Preface

Piezoelectric materials exhibit electromechanical coupling. They are strained when placed in an electric field, and become electrically polarized under mechanical loads. Piezoelectric materials have been used for a long time to make various electromechanical devices. Examples include transducers for converting electrical energy to mechanical energy or vice versa, resonators for frequency control and selection with applications in telecommunication and timing, actuators, and acoustic wave sensors.

Due to material anisotropy and multi-field coupling, the three-dimensional equations of linear piezoelectricity are rather complicated. Theoretical analyses based on these equations usually present considerable mathematical challenges. The results obtained are often very lengthy, obscuring the underlying physical picture. In the analysis of piezoelectric devices, relatively few exact solutions from the three-dimensional equations can be obtained. Numerical techniques like the finite element method are usually needed. Another way to simplify the problems so that theoretical analyses are possible is to use approximate, lower-dimensional structural theories of plates, shells, beams and rods. These two approaches are both very useful in general in the modeling and design of piezoelectric devices.

Polarized ceramics are common materials for piezoelectric devices. They are transversely isotropic and allow the so-called shear-horizontal (SH) or antiplane motions. These motions are with one displacement component only along the poling direction depending on two spatial coordinates, with coupling to an electric potential depending on the same two spatial coordinates. For these motions the mathematical problem is relatively simple. Useful problems of practical interest can often be solved analytically, sometimes with elegant results showing the physics involved clearly. Beginning from the discovery of the simple and truly piezoelectric Bleustein–Gulyaev surface waves over a ceramic half space in 1968, many theoretical results on antiplane motions of polarized ceramics have been obtained for device applications. This book collects a series of solutions of antiplane motions of polarized ceramics. Although

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some static problems are included, the main purpose is to present results on dynamic problems related to acoustic wave devices. Both surface acoustic waves (SAW) and bulk acoustic waves (BAW) are considered. The operating principles of quite a few acoustic wave and electromechanical devices are exhibited through antiplane problems.

Since the structures of the material tensors of crystals with 6mm symmetry are the same as those of polarized ceramics, 6mm crystals are mathematically the same as polarized ceramics within the theory of piezoelectricity. Therefore solutions for polarized ceramics are also applicable to 6mm crystals which include widely used materials like zinc oxide and aluminum nitride. Crystals of 4mm symmetry differ from 6mm crystals only in that $c_{66} = (c_{11}–c_{12})/2$ is no longer valid for 4mm crystals. This, however, makes no difference for antiplane motions. Therefore the results in the present book are also valid for 4mm crystals like dilithium tetraborate and strontium barium niobate.

The results presented in this book are simple and basic, and therefore are useful for educational purposes. The study of antiplane motions of polarized ceramics is an active research area. This book is also useful as a reference for researchers. The problems analyzed in this book can provide motivation and solution techniques for further studies of other useful problems.

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