Sensors and Materials, 5, 3 (1993) 143–181
MYU, Tokyo

S & M 0135

Review of Excitation and Detection Mechanisms for Micromechanical Resonators

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(Received April 23, 1993; accepted August 13, 1993)

Key words: *resonant sensor, excitation, detection*

With the application of silicon resonant sensors in mind, commonly used mechanisms for excitation and detection of transversal vibrations in micromechanical silicon structures are modelled and compared. Three types of mechanisms are distinguished: the reversible excitation/detection mechanisms (the electrostatic mechanism using an air gap, the electrostatic mechanism using a dielectric thin film, the piezoelectric mechanism and the magnetic mechanism), the irreversible excitation mechanisms (electro- and optothermal excitation) and the irreversible detection mechanisms (piezoresistive detection and optical detection techniques). The model is applied to prismatic beams; however, it can easily be used to model other structures, provided that the modes of vibration are known. The method used is highly systematic, which makes comparison of the mechanisms with respect to many aspects possible. In this paper, they are compared in terms of the magnitude of the induced driving forces, the sensitivity of the detection mechanisms, the effect of electrical loads on the quality factor of vibration, electromechanical coupling factors, scaling factors, stability, and the effect of the mechanisms on the resonance frequency.

1. Introduction

In the past decade, much research has been done by many research groups on silicon micromechanical resonant sensors vibrating in a transversal mode.[1,2] The operating principle is that the resonance frequency of a vibrating structure depends on the quantity to be measured. This kind of sensor has the potential of measuring