T-EBC COATING SYSTEM FAILURE MODES

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The failure modes during steam cycling between 110 ° and 1316°C of silicon-ytterbium silicate EBC systems applied to silicon carbide substrates have been investigated. Premature delamination failure at silicon-ytterbium monosilicate (YbMS) interfaces is shown to result from thermal expansion mismatch driven channel cracking of the YbMS layer. These coating penetrating cracks enabled water vapor and oxygen to reach the silicon bond coat layer outer surface from the start of the thermal cycling process, and resulted in the rapid growth of an upper (b-phase) cristobalite thermally grown oxide (TGO) layer on the silicon surface. This silica layer suffered rapid edge erosion followed by thermal contraction mismatch induced delamination crack extension from the edge of the samples during cooling. Replacement of the steam erosion resistant monosilicate by its dislicate counterpart eliminated the channel crack oxidizer pathways to the silicon surface and delayed the growth of the silica TGO. The eventual failure of this coating architecture was governed by the development of a significant delamination driving force at the silicon - ytterbium dislicate interface as the TGO thickness exceeded ~5 mm. Coating failure life was then governed by the rate of permeation of oxidants through the ytterbium dislicate and by the very large thermal stresses developed during the upper to lower cristobalite transformation. Interestingly, the oxidant permeation is likely to increase during prolonged cycling as the diffusion barrier dislicate layer thickness was decreased by steam erosion. Preliminary results from investigations of several concepts for extending the coating system life will be described. One sought to utilize a thermal barrier coating to reduce the EBC temperature and water vapor flow rate at the ytterbium dislicate outer surface. A second has investigated the use of thin hafnia layers applied to the silicon bond coat outer surface to induce the formation of a composite silica/hafnium silicate TGO to reduce the thermal strain energy for delamination.

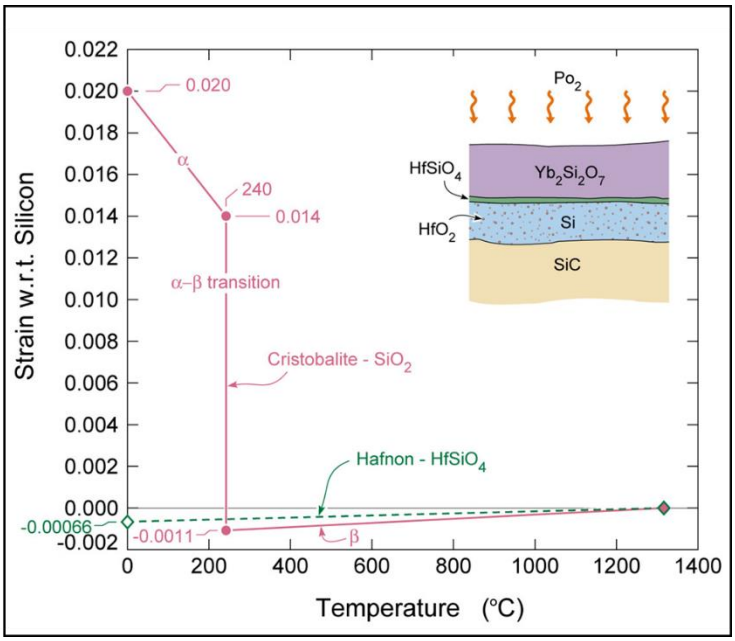

Figure 1 – Thermal expansion mismatch strain as a function of temperature during the cooling of a ytterbium dislicate – silicon EBC in which either a □-cristobalite or a hafnium silicate TGO had formed on the silicon bond coat.