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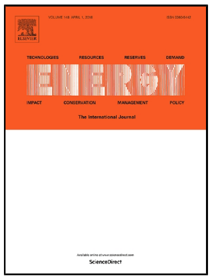

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Abstract

In this paper, an electret-based capacitive energy harvesting device with out-of-plane gap closing scheme has been modeled and analyzed. The device is composed of a micro cantilever and a substrate which form a variable capacitor and is in series with a resistance. An electret material is used to provide the bias voltage which is needed in capacitive energy harvesters in order to scavenge energy from ambient vibration. The ambient vibrations is applied to the system as a harmonic base excitation. The motion equations and the corresponding boundary conditions are derived using Hamilton's principle based on Euler-Bernoulli beam theory, and the Kirchhoff's voltage law is employed to couple the mechanical and electrical domains. The electro-mechanical governing equations are discretized using Galerkin procedure and integrated numerically over time. In order to verify the derived formulation, an energy conservation approach is employed in the free oscillation of the device. The stability of the system in the electrostatic field is investigated in both static and dynamic cases. By investigating the behavior of the system in free oscillations, the resistance is found to affect the behavior of the micro-cantilever as a damper with a Lorentzian variation, with the maximum equivalent damping coefficient corresponding to the resistance of 100 MΩ. The performance of the energy harvester in the presence of ambient vibrations is evaluated based on the frequency response of the device, and the effect of various parameter as investigated on the device performance, among which the resistance appears to have the most dominant effect on the system. It is found that in low resistances, the micro-cantilever exhibit a softening behavior due to the large electrostatic pressure acting on it, however, by increasing the resistance, the frequency response of the system becomes linear. Besides, the resistance affects the amplitude of the micro-cantilever due to its damping effect. For the case study considered here, a theoretical harvested power in the order of 1 microwatt is harvested by the device for a frequency of 2.5 MHz and the electret surface voltage of 180 V. Of course, by adjusting the physical properties, the device can be fitted for the needs of the target application.

Keywords

Energy harvesting, capacitance, electret, micro-cantilever, MEMS (Micro-electro-mechanical Systems)