INFLUENCE OF SURFACE DEPOSITED RARE EARTH OXIDES ON OXIDATION BEHAVIOR OF AISI 304 - A MORPHOLOGICAL STUDY

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Metallic materials for use in high temperature gaseous environments rely for their protection on the formation of a compact and adherent layer of either chromia, alumina or silica. The former two are used to a greater extent than the latter. The addition of rare earth (RE) elements have been shown to improve significantly the oxidation behavior of chromia forming alloys, especially in terms of reduced rates and increased scale adhesion. These two aspects are a consequence of the formation of a thin, uniform, fine grained and plastic layer of chromia[1]. Traditionally, the RE have been added to the alloy either in elemental form or as an oxide. The same effect, but to a reduced extent, has been observed when the RE were applied to the alloy surfaces[2]. A number of techniques have been used to apply RE to the surfaces of alloy substrates and the sol gel process is considered to be significantly more efficient[3]. This paper presents the effect of applying RE sols prepared by different methods on the morphology of the surface gel and consequently on the morphology of the scale formed upon oxidation at 1000°C for 20h. The sols were prepared from pure RE oxides, with nitric acid, water and certain additives. Sols were prepared with (a) no additive, (b) poliacrylamide and (c) a non-ionic surfactant. AISI 304 specimens were immersed in the RE sols and (a) dried and oxidised or (b) dried, calcined and oxidised.

The surface of the specimens with the as dried or dried and calcined sol with no additive revealed non-adherent RE oxide that was unevenly distributed. The RE oxide formed in the presence of poliacrilamide, although uniformly distributed over the surface, revealed considerable variations in oxide particle size and large interparticle spacing (figure 1). The RE oxides formed from the sols containing the surfactant were dense and uniformly distributed, but with some discontinuities. Figures 2a,b and c show the surface oxides of Pr, Y and Ce. Significant differences in morphology can be observed with the nature of oxide.

The surfaces of the oxidised specimens revealed, besides the applied RE surface oxide, chromium and/or iron oxide. The surfaces of oxidised AISI 304 covered with oxides of Pr, Y and Ce showed predominant chromia formation (figure 3a) where as that covered with Dy, predominantly iron oxide (figure 3b). The cross sections revealing the metal/metal oxide interface have also been examined and differences in the thickness of the surface oxide as well as the zone of internal oxidation have been noted, primarily as a function of nature of RE oxide and method of preparation. These data will also be presented and discussed.

References

1 - Bonnet, G.; Aguilar, G. - Corrosion Science, 35, 5, (1993), 893.
2 - Ramanathan, L. V. - Corrosion Science, 35, 5, (1993), 871.
3 - Stringer, J. - Mat. Sci. and Eng., A120, (1989),.129.

Figure 1

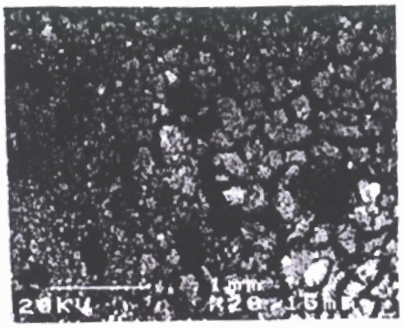

Figure 2

a b c

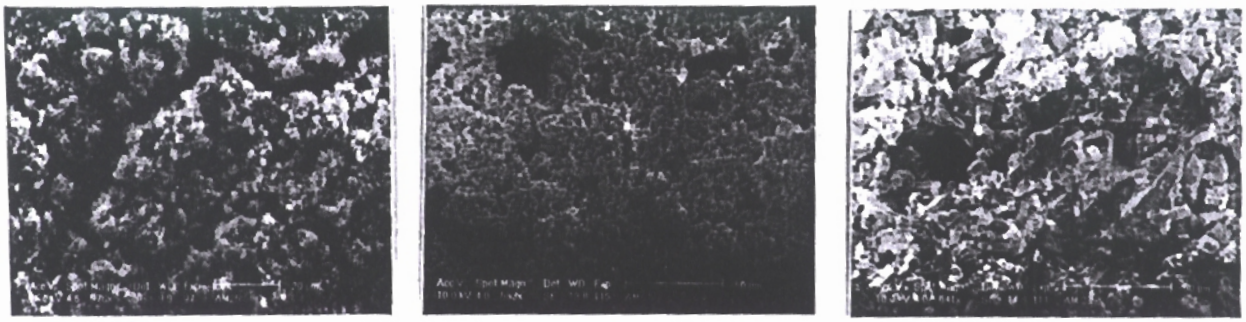

Figure 3

a b

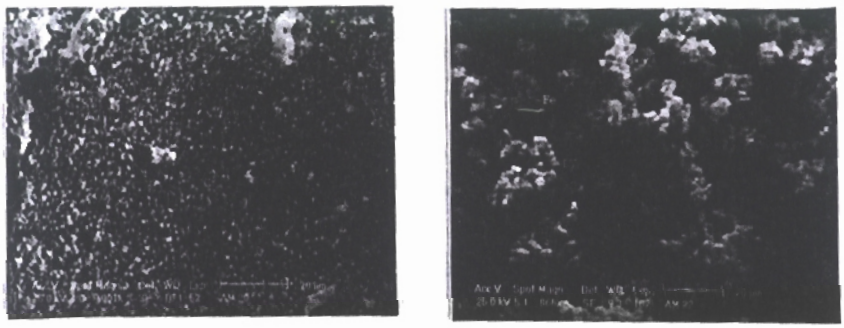

Figure 1: Scanning electron micrographs (SEM) of AISI 304 covered with RE oxide and poliacrilamide.

Figure 2: SEM of AISI 304 covered with oxides of (a) Pr, (b) Y and (c) Ce.

Figure 3: SEM of oxidised AISI 304. (a) Y covered, (b) Dy covered.