Failure Behaviors of LaZrCeO Thermal Barrier Coatings under High Temperature

Bo Yu, Zaoyu Shen, Yuqing Luo

Key Laboratory of Advanced Corrosion and Protection for Aviation Materials, Beijing Institute of Aeronautical Materials, Aero Engine Corporation of China, Beijing 100095 (P. R. China)

Abstract The development of new thermal barrier coatings with low thermal conductivity and high service temperatures has become one of the key technologies for the development of the next generation of high-performance engines.This paper uses electron beam physical vapor deposition (EB-PVD) technology to prepare LaZrCeO/YSZ dual ceramic thermal barrier coatings on a Ni-based superalloy substrate. The composition, phase structure, and thermal cycling life of the thermal barrier coatings were studied. The failure mechanism of the thermal barrier coating under 1300°C thermal cycling was analyzed. The results show that the coating phase is a composite of pyrochlore and fluorite structures, with a typical columnar crystal structure. A 1300°C flame thermal shock test indicates that the LaZrCeO/YSZ dual ceramic thermal barrier coating with a composite pyrochlore and fluorite structure has a thermal shock life exceeding 4000 cycles, demonstrating good thermo-physical properties. As the thermal cycling progresses, the Al element in the metal bond layer diffuses outward, forming TGO, and the Cr element reacts with $La_2Zr_2O_7$ and O to form $LaCrO_3$ and ZrO_2. Cracks in the TGO layer or interface layer reduce the toughness between the metal bond layer and the ceramic layer, ultimately leading to the failure of the thermal barrier coating.

Keywords

Thermal Barrier Coatings; of LaZrCeO Therm; Microstructural Evolution; Residual Stress; Element Diffusion

Reference

[1] N. P. Padture, M. Gell, E. H. Jordan. Thermal Barrier Coatings for Gas-Turbine Engine Applications. Science 296 (2002) 280-284.

[2] A. G. Evans, D. R. Mumm, J. W. Hutchinson, G. H. Meier, F. S. Pettit. Mechanisms Controlling the Curability of Thermal Barrier Coatings. Prog. Mater. Sci. 46 (2001) 505-553.

[3] J. M. Drexler, A. D. Gledhill, K. Shinoda, A. L. Vasiliev, K. M. Reddy, S. Sampath, N. P. Padture. Jet Engine Coatings for Resisting Volcanic Ash Damage. Adv. Mater. 23 (2011) 2419-2424.

[4] C. G. Levi. Emerging Materials and Processes for Thermal Barrier Systems. Curr. Opin. Solid State Mater. Sci. 8 (2002) 77-91.

[5] D. R. Clarke, C. G. Levi. Material Design for the Next Generation of Thermal Barrier Coating. Annu. Rev. Mater. Sci. 33 (2003) 383-417.