MICROSTRUCTURAL EVOLUTION OF ENVIRONMENTAL BARRIER COATINGS IN HIGH-TEMPERATURE STEAM

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Environmental Barrier Coatings (EBCs) are required for use of SiC-based composites in hot sections of gas turbine engines. The primary function of EBCs is to limit the interaction of SiC with steam in the combustion environment. Due to the additional constraints of thermal expansion match and chemical compatibility with the SiC substrate, state-of-the art EBCs are typically fabricated from complex silicates. These silicates typically have sufficiently high silica activities that they also react with the steam by the following generic reaction.

$$a\ MO_x \cdot b\ SiO_2 + 2H_2O(g) = Si(OH)_4(g) + a\ MO_x \cdot (b\text{-}1)\ SiO_2 + \text{porosity}$$

This reaction has been extensively studied for the model EBC material $Y_2Si_2O_7$ using 1200°C exposures in a steam-jet furnace [1]. Representative microstructures are shown in Figure 1. The amount of porosity formed at short times can be estimated from the volume change that accompanies the transformation from the high silicate to the low silicate, i.e., the transformation of $Y_2Si_2O_7$ to Y_2SiO_5 results in a volume reduction of ~30%. Several features of note have been observed. First, the depth of silica depletion increases with time following parabolic kinetics in phase pure material. Second, the pore structure is faceted and columnar at short times. Finally, after longer term exposures the porous Y_2SiO_5 surface layer sinters, the pores coarsen, the overall volume fraction of pores decreases, and the tortuosity of the porous structure increases. Given this observed microstructural evolution, we propose that an EBC silicate material can potentially be selected such that the silica-depleted surface layer sinters and self-heals, forming a more stable barrier layer that limits further reaction with high-temperature steam. Three silicates are investigated to explore *i)* the effects of volume change on silica depletion and *ii)* sinterability of the silica-depleted oxide. These silicates include $Ba_{1-x}Sr_xAl_2Si_2O_8$, $Yb_2Si_2O_7$, and $HfSiO_4$. Preliminary results for the microstructural evolution of these silicates in high-temperature, high-velocity steam will be presented along with our more comprehensive study of $Y_2Si_2O_7$ stability in steam.

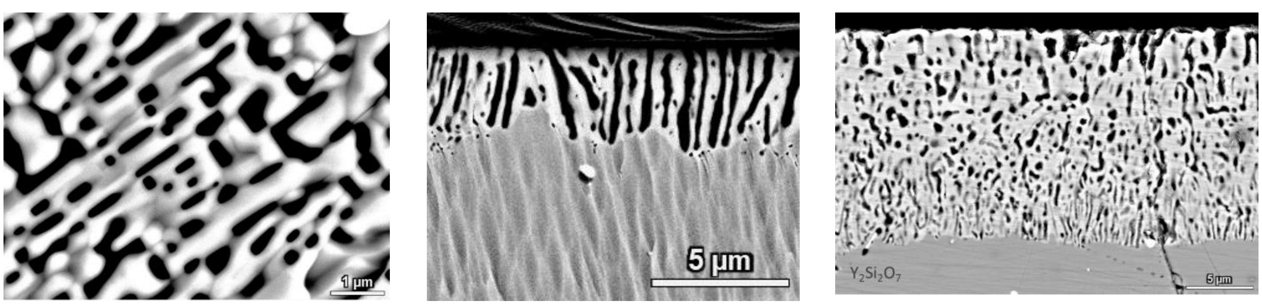

Figure 1 – Porous Y_2SiO_5 surface layer formed on $Y_2Si_2O_7$ after exposure at 1200°C, 1 atm steam flowing at ~160m/s. Left: surface view after 6h; Middle: cross-section after 12h; Right: cross-section after 250h.

[1] R.A. Golden, E.J. Opila, "A Method for Assessing the Volatility of Oxides in High-Temperature High-Velocity Water Vapor," J. Eur. Cer. Soc. 36, 1135-1147 (2016).