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Multilayered thermal barrier coatings

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Thermal barrier coatings (TBCs) are finding increasing applications in gas turbines to provide thermal, corrosion and erosion protections for the metallic hot-section components in order to achieve higher gas temperature capability, improved efficiency and durability. YSZ has large thermal expansion coefficient and extremely high fracture toughness, but the high thermal conductivity and phase transformation below 1200℃ are its intrinsic shortcomings. Currently, the long-term application temperature of YSZ coating is below 1200℃, which cannot match the requirements of the next generation gas turbine operated at a higher gas temperature. We have successfully developed the multilayered TBCs based on rare earth composite oxides and YSZ. LMA/YSZ, LZ7C3/YSZ and LZ/YSZ double-layered or functionally graded TBCs have outstanding thermal cycling lives which are much longer than that of single layered YSZ coating due to the thermal stress relief.

A novel non-destructive inspection technique was developed to measure the residual stresses in TBCs by using Eu^{3+} photoluminescence piezo-spectroscopy. The relationship between the strongest peak of $^5D_0 \rightarrow {}^7F_2$ and stress was determined by the high-pressure experiments and used to evaluate the residual stresses. When the top ceramic coat LZ7C3 in the double-layered coating LZ7C3/YSZ:Eu spalled, the inner YSZ:Eu could produce visible luminescence under UV illumination, providing an indication of the spallation location. The LZ7C3/YSZ:Eu coating spalled bit by bit from LZ7C3 to YSZ:Eu during thermal cycling. The similar thermal expansions of LZ7C3 and YSZ:Eu prolonged the thermal cycling life of the coating.