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Mathematical modeling of a MEMS resonator: application of thermo-elastic and stress-strain equations

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ABSTRACT

Micro Electro Mechanical Systems (MEMS) resonators are miniaturized devices that can be used to select frequencies of a specific signal, like Radio Frequency (RF). These devises are very important to improve the telecommunications industry. It is essential that a resonator vibrates consistently at a desired frequency and to reach that condition using the minimum energy. One way to measure the efficiency of a resonator is by means of the quality Q factor; defined as the ratio between the total storage energy and the loss of energy per cycle. A MEMS resonator with a high Q factor has benefits such as low energy consumption, small size, and easy integration with other devices. In order to minimize the loss of energy per cycle several alternatives can be explored as geometries, materials and dampers. In the present research a mathematical model is proposed to simulate the thermo-elastic damping of a MEMS resonator based on the double interaction between temperature and structure. Thermal stress heats or cools the material locally, which produces thermal stresses. Several geometries and materials are considered in the design of the resonator. By doing so, a static characterization is obtained that enables a recommendation of the optimizer Q factor design. The mathematical model is three dimensional and includes a system of four linear, time independent, partial differential equations. The Q factor is computed after an eigenfrequency analysis for temperature, considering the complex angular frequency. The results obtained by the model are compared against those reported in specialized literature. The model is solved using the Finite Element Method.

Key words: MEMS resonator, Thermo-elastic damping, Finite Element.

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