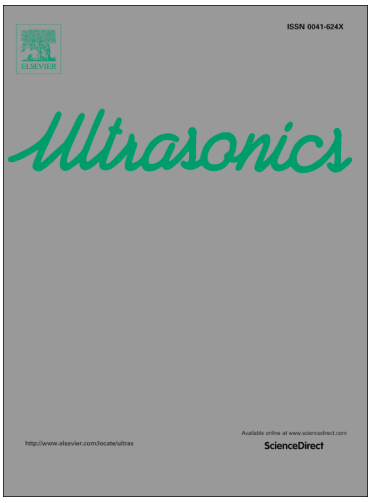

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Peculiarities of Energy Trapping of the UHF Elastic Waves in Diamond-based Piezoelectric Layered Structure. I. Waveguide Criterion

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Abstract: Finite Element Modeling of the peculiarities of the trapping energy phenomenon in application to the piezoelectric layered structure (PLS) "Al/(001) AlN/Mo/(100) diamond" has been fulfilled. The resonant properties of longitudinal bulk acoustic waves (BAW) as well as frequency dependence of impedance within the 1 – 6 GHz band have been studied. The investigation of distribution of elastic energy flow and elastic displacements in a PLS cross-section allowed us to obtain an important information on energy trapping (ET) in PLS.

Experimentally and as a result of modeling, it has been found that *Q* minimums are observed in PLS at quarter-wave resonance in the thin-film piezoelectric transducer **(**TFPT). Maximal *Q* value was observed at half-wave resonance in TFPT.

It has been established that the ET-effect depends considerably on the mutual location of the *n*-th overtone's antiresonant frequency $f_{a,n}$ and cut-off frequencies of substrate $f_{s,n-k-1}$ and $f_{s,n-k}$ where $f_{s,n-k-1} < f_{a,n} < f_{s,n-k,}$ and $k = 0,\ 1,\ 2,\ldots$ is the number of half-length waves to be stowed on the thickness of TFPT. The total violation of the ET-effect will be arisen at the condition $f > f_{s,n-k}$, when the BAW energy excites the symmetrical or antisymmetrical Lamb waves.

Keywords: Finite Element Modeling, diamond, aluminum nitride, trapping energy, quality factor, piezoelectric layered structure, High-overtone Bulk Acoustic Resonator.

1. Introduction

The phenomenon of energy trapping of bulk acoustic waves was first discovered by Bechmann [1], who noted disappearance of so-called inharmonic overtones with reduction of electrode diameter of quartz piezoelectric resonator and proposed a design criterion on electrode and substrate diameter in terms of wafer thickness. As a result, under specified conditions the acoustic energy was efficiently concentrated in a piezoelectric plate within a region between the top

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