670. Numerical study of cantilevers with non-uniform width for enhancing the performance of vibration-driven micropower generator based on piezoelectric conversion

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Abstract. This study is dedicated to investigation of rectangular- and trapezoidal-shaped cantilevers for achieving improved efficiency of the piezoelectric micropower generation. The developed finite element model of a unimorph piezotransducer with a proof-mass at the tip is used to examine how different cantilever shapes and proof-mass dimensions influence stress distribution, dynamic response and voltage output of the microgenerator. Numerical results indicate that cantilevers with increasingly triangular shape permit markedly larger kinematic excitation magnitudes and generate slightly larger voltages for a comparable deflection level.

Keywords: energy harvesting, piezoelectric micropower generator, unimorph transducer, finite element model, dynamics, trapezoidal cantilever, triangular shape, strain uniformity.

1. Introduction

Rapid advances in wireless technology and low-power electronics have led to the deployment of autonomous wireless sensor networks for various applications including environmental and structural health monitoring, gas and chemical sensing, motion and explosive detection, etc. Current wireless devices are designed to employ electrochemical batteries for powering. However the use of batteries can become increasingly troublesome because of their limited lifespan and inadmissibly high cost related to their replacement in hardly accessible and remote locations (battery replacement costs \$80–\$500 including labor and it exceeds the price of a sensor [1]). These issues together with the emerged concept of self-powered MEMS-based sensing devices have triggered active research of micropower harvesting technologies during the last 10 years or so. Different harvesting approaches are considered but vibrational energy has gained the most of attention due to its widespread availability. Vibration-to-electricity converters are usually based on electromagnetic, electrostatic and piezoelectric transduction. The latter is regarded to be the most promising for realization of piezoelectric micropower generators (PMPGs) due to relatively easy microfabrication, simple geometry and fewer peripheral components resulting in lower device cost [2-3].

Cantilever-type PMPGs attracted the largest attention in the research community. They are very efficient when the driving vibration matches their resonant frequency. However when they are not operated in resonance the output power diminishes by orders of magnitude [4]. Therefore such PMPGs are highly suitable only for applications with well-defined excitation frequency.

A lot of studies have been conducted on PMPGs over the past decade however their efficiency is still very low. State-of-the-art PMPG prototypes currently harvest only about 5% of the available power [5]. Thus, considerable research work is still needed in different fields in order to improve efficiency of the microgenerators. In terms of materials research, current