Accepted Manuscript

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PII: S0955-2219(18)30050-5
DOI: https://doi.org/doi:10.1016/j.jeurceramsoc.2018.01.035
Reference: JECS 11703

To appear in: *Journal of the European Ceramic Society*

Received date: 30-11-2017
Revised date: 21-1-2018
Accepted date: 22-1-2018

Modeling complex crack paths in ceramic laminates: a novel variational framework combining the phase field method of fracture and the cohesive zone model

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Abstract

The competition between crack penetration in the layers and cohesive delamination along interfaces is herein investigated in reference to laminate ceramics, with special attention to the occurrence of crack deflection and crack branching. These phenomena are simulated according to a recent variational approach coupling the phase field model for brittle fracture in the laminae and the cohesive zone model for quasi-brittle interfaces. It is shown that the proposed variational approach is particularly suitable for the prediction of complex crack paths involving crack branching, crack deflection and cohesive delamination. The effect of different interface properties on the predicted crack path tortuosity is investigated and the ability of the method to simulate fracture in layered ceramics is proven in relation to experimental data taken from the literature.

Keywords: Phase field model of fracture; Cohesive zone model; Crack deflection; Crack branching; Laminates.

1. Introduction

Ceramic materials are largely used in technological applications, especially with the aim of achieving a desired resistance to severe wear or corrosive phenomena at high temperatures. However, the main drawback of ceramics regards their brittleness and,to increase their toughness, laminates are often used alternating ceramic and metallic layers. For instance, in [1, 2], Al/SiC and Al/TiN laminates have been explored and tested. The metallic layers make the composite able to withstand higher deformations by means of the development of plasticity at several locations within the specimen, and therefore increasing the overall toughness of the laminate. The same toughening process has been achieved by alternating ceramic layers with polymeric layers in [3]. The main drawback of these solutions is that metals and polymers loose their

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