Effect of mixed nanocrystalline rare earth oxide coatings on high temperature oxidation of a ferritic stainless steel AISI 409

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Rare earths (RE) have been used to improve the high temperature oxidation resistance of chromium dioxide and alumina forming alloys. The RE can be added to the alloy as elements or as oxide to form dispersions. It can also be applied as a RE oxide coating on the surface of the alloy. In this investigation the sol-gel technique was used to prepare sols of the RE oxides as it produces nanocrystalline oxide particles. In an effort to increase further the oxidation resistance of high temperature alloys, optimization of RE oxide additions to the alloy surface was attempted. This paper presents the effect of nanocrystalline oxide gel coatings of CeO_2, Nd_2O_3, Pr_2O_3, CeO_2 + Nd_2O_3, CeO_2 + Pr_2O_3 and Pr_2O_3 + Nd_2O_3 on the oxidation behavior of a ferritic stainless steel AISI 409 at 1000 °C in air using a thermogravimetric balance. The morphology of the pure oxides was studied and the following formats were observed: CeO_2 – rods; Nd_2O_3 – platelets; Pr_2O_3 – needles; La_2O_3 – cuboids. The average oxide particle sizes and the average crystallite sizes were also determined. The oxidation rate of the coated steel specimen was significantly less than that of the uncoated steel specimen, due to formation of a fine layer of chromium dioxide at the steel/oxide interface. The oxidation rates of the different REO coated steel specimens varied with the type of REO. The mixed oxide containing Pr_2O_3 increased significantly the oxidation resistance of the steel. The CeO_2 + Nd_2O_3 mixture did not increase oxidation resistance of the steel further, compared to those with either one of these two rare earth oxides. The differences in the influence of a specific rare earth oxide or a mixture are attributable to differences in the ionic radii of the RE and the morphology as well as the crystallite sizes of the RE oxides.