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Thermal Expansion Studies of Electron Beam Evaporated Yttria Films on Inconel-718 Substrates

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Abstract

In this paper, phase pure cubic yttrium oxide (Y_2O_3) films deposited by electron beam physical vapor deposition technique on Inconel-718 substrate at different substrate temperatures (773-973 K) are investigated. The structure and phase evolution in the films of Y_2O_3 as a function of substrate temperature have been evaluated by X-ray diffraction. Atomic force microscopy and scanning electron microscopy were used to examine the surface roughness and morphology of the as-deposited Y_2O_3 films. The adhesion behavior of the Y_2O_3 film with Inconel-718 substrate was investigated using scratch indentation testing. The thermal expansion coefficient (TEC) of Inconel-718 substrate and Y_2O_3 film coated on Inconel-718 substrate were determined by high temperature X-ray diffraction (HTXRD) measurement in the temperature range of 298-1273 K with temperature interval of 100 K. The linear TECs of Inconel-718 and Y_2O_3 film at 1273 K were found to be 1.22×10^{-5} K^{-1} and 7.02×10^{-6} K^{-1}, respectively. Thermal stability of the Y_2O_3 coated Inconel-718 substrate tested at 1273 K in air over a period of 100 h is also discussed.

Keywords: Yttria, High temperature X-ray diffraction, Thermal expansion coefficient, Thermal stress.

1. Introduction

High temperature oxidation is one of the major material degradation problems which affects the reliability and safety of the components used in power plants, petroleum and gas turbine industries [1,2]. Inconel-718 is a nickel-chromium based superalloy exhibiting excellent resistance to chemicals used in high temperature applications [3]. However, during long-term high temperature exposure, chromium depletion from the alloy leads to stress corrosion cracking (SCC) or inter-granular corrosion (IGC) which leads to failure of the alloy components [4]. Development of ceramic diffusion barrier coatings on alloy surface can potentially delay or