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Effect of initial stress on the propagation behavior of SAW in a layered piezoelectric structure of ZnO/Al_2O_3

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Highlights:

- A physical model for Acoustoelastic effect in layered piezoelectric structure is described.
- Various experimental measurements of ZnO/Al_2O_3 is used for the numerical calculations.
- Influence of the measured initial stress on the SAW velocity and on the coupled electromechanical coefficient.

Abstract

Theoretical analysis of surface acoustic wave (SAW) propagation in a pre-stressed layered piezoelectric structure basing on the modified ordinary differential equation (ODE) is described. Numerical calculations involve a thin piezoelectric layer of ZnO bonded perfectly to an elastic substrate of Al_2O_3. ZnO thin films are deposited on Al_2O_3 substrates using plasma assisted molecular beam epitaxial (MBE). The crystallographic orientation of ZnO thin films and the surface morphology are analyzed by X-ray diffraction (XRD) and atomic force microscopy (AFM) respectively. The density and the thickness of the ZnO films are determined by X-ray reflectivity. The initial stress and strain of ZnO films are measured by X-ray diffraction method. The effect of initial stress on the propagation behavior of Rayleigh and Love waves and on the coupled electromechanical factor is discussed.
Keywords: **S**AW ; Initial stresses; ZnO thin films

1. Introduction

Recently, there has been a growing interest in studying the effect of external perturbations such as residual stresses and strains on the propagation of acoustic waves. The presence of a biasing state induced by these perturbations can significantly affect the characteristics of bulk acoustic wave (BAW) and surface acoustic wave (SAW). In the field of thin film technology, understanding and predicting the propagation behavior of SAW under an initial mechanical stress is of primary importance. The initial stresses in the film are inevitable and important because they may result in frequency shift, a change in the velocity of SAW and controlling the selectivity of a filter and temperature compensation of the devices [1]. To improve the performance or to select the most suitable operating conditions of SAW devices, several theoretical and experimental studies have been carried out to analyze the different types of plane waves in various electrical or mechanical pre-stressed structures; both piezoelectric