Experimental characterization and numerical simulations of fracture of interfaces in mode I and II for printed circuit boards application

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Abstract

The ongoing trend towards miniaturization in electronic devices leads to the developement of a new generation of printed circuit boards with embedded active components. This trend is motivated by the e-mobility and power electronics. During their lifetime, PCBs experience thermal stresses due to heat generated by active components or the surrounding environment. PCBs are complex assemblies composed of various materials. Each constituent has distinct thermo-mechanical properties. In particular, the heterogeneities of thermal expansion coefficients are the main cause of thermal stresses that can lead to layer delamination, occurring between insulating substrates or between copper and the insulating substrates.

Historically, the prevalent technique for quantifying the interfacial energy within PCBs has been the peel test, providing an estimation of the interface energy based on the IPC standard (1). However, during peeling, copper tends to experience large plasticity. Consequently, the analysis of peel tests with plasticity developement in the film has been extensively explored in the literature (2). More recently, in (3) and (4), focusing on the elasticplastic response of copper, the peel test has been analysed to identify the cohesive behavior of the substrate/copper interface. Nevertheless, it has been observed that this approach is challenging when seeking a precise evaluation of the mechanical response of the interface.

To address this challenge, we propose to adapt the Double Cantilever Beam (DCB) and End Notched Flexure (ENF) (5) tests, initially developed for thick composites, to the PCB domain where the layer thickness is very limited (copper thickness is around 17 to 35 μm). The experimental configuration has been validated by FE simulations prior to tests. It is shown by FE simulations that the plastic dissipation for the DCB and ENF configurations is very limited compared to one occuring during peel test. Moreover, an interesting feature of the two tests is the controlled mode fracture while in the peel test, the fracture process taking place is under a mixed mode (I and II). The main outcome of this dialogue between

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FEA and experimental tests is the estimation of the critical strain energy release rate in mode I and mode II (GIc and GIIc) and the associated critical stress. The shape of the traction-separation law will also be discussed.