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Reverberation-Ray Matrix Analysis of Acoustic Waves in Multilayered Anisotropic Structures

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1. Introduction

Natural multilayers can be frequently observed, like the layered soils and rocks for example (Kausel & Roesset, 1981; Kennett, 1983). They are also increasingly used as artificial materials and structures in engineering practices for their high performances (Nayfeh, 1995). For instances, cross-ply and fibrous laminated composites have been applied in naval vessels, aeronautical and astronomical vehicles, and so on for the sake of high strength and light weight (Nayfeh, 1995); piezoelectric thin film systems have been used in various surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices in electronics and information technology in order to accomplish smaller size, lower energy consumption, higher operating frequency and sensitivity, greater bandwidth, and enhanced reception characteristics (Auld, 1990; Adler, 2000). Consequently, as a widespread category of inhomogeneous materials and structures, multilayered structures deserve special concern about their mechanical and acoustical behavior, especially the dynamic behavior since it is what these structures differ most markedly from the homogeneous materials and structures. Investigation of acoustic wave propagation in multilayered structures plays an essential role in understanding their dynamic behavior, which is the main concern in design, optimization, characterization and nondestructive evaluation of multilayered composites (Lowe, 1995; Chimenti, 1997; Rose, 1999) and acoustic wave devices (Auld, 1990; Rose, 1999; Adler, 2000). Nevertheless, the top and bottom surfaces and the interfaces in a multilayered structure cause reflection and/or transmission of elastic waves, giving rise to coupling of various fundamental wave modes in adjacent layers. In multilayered structures consisting of anisotropic media, even the fundamental wave modes themselves are mutually coupled in each layer (Achenbach, 1973). As a result, the analysis of acoustic waves in multilayered structures always remains an extraordinary complex problem, and it is very difficult to obtain a simple and yet numerically well-performed, closed-form analytical solution for a general multilayered structure.

For the above reasons, various matrix formulations have been developed for the analysis of acoustic wave propagation in multilayered media from diverse domains (Ewing et al., 1957; Brekhovskikh, 1980; Kennett, 1983; Lowe, 1995; Nayfeh, 1995; Rose, 1999), since the beginning of this research subject in the midst of last century. Most of these matrix methods...


SAW devices are widely used in multitude of device concepts mainly in MEMS and communication electronics. As such, SAW based micro sensors, actuators and communication electronic devices are well known applications of SAW technology. For example, SAW based passive micro sensors are capable of measuring physical properties such as temperature, pressure, variation in chemical properties, and SAW based communication devices perform a range of signal processing functions, such as delay lines, filters, resonators, pulse compressors, and convolvers. In recent decades, SAW based low-powered actuators and microfluidic devices have significantly added a new dimension to SAW technology. This book consists of 20 exciting chapters composed by researchers and engineers active in the field of SAW technology, biomedical and other related engineering disciplines. The topics range from basic SAW theory, materials and phenomena to advanced applications such as sensors actuators, and communication systems. As such, in addition to theoretical analysis and numerical modelling such as Finite Element Modelling (FEM) and Finite Difference Methods (FDM) of SAW devices, SAW based actuators and micro motors, and SAW based micro sensors are some of the exciting applications presented in this book. This collection of up-to-date information and research outcomes on SAW technology will be of great interest, not only to all those working in SAW based technology, but also to many more who stand to benefit from an insight into the rich opportunities that this technology has to offer, especially to develop advanced, low-powered biomedical implants and passive communication devices.

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