Nucleation and Growth Behavior of Chemically Vapor Deposited Alpha-Al2O3 on Single Crystal Ni-based Superalloy Surface

Yi-Feng Su[1] and Woo Lee[1]

[1] Stevens Institute of Technology
Department of Chemical, Biochemical, and Materials Engineering
Hoboken, NJ 07030
USA

Alpha-Al2O3 is one of the most stable materials in high-temperature combustion environments. However, it is also known that alpha-Al2O3 is one of the most difficult materials to prepare in the form of thin-film. We have developed a novel procedure for preparing a high-quality a-Al2O3 coating layer directly on the surface of a single crystal Ni-based superalloy by chemical vapor deposition (CVD). The key feature of this procedure was to pretreat the alloy surface with a CO2+H2 mixture at 1050° C for 1 min prior to a CVD step with AlCl3, CO2, and H2 precursors for 10 min at 1050°C in the same reactor chamber. Characterization results showed that the pretreatment step resulted in the formation of a continuous oxide layer (∼50 nm) on the alloy surface which consisted of alpha-Al2O3 as the major phase along with a trace amount of theta-Al2O3. The subsequent CVD-Al2O3 layer was 150 nm thick, and consisted of small columnar grains (∼100 to 200 nm) with alpha-Al2O3 as the major phase with a minute amount of theta-Al2O3. It appeared that the preferential nucleation of alpha-Al2O3 in the pre-oxidized layer was promoted by: (1) rapid heating of the alloy surface to the temperature region, where a- Al2O3 was expected to nucleate and (2) the low oxygen pressure environment of the pre-oxidation step which kept the rate of oxidation low.