STRESSES IN YTTERBIUM SILICATE MULTILAYER ENVIRONMENTAL BARRIER COATINGS

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Due to their excellent high temperature properties, low density, and good thermomechanical stability silicon-based ceramics (SiC, Si_3N_4) are one of the most promising materials systems for high temperature structural applications in gas turbine engines. However, their passivating SiO_2 surface layer reacts with water vapor contained in combustion environments. The resulting hydroxide layer volatilizes, leading to component recession. Environmental barrier coatings have been developed to shield the substrate from degradation. Aluminosilicate and Ba-Sr-Al-silicate (BSAS) glass ceramic multilayer coatings have been identified as a promising system for SiC substrates. Although these materials show good long-term performance in clean environments, their use is limited to temperature up to ~1300ºC due to BSAS water vapor recession and BSAS-silica chemical reaction. Other durability issues include degradation by Ca-containing molten deposits and cracking induced by thermal expansion coefficient mismatches between the layers of the coating system.

Next-generation , plasma-sprayed multilayer coatings based on ytterbium silicate (Yb_2SiO_5 and $Yb_2Si_2O_7$) topcoats with a nominal thickness of 200 μm were investigated in this research. Preliminary studies have shown these ytterbium silicates to have very low volatilities in high-temperature environments. Using microfocused high-energy X-rays in a transmission diffraction geometry, internal elastic strains in each layer were measured and stresses determined. Experiments were carried out on as-sprayed and ex-situ heat-treated samples, as well as samples heated in situ to 1400°C in order to analyze the strain and phase evolution, as a function of depth and temperature. In situ mechanical loading experiments were also carried out to determine the X-ray elastic coefficients of these materials, some of which had not previously been established.

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