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THERMOELASTIC DAMPING ANALYSIS OF QUARTZ SAW RESONATOR

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ABSTRACT

Surface acoustic wave (SAW) resonators are widely used in many kinds of microelectronic devices. Due to the recent reduction in size and increase in driving frequencies of these resonators, thermoelastic damping, a phenomenon induced by the coupling between the heat transfer and the strain rate, is becoming an important issue to study in their design process. The effect of thermoelastic damping is investigated first by Zener [1] for a simple one dimensional vibration model with isotropic material property. He has obtained an approximate expression for the quality factor in terms of the size and frequency parameters. Then, the exact expression for the quality factor was developed by Lifshitz and roukes [2] for beam models of MEMS and NEMS. For more realistic and complicated problems for two-dimensional isotropic models, finite element methods were used [3], [4]. Also for three-dimensional piezo-thermoelastic bodies, FEM was developed to have transient responses.

In the present study, a finite element method based on the set of the governing differential equations for a fully coupled three-dimensional piezo-thermoelastic model is presented, and used for analyzing the damping characteristics of bulk models of quartz SAW resonators. The finite element method is formulated for harmonic vibration of the piezo-thermelastic body, and the frequency response and eigenfrequencies are studied for quartz. The numerical results are compared with those obtained by a collocation method. The size and temperature effects on the resonance peak and quality factor are investigated.

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