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Mechanical and Chemical Performance of Multilayered EBCs with Graded YbMS/YbDS Compositions

Abstract:
Silicon carbide (SiC)-based composites used in gas turbines require environmental barrier coatings (EBCs) to ensure durability under extreme conditions. These coatings must resist high-temperature water vapor, be chemically and thermally compatible with the substrate, and withstand corrosion from molten silicates (CMAS). Rare earth-based silicates, such as ytterbium monosilicate (Yb_2SiO_5, YbMS) and ytterbium disilicate ($Yb_2Si_2O_7$, YbDS), are promising EBC materials due to their phase stability at high temperature. YbMS provides excellent resistance to CMAS and water vapor but is more brittle and has a higher coefficient of thermal expansion (CTE). YbDS, while less resistant, offers better CTE compatibility with SiC substrates. Bi-layer coatings using both materials often fail due to cracking in the brittle YbMS layer. To overcome this, we developed advanced multilayered EBCs using air plasma spraying (APS), consisting of a silicon bond coat followed by up to five engineered layers with graded YbDS/YbMS compositions. This design aims to reduce internal stresses and improve mechanical integrity while maintaining environmental resistance. Depositions were carried out using a dual feeder system, adjusting the feed rates of pure YbDS and YbMS powders to achieve the desired proportions. The microstructural observations showed that the composition of each layer was consistent with the designed one. The coatings were further evaluated through adhesion, thermal cycling fatigue, CMAS corrosion, and water vapor corrosion tests. Additional testing was performed on five-layer systems that were heat-treated and on versions with asymmetric layer thicknesses, both designed to further enhance the performance and durability of the coating