An Electroelastic Problem of a Semi-infinite Body with D_∞ Symmetry Subjected to Distributed Surface Loading

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ABSTRACT

Wooden materials and biodegradable polymers have attracted much attention as promising materials to achieve carbon neutrality and biodegradability, respectively. To ensure the quality of wooden materials, nondestructive evaluation techniques need to be developed. By using piezoelectric effects, the mechanical behaviors of wood were investigated [1, 2]. On the other hand, the films made of poly-L-lactic acid (PLLA), as one of biodegradable polymers, are expected to be employed in the human–machine interface devices [3]. For safe operation of applications using these materials, the electroelastic field inside the material must be elucidated.

Both of wooden materials and films of PLLA have D_∞ symmetry, which is characterized by the coupling between an electric field and the shearing motion around it. Such a peculiar anisotropy makes it difficult to analyze the internal electroelastic field, which is quite unlike other widely used piezoelectric polymers with C_{6v} symmetry.

In this paper, therefore, we analyze the electroelastic field in a body with D_∞ symmetry. As a first step to construct an analytical technique for analyzing the field, we treat a semi-infinite body subjected to locally distributed surface loading. First, the displacement and electric field are expressed in terms of the potential functions. The governing equations for these functions are obtained by the equilibrium equations of stresses and the Gauss law. By solving the governing equations, the electroelastic field quantities are obtained. Moreover, by performing numerical calculation, the field quantities, including stress, electric potential, and electric field, are investigated qualitatively and quantitatively, which helps us to understand the behaviors of the body with D_∞ symmetry.

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