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ORIGINAL

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The influence of poling direction on an interface crack with contact zones in a piezoelectric bimaterial

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Abstract The plane strain problem for an interface crack between two different piezoelectric materials with an arbitrary polarization direction under remote mechanical loading is analyzed. Mechanically frictionless and electrically permeable contact zones are assumed at the crack tips, and the remaining part of the crack is considered as electrically permeable. An analytical method is used based upon the presentations of the field variables via sectionally analytic vector functions with the resulting formulation and the solution of the combined Dirichlet–Riemann boundary value problem. Clear analytical expressions for crack opening and stresses along the bimaterial interface as well as for stress intensity factors are derived. Furthermore, a system of the transcendental equations for the determination of the contact zones lengths in the sense of Comninou is obtained. The numerical analysis performed for a certain piezoelectric bimaterial showed an essential influence of the changing poling direction on the stress intensity factors and the contact zones lengths as well as on the crack opening displacement and the variations in the stress at the bimaterial interface.

Keywords Piezoelectric material · Interface crack · Contact zones · Poling directions · Exact solution

1 Introduction

Piezoelectric materials, due to their intrinsic property of converting electrical energy into mechanical energy and vice versa, belong to the most actively developed contemporary materials, widely used in the design of smart devices like sensors, transducers, and actuators. However, piezoelectric materials are brittle in nature with very low fracture toughness and prone to various micro-defects arising during their manufacturing and service life. This can significantly reduce the lifetime of smart devices and even lead to premature failure and fracture of these devices under the influence of external loadings. Many of these devices are composite structures; hence, interface cracking can be considered as an important failure type and should be investigated and understood thoroughly.

The problem of micro-defects and cracks in piezoelectric materials has received much attention in the literature and has been studied intensively. Particularly, several books [1–4] and review articles [5–11] devoted

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