MEMS Piezoelectric Ambient Vibration Energy Harvesting for Wireless Sensors

N.E. duToit, A. Mracek, B.L. Wardle (with W. Choi, S.-G. Kim)
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Recently, numerous investigations have focused on the development of distributed wireless sensor node networks. Power for such devices can be supplied through harvesting ambient environmental energy available as mechanical vibrations, fluid motion, radiation, or temperature gradients [1]. Envisioned applications include building climate control and warehouse inventory control, identification and personalization (RFID tags), structural health monitoring (aerospace and automotive sectors), agricultural automation, and homeland security.

Advances in “low-power” DSP’s (Digital Signal Processors) and trends in VLSI (Very Large Scale Integration) system design have reduced power requirements to 10’s-100’s of μW. These power levels are obtainable through piezoelectric harvesting of ambient vibration energy. Current work focuses on harvesting this energy with MEMS resonant structures. Coupled electromechanical models have been developed to predict the electrical and mechanical performance obtainable from known low-level ambient vibration sources. These models have been validated by comparison to prior published results [2] and tests on a MEMS device. A non-optimized, uni-morph beam prototype (see Fig. 1) has been designed and modeled to produce 30 $\mu W/cm^3$ [3]. A MEMS fabrication process for a prototype device is presented based on past work at MIT [4]. Dual optimal frequencies with equal peak powers and unequal voltages and currents are characteristic of the response of such coupled devices when operated at optimal load resistances (see Fig. 2).

Future work will explore active sources such as aircraft skin for harvestable power, fabrication and testing of the uni-morph prototype beam, and optimization of device configurations for aerospace structural health monitoring applications. System integration and development, including modeling the power electronics, will be included.

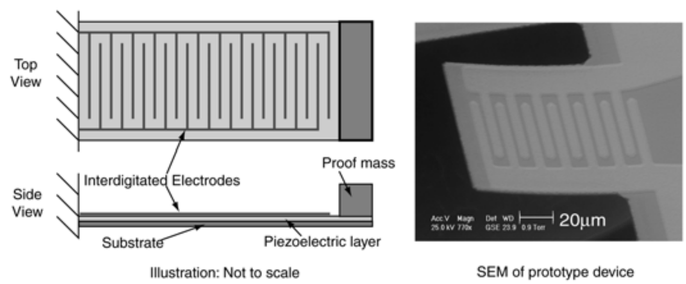

Figure 1: Illustration of MPVEH unimorph configuration (left) and SEM of a prototype device (right).

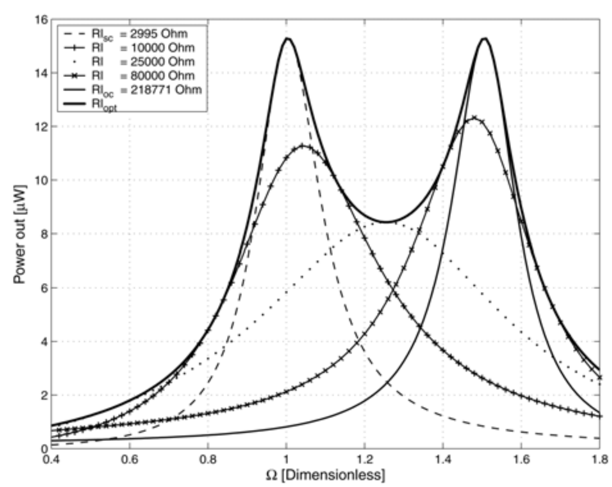

Figure 2: Power vs. normalized frequency with varying electrical load resistance [3].

References:

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