

## Accepted Manuscript

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PII: S0968-4328(17)30148-8  
DOI: <http://dx.doi.org/doi:10.1016/j.micron.2017.07.009>  
Reference: JMIC 2459

To appear in: *Micron*

Received date: 8-4-2017  
Revised date: 20-7-2017  
Accepted date: 20-7-2017

Please cite this article as: Karimpour, Masoud, Ghaderi, Reza, Raeiszadeh, Farhad, Vibration Response of Piezoelectric Microcantilever as Ultrasmall Mass Sensor in Liquid Environment. *Micron* <http://dx.doi.org/10.1016/j.micron.2017.07.009>

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# Vibration Response of Piezoelectric Microcantilever as Ultrasmall Mass Sensor in Liquid Environment

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## Highlights

- Vibrating behavior of piezoelectric MC as well as its sensitivity as a mass nanosensor are investigated and compared in both air and liquid environments.
- Piezoelectric microcantilever is considered as ultrasmall mass sensor.
- Frequency sensitivity due to deposited mass is calculated.
- Effect of liquid environment on frequency sensitivity is considered and compared with effect of air environment.
- With the aim to achieve optimal geometric dimensions for the piezoelectric MC, sensitivity analysis was additionally performed in order to increase frequency sensitivity.

## Abstract

The present study aims to analyze the vibrating behavior of a piezoelectric microcantilever (MC) as a mass nanosensor. The vibrating behavior of the MC as well as its sensitivity as a mass nanosensor are investigated and compared in both air and liquid environments. To this end, Euler-Bernoulli theory was used to model the vibrating behavior of piezoelectric MC with added mass at its free end. Frequency analysis was conducted by considering geometric discontinuities and taking added mass into account. The effect of liquid environment applied to the MC (as hydrodynamic forces) was based on a string of spheres model. Since changes in resonance frequency are used as the measurement parameter in mass sensors, changes in resonance frequency during absorption of nanoparticles was selected as the main parameter to be investigated in this study. Ultimately, with the aim to achieve optimal geometric dimensions for the piezoelectric MC, sensitivity analysis was additionally performed in order to increase the frequency sensitivity. According to the results, frequency sensitivity of the piezoelectric MC decreased in liquid environment compared to air environments. Moreover, increases in fluid density and viscosity caused a decreased frequency sensitivity. Simulation results indicate that the second vibrating mode in air and liquid environments is the appropriate operating mode for this type of MC.

**Keywords:** Piezoelectric Microcantilever; Mass Sensor; Liquid; Sensitivity Analysis; Resonance Frequency.

## 1. Introduction

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