1 Introduction

The evaluation of the stress intensity factors for interface corners is required in many different engineering branches in which the most representative one is electronic packaging. The natural three-dimensional properties (e.g., geometries, loadings, and boundary conditions) cannot be avoided when analyzing a case realistically. Interface corners appearing in most engineering products may be formed by two or more dissimilar media especially in electronic devices (e.g., the corner placed in the solder ball, conductive cooper, and printed wired board shown in the region circled within the dash line of Fig. 1). A commonly used fracture parameter, stress intensity factors (SIFs), is treated as the assessment of the fracture behavior for interface corner in this paper.

Based on the authors’ recent studies, it is found that several combinations of interface corners possess more than one singular order of stresses and the most critical one may be associated with one, two, or three modes of stress intensity factors. Therefore, if only the most critical singular order of stress is taken into account, it is possible to lose the opportunity to compute all three modes of stress intensity factors. To fully understand the failure behavior of interface corners, several different path-independent integrals, such as J-integral [2], L-integral [3], M-integral [4], and H-integral [5] were proposed in literature to avoid the complexity of stresses around the crack/corner tip. Because the mixed-mode characteristics and the availability of the near tip and complementary solutions of interface corners, in this paper we adopt the $H$-integral to compute SIFs for three-dimensional interface corners. Even if the $H$-integral was proposed around 35 years ago, most of them were employed to deal with two-dimensional problems such as [6,7] for 2D cracks or corners in homogeneous materials and [1,8–13] for 2D interface cracks or corners between two dissimilar materials. For three-dimensional problems, Meda et al. [14] and Ortiz et al. [15] considered the applications to 3D cracks and solve different modes of stress intensity factors by different $H$-integral. In this paper, a new domain-independent $H$-integral is proposed to deal with all crack/corner problems and all modes of stress intensity factors can be determined simultaneously through one $H$-integral.

When employing $H$-integral to compute the stress intensity factors, the near tip solutions and their associated complementary solutions for the considered crack/corner problems are needed. Although no analytical near tip solutions have been obtained for the general three-dimensional crack/corner problems, in this paper the near tip solutions obtained for the generalized plane stress and generalized plane strain multilayer problems [16,17] have been proven to be useful for the present 3D crack/corner problems. The reasons for this successful application are (1) along the 3D crack/corner front each point can be treated as a tip of 2D crack/corner, which can be considered to be in generalized plane stress condition for cracks in the outer portion and in generalized plane strain condition for cracks in the inner portion and (2) besides the typical 2D stress/strain components, the additional third directional stress/strain components such as $\sigma_{13}$, $\sigma_{23}$, and $\epsilon_{13}$, $\epsilon_{23}$ are all available in the solutions obtained by employing Stroh formalism for two-dimensional anisotropic elasticity [18].

Keywords: stress intensity factors, three-dimensional interface corner, domain-independent $H$-integral