Effect of a 50 nm-thick Sol-Gel Alumina Film on the Oxidation Behavior of Ni-Based Superalloy

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We have recently shown that a 150 nm-thick α-Al_2O_3 layer prepared by chemical vapor deposition (CVD), which was directly deposited on the surface of a Ni-based superalloy, could substantially reduce the growth rate of thermally grown oxide (TGO) [1, 2]. The CVD layer also improved its isothermal spallation resistance up to 500 hours at 1150ºC [1]. In the present study, we prepared another artificial alumina layer by a sol-gel route using aluminum alkoxide as a precursor.

The sol-gel Al_2O_3 layer also reduced the growth kinetics of the TGO formed on the alloy surface. The average TGO thickness was measured to be ~1.55 μm with the initial layer, whereas the thickness was ~3.4 μm without the sol-gel Al_2O_3 after 100 hours of isothermal oxidation in air at 1150ºC. Also, the artificial layer produced an adherent TGO and no spallation could be observed on the surface of the coated sample in comparison to an uncoated one. In this presentation, we will describe in more detail as how the aluminum alkoxide precursors transforms to an α-Al_2O_3 thin-film at the early stage of high temperature exposure, as the key mechanism for the beneficial effect. These results further demonstrate this thin alumina layer, regardless of processing methods, could be used to favorably alter the TGO growth behavior and consequently increase the oxidation resistance of Ni-based superalloys.

[1] Y.-F. Su, L.F. Allard, D.W. Coffey, and W.Y. Lee, Met. Mater. Trans., 35A, 1055, 2004.
[2] Y.-F. Su and W.Y. Lee, p. 33 in High Temperature Corrosion and Materials Chemistry IV, The Electrochemical Society, Pennington, NJ, 2003.