Accepted Manuscript

A phase-field model for solute-assisted brittle fracture in elastic-plastic solids

F.P. Duda, A. Ciarbonetti, S. Toro, A.E. Huespe

PII: S0749-6419(17)30455-2

DOI: 10.1016/j.ijplas.2017.11.004

Reference: INTPLA 2269

To appear in: *International Journal of Plasticity*

Received Date: 8 August 2017

Revised Date: 30 October 2017

Accepted Date: 19 November 2017

Please cite this article as: Duda, F.P., Ciarbonetti, A., Toro, S., Huespe, A.E., A phase-field model for solute-assisted brittle fracture in elastic-plastic solids, *International Journal of Plasticity* (2017), doi: 10.1016/j.ijplas.2017.11.004.

A phase-field model for solute-assisted brittle fracture in elastic-plastic solids

F.P. Duda[a,b,*], A. Ciarbonetti[c], S. Toro[c], A.E. Huespe[c,d]

[a]Programa de Engenharia Mecânica, COPPE, Universidade Federal do Rio de Janeiro, Cidade Universitária, Rio de Janeiro, CEP 21941-972, RJ, Brazil.
[b]Programa de Engenharia de Nanotecnologia, COPPE, Universidade Federal do Rio de Janeiro, Cidade Universitária, Rio de Janeiro, CEP 21941-972, RJ, Brazil.
[c]CIMEC-UNL-CONICET, Predio Conicet, Ruta Nac. 168 s/n - Paraje El Pozo, 3000 Santa Fe Argentina.
[d]CIMNE – Centre Internacional de Metodes Numerics en Enginyeria. E.T.S d'Enginyers de Camins, Canals i Ports, Technical University of Catalonia (Barcelona Tech) Campus Nord UPC, Mòdul C-1, c/ Jordi Girona 1-3, 08034, Barcelona, Spain

Abstract

A phase-field theory of brittle fracture in elastoplastic solids hosting mobile interstitial solute species is developed in this paper. The theory, which is formulated within the framework of modern continuum mechanics, provides a systematic way to describe the interplay between solute migration and solid deformation and fracture. A specialization of the theory, which accounts for both solute-induced deformation and solute-assisted fracture as well as for their mutual effects on solute migration, is selected for numerical studies. Toward this end, a numerical model based on the finite-element method for spatial discretization and a splitting scheme with sub-stepping for the time integration is proposed. The model is applied to the study of hydrogen-assisted crack propagation of high-strength steel specimens under sustained loads. The solutions obtained are validated by comparing them with numerical and experimental results reported in the literature. It is shown that the proposed model has the capability to capture important features presented in the studied phenomenon.

Keywords: fracture; elastoplasticity; phase-field; gradient damage mechanics; hydrogen-assisted cracking.

1. Introduction

Multicomponent materials such as polymer gels, interstitial solid solutions and intercalation compounds have in common the nature of their constituents: they are composed of a deformable host solid of fixed composition and mobile guest species that can enter into, move through, and accumulate within the interstices of the host solid. These materials have definite shape inherited from the host component and variable composition since the amount of guest species within the host

*Corresponding author
Email addresses: duda@mecanica.coppe.ufrj.br (F.P. Duda), angelodata@gmail.com (A. Ciarbonetti), storo@cimec.unl.edu.ar (S. Toro), ahuespe@intec.unl.edu.ar (A.E. Huespe)