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Effects of the constitution of CrON diffusion barrier on the oxidation resistance and interfacial fracture of duplex coating system

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A B S T R A C T

The duplex coating system of a NiCrAlY overlayer with a CrON diffusion barrier with different phase contents was deposited by AIP method. The duplex coatings were characterized regarding their microstructure, and the ability of the diffusion barrier was evaluated. The oxidation resistance and the interfacial strength of the duplex coatings were investigated. The results indicated that the duplex coating system with a diffusion barrier with an O/N ratio ~66 and a lower Cr_2O_3 phase content exhibited more excellent oxidation resistance and lesser interdiffusion than with a diffusion barrier with O/N ~30.1. The exposed coating samples possessed an improved interfacial strength compared with the annealed samples in the two duplex coating systems. The stronger interfacial strength in the coating system with a diffusion barrier with a low Cr_2O_3 phase content was related to the fewer defects and lower residual stress in the diffusion barrier.

1. Introduction

MCrAlY (M = Ni and/or Co) coatings, due to good balance between oxidation resistance and mechanical properties, have been widely used as standalone overlayers or bond coats in the TBCs for protecting the superalloy component in the gas turbine engine systems [1,2]. In order to further enhance the efficiency of the gas turbine engine system, the inlet temperature has been continuously increased. Consequently, the MCrAlY coatings degrade rapidly after a long-term exposure to elevated temperatures. The main cause is ascribed to strong interdiffusion between the coating and the substrate [3,4]. The introduction of a diffusion barrier as an interlayer in the interface between the MCrAlY coating and the substrate is considered as the most effective solution to limit the interdiffusion and thereby prolong the service lifetime of the coating.

The investigations on diffusion barriers over the past two decades indicated that for a diffusion barrier to be excellent it should combine the good barrier ability with the strong adhesion to the substrate or the overlayer [3–8]. Developing a diffusion barrier which can markedly suppress the interdiffusion and does not weaken largely the interfacial strength of the coating system onto the substrate is a key for the practical application of diffusion barrier, so that diffusion barriers, such as RuNiAl and NiCrAlON with the close compositions to the overlayers were fabricated [5,6].

In previous studies [4–8] it was found that the coating system of MCrAlY overlayer with a CrN diffusion barrier had a strong interfacial strength, but the oxidation resistance of the duplex coatings was limited. On the other hand, the introduction of a pure Cr_2O_3 diffusion barrier can suppress the interdiffusion with high efficiency due to the formation of a dense Al_2O_3 interlayer during thermal treatment, although the interfacial strength is impaired by the presence of residual stresses. Thus, one can expect that the CrON system with the appropriate phase ratio of CrN and Cr_2O_3 can provide an excellent diffusion barrier for the MCrAlY coating/Ni-based substrate system. Up to now, the effect of the CrON diffusion barrier with different phase contents on the oxidation resistance and the interfacial strength of the duplex coating system have not been investigated; thus an in-dept investigation on the mechanisms of oxidation and the interfacial properties of the MCrAlY overlayer with a diffusion barrier is desired.

In this work duplex coatings consisting of a MCrAlY coating and a CrON diffusion barrier, with different phase ratios of CrN and Cr_2O_3, were deposited on Ni-based superalloy by arc ion plating (AIP). In the present paper the microstructure of the MCrAlY coating and of the diffusion barrier was studied, and the oxidation resistance of the duplex coating and the effectiveness of the diffusion barrier were investigated. The interfacial strength of the coating systems

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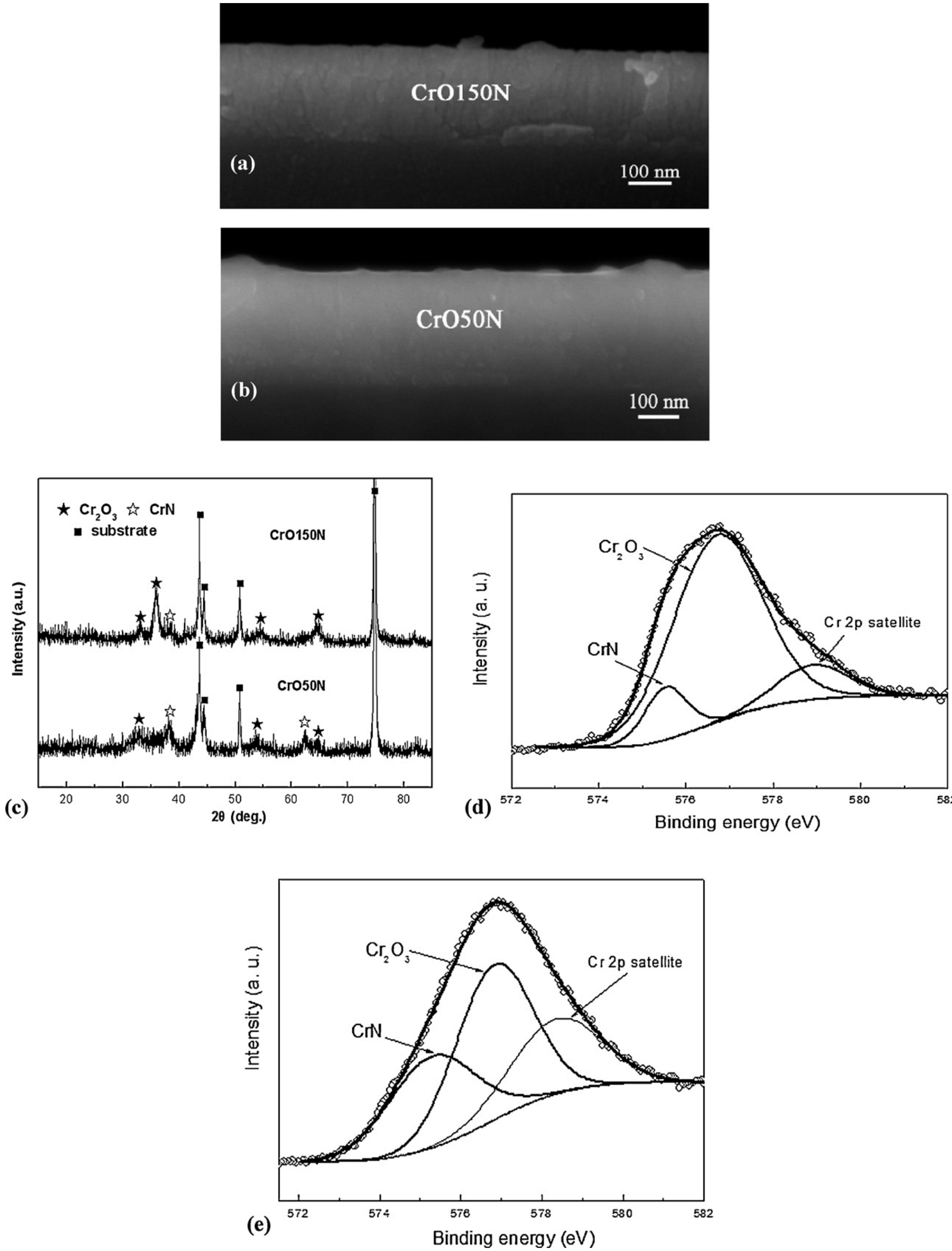

Fig. 1. Fractured cross-sectional SEM images ((a, b) on Si substrate), XRD patterns (c) and XPS patterns (d, e) of the as-deposited CrO150N (a, d) and CrO50N (b, e) diffusion barriers.