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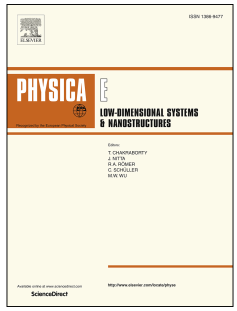

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Effects of processing force on performance of nano-resonators produced by magnetron sputtering deposition

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Abstract

Magnetron sputtering is a perfect technique for processing nanomaterials for engineering and medical applications. A material can be processed with specific mechanical properties, microstructure, and surface texture by controlling the parameters of magnetron sputtering. Therefore, studies should be conducted on investigating the processing conditions on the performance of nanomaterials processed by magnetron sputtering.

In this study, effects of the processing force on the surface roughness and vibration characteristics of micro/nano-resonators produced by magnetron sputtering deposition are revealed. The processing force is defined as the ratio of the sputtering power-to-the substrate's traveling velocity. By comparing the substrate's traveling velocity to the deposition rate of the sputtered particles, relations are derived for the thickness and surface roughness evolutions with the processing force. The coefficients of these relations are experimentally determined for mechanical resonators made of FeNiCr alloy. Then, the variations of the natural frequencies of these resonators with the processing force of magnetron sputtering and the deposition rate of the sputtered particles are depicted. It is demonstrated that special considerations should be given for the effects of the processing conditions and surface roughness when designing mechanical resonators produced by magnetron sputtering.

Keywords: deposition, magnetron sputtering, nano-resonators, surface roughness, frequencies.

1. Introduction

Today's engineering and medical devices incorporate micro/nano-resonators which reflect changes in their properties (*e.g.* frequencies) as a response for physical quantities. For example, nano-resonators are being used for measuring masses of nano-objects (*e.g.* atoms) by measuring the corresponding frequency changes [1-16]. Yang and Guo [1] designed a mass sensor that reflects a torsional mode frequency shift for a thin layer of an added surface mass. Moreover, optomechanical [2, 3] and electromechanical [5,6,7] micro/nano-resonators were designed. Using carbon nanotubes, ultrasensitive mass sensors with one-atom and one-proton resolutions were designed [6, 7, 8, 10]. Zhang and Zhao [12, 13] determined the mass, position, and induced force of a nanoparticle deposited on micro/nano-resonators based on the frequency shift measurements. Kang et al. [14, 15] investigated thermal effects on the sensitivity of carbon

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