loadings such as bending load, tensile load, torsional load etc. The results and analysis focus on the maximum load the film can bear and the maximum electrical output it can generate under the maximum allowable loading. Under these loadings, the film thickness is increased from 25 to 75 micrometers, increasing the durability and strength of the film under bending and tensile loading, consequently increasing the maximum voltage the film can generate, whereas in torsional loading, the voltage output is decreased as voltage is collected across the fixed width of the beam in torsional loading, instead, extra thickness stiffens the structure and dampens vital internal shear strains.<br>Additionally, the thesis highlights that the loading occurring at the resonant frequencies can increase the resulting stress in the film, consequently increasing the voltage output at comparatively minimal loading magnitudes. The analysis results in the design recommendation in the end that 25 µm thickness is suitable for the torsional loading, whereas 75 µm thickness is suitable for the bending and tensile loadings. |
| **3** | **Impact on SDG#___"** (min 500 words)<br><br>The rapid expansion of the Internet of Things (IoT), smart industrial automation, and decentralized micro-systems has created an urgent demand for self-sustaining electronic components. Traditional sensor networks often face significant operational constraints due to power delivery requirements and limited battery lifespans. The research conducted in this thesis focused on the structural dynamics, frequency response, and modal behaviour of zinc oxide (ZnO) piezoelectric thin-film micro-structures, directly aligns with and supports several key United Nations Sustainable Development Goals (SDGs). Specifically, the outcomes of this work contribute to SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 12 (Responsible Consumption and Production).<br><br>**SDG 7: Affordable and Clean Energy**<br>Piezoelectric zinc oxide (ZnO) thin films convert ambient kinetic energy such as industrial machine vibrations into usable electric power. By optimizing the dynamic response and resonance characteristics of these micro-cantilever structures, this research enables high-efficiency kinetic energy harvesting at the micro-scale. This advances the development of |

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| | self-powered sensor networks and supports the transition toward decentralized, green energy solutions.<br><br>**SDG 9: Industry, Innovation, and Infrastructure**<br>Piezoelectric MEMS devices play a critical role in Structural Health Monitoring (SHM) by accurately tracking dynamic strain and vibrational changes in real time. Understanding thin-film modal behaviours ensures high-precision sensing without signal distortion, enabling early anomaly detection in critical infrastructure like bridges and industrial machinery. This predictive maintenance capability extends asset lifespans, reduces failure risks, and drives sustainable technological innovation.<br><br>**SDG 12: Responsible Consumption and Production**<br>Replacing conventional chemical batteries with self-sustaining thin-film energy harvesters significantly reduces battery consumption and hazardous e-waste. Additionally, zinc oxide serves as a non-toxic, lead-free alternative to common lead-based piezoelectric materials like PZT. Utilizing ZnO minimizes toxic substance exposure during manufacturing and disposal, fostering environmentally responsible production and consumption cycles. |
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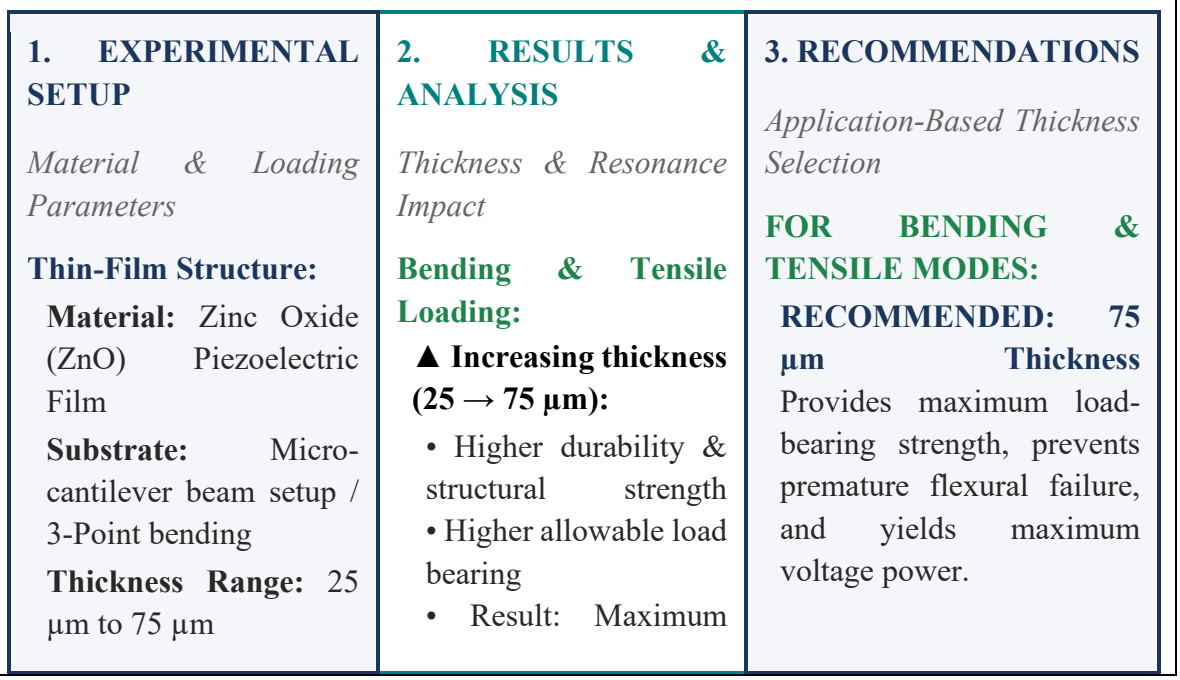
| **6** | **Graphical Abstract** |



**Mechanical Loading Modes:**

1. **Bending Load:** Cantilever and 3-point Bending
2. **Tensile Load:** Axial stretch along length
3. **Torsional Load:** Twisting moment around central axis

**Measured Parameters:**

- Maximum allowable loading (Strength)
- Peak voltage output generated (V_max)

voltage output INCREASED

**Torsional Loading:**

**▼ Increasing thickness (25 → 75 µm):**

- Voltage collected across fixed beam width
- Extra thickness over-stiffens structure
- Dampens vital internal shear strains
- Result: Voltage output DECREASED

**Resonant Frequency Loading:**

**★ Operating at Resonance:**

- Significantly amplifies internal stress
- Maximizes voltage at minimal input loads

**FOR TORSIONAL MODES:**

**RECOMMENDED: 25 µm Thickness**

Preserves structural flexibility, avoids unnecessary shear damping, and maximizes torsional voltage extraction.