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Effect of Fractal Parameters on Response of Nanobeam: A Finite Element Approach

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Abstract

Finite element analysis facilitates optimal design of MEMS/NEMS devices for reliability. The same is used here to analyze the effect of types of fractal rough surfaces on static response of nanobeams Three-dimensional rough surfaces are generated using modified two variable Weierstrass-Mandelbrot function with given fractal parameters. Beam with various fractal roughness are modelled to observe the variations in the bending stresses and displacements. The results of the analysis will be useful to designers to develop the most suitable geometry for nanostructures.

Keywords

Nanobeam, Roughness, Fractal, Finite Element Method

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1. Introduction

A large variety of micro/nano-electro-mechanical systems (MEMS/NEMS) are produced using lithographic and other fabrication techniques. Some of the industrial applications of these include digital light products (DLP) devices for digital projection displays, capacitive-type silicon accelerometers for automotive sensory applications, and many more other sensors and actuators. Friction/stiction and wear limit the lifetimes and compromise the performance and reliability of these devices involving relative motion [1]. Structural integrity is of paramount importance in all these devices. Load applied during the use of devices can result in component failure. Cracks can develop and propagate under tensile stresses leading to failure [2]. Stress and deformation analyses are carried out foran optimal design. In general MEMS/NEMS applications need extreme reliability. Recent developments in science and engineering have advanced capability to fabricate and control structures on the scale of micro/nanometers, and have brought problems of material behavior on the micro/nanometer scale into the domain of engineering. Reliability studies are the key for practical applications and commercialization of today's advanced MEMS/NEMS systems. Many current and potential applications for MEMS/NEMS are not really practical, because their mechanical properties have not been established [3-5].

It is essential for designers of MEMS/NEMS devices to have mechanical property information at the nanoscale as most mechanical properties are known to exhibit a dependence on specimen size. Single-crystal silicon and silicon-based materials are the most common materials used in MEMS. An early study showed silicon to be mechanically resilient material in addition to its favorable electronic properties [6]. Researchers have conducted tests to evaluate mechanical properties of silicon and silicon-based small scale structures including tensile tests and bending tests [7-10]. Recently researchers have used atomic force microscopy-based

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