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Original Research

Effect of Y_2O_3 content in the pack mixtures on microstructure and oxidation resistance of B–Y modified silicide coating

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Abstract

B–Y modified silicide coatings were prepared on Nb–Si based alloy by pack cementation at 1300 ℃ for 10 h. The effect of Y_2O_3 content in the pack mixtures on microstructure and oxidation resistance of the coatings was investigated. The results show that the four coatings have similar structures, which possess a $(Nb,X)Si_2$ outer layer and a $(Nb,X)_5Si_3$ transitional layer. Y_2O_3 content in the pack mixtures has an obvious effect on the Si content in the coating. The mass gains of the coatings prepared with 0.5, 1, 2 and 3 wt% Y_2O_3 in pack mixtures are 2.33, 1.96, 2.05 and 2.86 mg/cm^2 after oxidation at 1250 ℃ for 100 h, respectively. The coating prepared with 1 wt% Y_2O_3 exhibits the best oxidation resistance due to the formation of a dense glass-like borosilicate scale.

Keywords: Coating; High-temperature alloys; Intermetallics; Oxidation

1. Introduction

Niobium silicide based alloys have attracted much attention as candidates for high temperature structural materials because of their high melting points, low density and high strength at high temperatures [1–3]. However, the widespread application of Nb–Si based materials is still limited due to their poor oxidation resistance at elevated temperatures. Alloying can enhance the oxidation resistance of Nb alloys, but simultaneously it degrades the mechanical properties [3–7]. Thus, in order to be used at high temperatures in air, Nb–Si based alloys need to be coated with oxidation-resistant materials [8–10].

An oxidation-resistant coating must serve as a barrier against oxygen penetration and form a dense, adherent and slow-growing oxide scales. Silicide and aluminide coatings on Nb–Si based alloys were found to be suitable for improving their high-temperature oxidation performance by forming the protective oxide scales such as SiO_2 and Al_2O_3, respectively [9–14]. Specially, silicide coatings can offer relative good oxidation resistance at high temperatures due to the formation of amorphous SiO_2 scale, which may flow and heal cracks [15]. However, there are two major factors limiting the long-term application of silicide coating at high temperature. Firstly, the high viscosity of SiO_2 results in reducing the ability to heal the pores and cracks at high temperature. Fortunately, Perepezko et al. have studied that adding B to silicide coatings can improve the oxidation resistance of the coatings by lowering the scale viscosity [8,16–18]. Secondly, the brittleness of pure silicide coatings hinder their long-term applications seriously. Adding a small amount of active elements, such as Y, Ce and La, etc, to the coatings has proved to be available to refine the grain sizes and modify the brittleness of the coatings, and correspondingly reduce the oxidation rate and improve the adherence of the oxide layer [7,19–23]. Guo et al. showed that Si–Y co-deposition coating had superior oxidation resistance at high temperature [24–26]. Moreover, the addition of Y improved the sintering characteristics and plasticity of the oxides, which reduced the stress in the scale [27].

However, few studies focused on the B–Y modified silicide coating simultaneously. Thus, in this study the B–Y modified silicide coating was prepared on the surfaces of Nb–Si based alloy by pack cementation process. The effects of Y_2O_3

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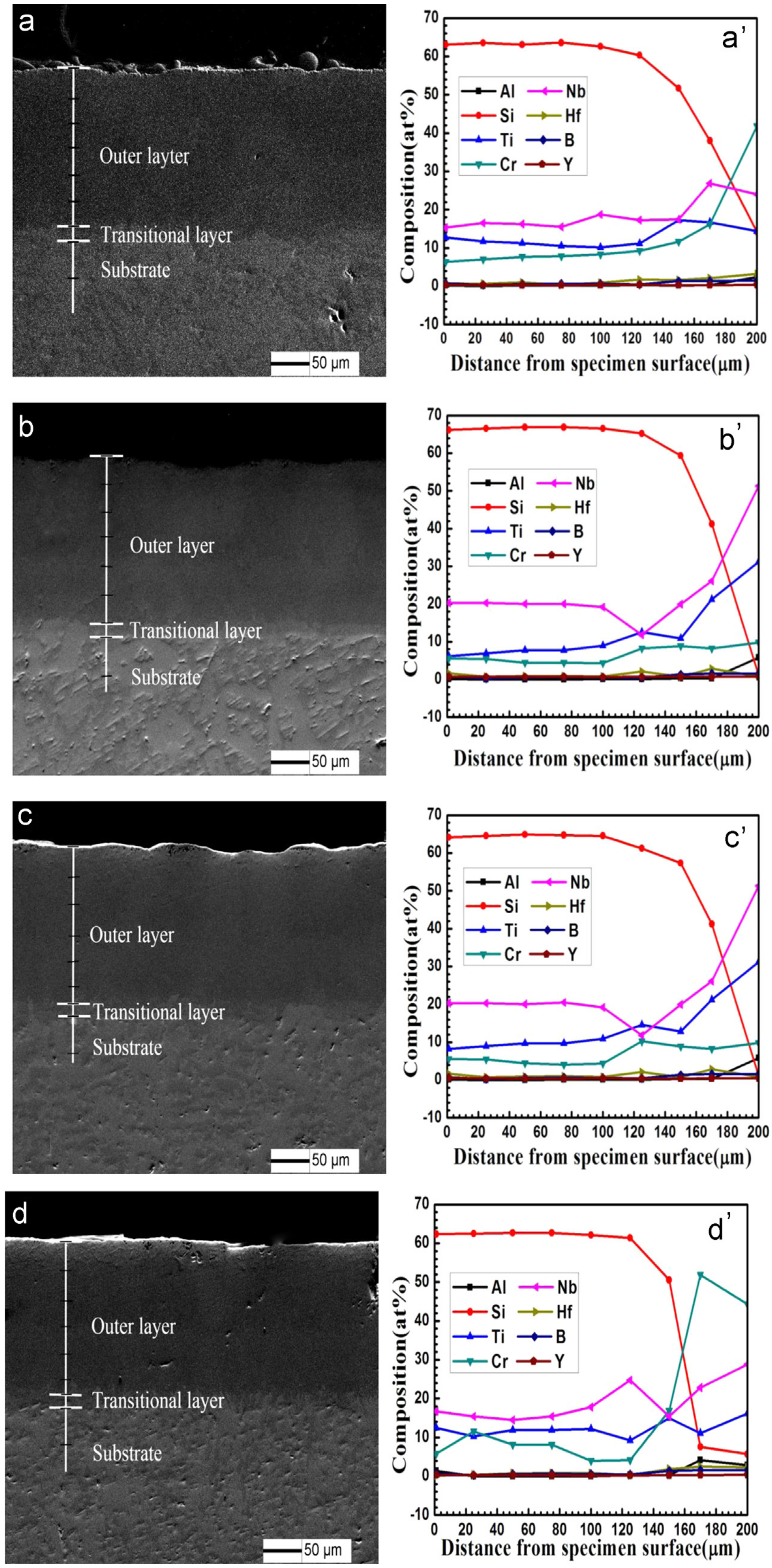

Fig. 1. Cross sectional BSE image and major elemental concentration profiles of B–Y modified silicide coating prepared with pack mixtures containing different mass fractions of Y_2O_3: (a,a′) 0.5%; (b,b′) 1%; (c,c′) 2%; (d,d′) 3%.