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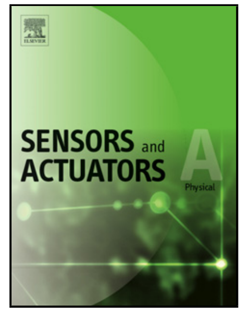

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Auxetic Structure for Increased Power Output of Strain Vibration Energy Harvester

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Highlights

- An auxetic substrate increases power output of a piezoelectric element.
- This substrate increases the stress in the element both axially and laterally.
- A power gain of up to 14.3 times a plain harvester was observed experimentally.

Abstract

This paper develops an auxetic (negative Poisson's ratio) piezoelectric energy harvester (APEH) to increase the power output when harnessing strain energy. The APEH consists of a piezoelectric element bonded to an auxetic substrate. The auxetic substrate concentrates the stress and strain into the piezoelectric element's region and introduces auxetic behaviour in the piezoelectric element, both of which increase the electric power output. A finite element model was developed to optimise the design and verify the mechanism of the power increase. Three APEHs were manufactured and characterised. Their performance was compared with two equivalent strain energy harvesters with plain substrates. Experimental results show that the APEHs, excited by sinusoidal strains peak-to-peak of 250 με at 10 Hz, are able to produce electric power of up to 191.1 μW, which is 14.4 times of the peak power produced by the plain harvesters (13.4 μW). The power gain factor is constant between samples as the amplitude and frequency of their applied strains are varied. The model and experimental results are in good agreement, once accounting for the imperfect bonding of the epoxy using the spring constant of the Thin Elastic Layers on the modelled epoxy surfaces.

Keywords: Vibration Energy Harvesting; Auxetic; Piezoelectricity; Strain Energy Harvesting

1. Introduction

Energy harvesting is concerned with utilising small amounts of energy available within the local environment to power small electronic devices [1–3]. Popular potential applications of this technology include self-powered sensor nodes in a distributed wireless network, typically used for structural health monitoring. Being powered in-situ means these sensors won't require routine battery replacement, and can thus be embedded into a structure or benefit from quick, easy, and flexible retrofitting without additional (re)wiring [4,5]. Given adequate power availability, this technology could recharge mobile devices on the move. Other applications such as powering wireless switches, doorbells and security equipment [6], keyboards [7], and asset management trackers [8,9] are being explored.