Effects of an alpha-Al2O3 Layer on Morphological Development and Growth Kinetics of the Thermally Grown Oxide Formed on Ni-Based Superalloy Surface

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It is postulated that a thin alpha-Al2O3 layer, if it could be deposited directly on an alumina scale forming alloy surface, will guide the alloy surface to form a thermally grown oxide (TGO) that is more tenacious and slower growing than what is attainable with state-of-the-art bond coatings used for thermal barrier coating (TBC) applications. In this work, a 150 nm-thick coating layer consisting of alpha-Al2O3 as the major phase with a minute amount of theta-Al2O3 was deposited on the surface of a single- crystal Ni-based superalloy by chemical vapor deposition (CVD). Within 0.5 h of oxidation at 1150C, the resulting thermally grown oxide (TGO) formed on the alloy surface underwent significant lateral grain growth. Consequently, within this time scale, the columnar nature of the TGO became established. After 50 h, a network of ridges was clearly observed on the TGO surface instead of equiaxed grains typically observed on uncoated alloy surface. The alloy coated with CVD-Al2O3 also produced a much more adherent and slow growing TGO in comparison to that formed on the uncoated alloy surface. The CVD-Al2O3 layer also improved its spallation resistance. Without the CVD-Al2O3 layer, more than 50% of the TGO spalled off the alloy surface after 500 h in oxidation with significant wrinkling of the TGO that remained on the alloy surface. In contrast, the TGO remained intact with the CVD-Al2O3 layer after the 500 h exposure. Furthermore, the CVD layer significantly reduced the degree of internal oxidation of Ta-rich areas which were present in the superalloy as casting defects. The present study demonstrated that this thin alpha-Al2O3 coating concept could be used as a novel means of favorably altering the TGO morphology and consequently increasing the oxidation resistance of Ni-based superalloys for next generation TBC applications.