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POTENTIAL IMPACTS OF ALTERNATIVE FUELS ON THE EVOLUTION AND STABILITY OF TURBINE HOT-SECTION MATERIALS

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This talk will provide an overview of a research program focused on evaluating the potential impacts of alternative fuels (coal-derived syngas, high-hydrogen content fuels, bio-derived synthetics) on the degradation of hot-section materials through accelerated attack of protective thermally grown oxides (TGOs) and thermal barrier coating (TBC) systems. A primary focus is the role of elevated water vapor levels, volatility, and vapor phase transport processes on the evolution of TGO and TBC systems. Materials exposure studies will be described that demonstrate that differing simulated combustion environments affect both the growth rate and the stability of the resulting thermally grown oxides. In systematic studies of oxide growth on MCrAlY bond coat materials in simulated combustion environments with varying pH_2O, it is shown that the extent of spinel formation during transient oxidation is highly dependent upon the water vapor content in the exposure environment, and furthermore that the evolution of surface oxides is highly dependent upon volatilization and removal of spinel phases formed during transient oxidation periods. The pH_2O dependence of spinel formation during transient oxidation*, and evolution/removal during subsequent exposure to the simulated combustion environments,* is found to be spatially-correlated with the underlying metal phase distributions, and hence is highly dependent upon the composition of the bond coat materials. These observations were verified by carrying out site-specific characterization of the growth and evolution of the surface spinels, with high-resolution imaging and characterization of the oxides that are formed (and spatially correlated with the initial microstructure). Observations of transient spinel volatilizing from TGO surfaces in high pH_2O environments were supported by measurements of nickel volatilizing from pre-fabricated $NiAl_2O_4$ spinel pellets as a function of the simulated combustion environment. Additionally, this talk will discuss the role of high pH_2O environments on TBC materials stability, as well as vapor-phase transport processes and mechanisms affecting TBC system lifetimes.

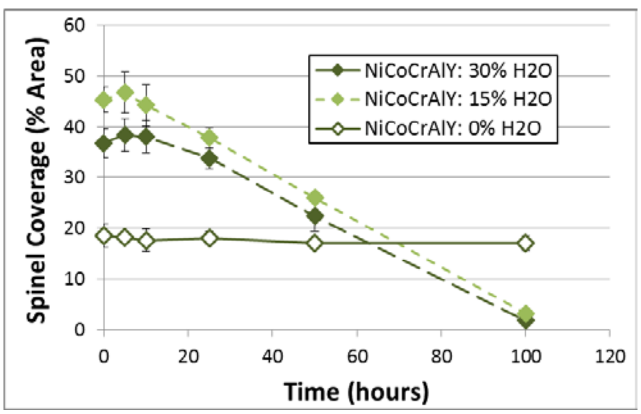

Figure 1 – Spinel surface area coverage versus time for NiCoCrAlY specimens oxidized in 30, 15 and 0% H_2O.

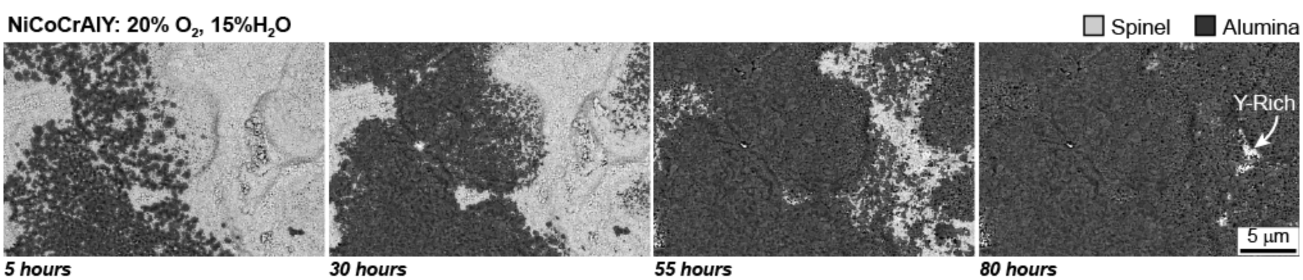

Figure 2 – A "timelapse" of NiCoCrAlY TGO (20% O_2, 15% H_20) from 5 to 80 hours. All backscatter images (5kV) were taken at the same site with 25 hours of oxidation (plus ramping times) separating them.