Zhou, H., Qu, J., and Cherkaoui, M., Finite Element Analysis of Oxidation Induced Metal Depletion at Oxide–Metal Interface, Computational Materials Science, 48, 2010, pp. 842–847

Abstract

In many situations, chromium depletion and voiding below oxide/alloy interface accompany with the selective oxidation of Cr–contained alloys. At the same time, stresses are induced at the oxide/alloy interface, in the metal and in the oxide. The combination of depletion and stress generation initiates interfacial crack-like voids which eventually lead to spallation of the oxide scale. In this paper, a continuum thermodynamic model which accounts for stress-diffusion interaction in the oxidation of Cr–Fe alloys is carried out via a two-dimension finite element implementation. For the purpose of generating depletion areas, grain areas and grain boundary areas in the alloy are defined via random Voronoi tessellation. Periodic boundary condition is also employed. The model predicts that the depletion of chromium mostly occurs at the fast diffusion area (grain boundary), and large normal tensile stresses are generated at both metalscale interface and alloy grain boundaries. Once the depletion-induced voids reaches a certain level at the interface, concentration of stress could induce further propagation of interfacial crack.

Keywords

Cr–Fe alloys, Oxidation, Stress, Finite element, Voronoi tessellation