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Thermal Expansion and Residual Stress Behaviour of Electron Beam Evaporated Yttria Stabilized Zirconia Films on Inconel-690 Substrates

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Abstract

Nuclear vitrification components used in melter pot made of Ni-base superalloys degrade prematurely due to alloy-waste glass interaction and the formation of secondary precipitates. Deposition of cubic yttria stabilized zirconia (c-YSZ) coating has been recommended as a diffusion barrier material to delay or reduce the failure of the alloy and to enable an extended life. In the present work, c-YSZ films have been deposited on Inconel-690 substrate by electron beam evaporation technique at a various substrate temperature from 673 K to 973 K. The residual stress in the film surface and at the film/substrate interface was measured using grazing incidence x-ray diffraction (GIXRD) with various incidence angles. It was observed that the residual stress at the film/substrate interface region changes from tensile to compressive when the substrate temperature was increased from 673 K to 973 K during deposition. Furthermore, the thermal expansion coefficient (TEC) of Inconel-690 substrate and YSZ film coated Inconel-690 substrate were determined by high temperature (HTXRD) measurement in the temperature range of 298-1273 K with 100 K interval. The linear TECs of Inconel-690 and YSZ coated Inconel-690 at 1273 K were found to be 1.53×10^{-5} K^{-1} and 6.04×10^{-6} K^{-1}, respectively.

Keywords: Residual stress, Thermal expansion coefficient, High temperature x-ray diffraction, Cubic yttria stabilized zirconia

1. Introduction

The materials used in vitrification components of the nuclear waste processing furnace experience variable modes of degradation during processing of high-level nuclear waste (HLW) [1-3]. Plant scale vitrification process makes the nature of degradation even more complicated.