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X-ray diffractional, spectroscopic and thermo-physical properties analyses on Eu-doped lanthanum zirconate ceramic for thermal barrier coatings

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Abstract: To improve the protective temperature of thermal barrier coatings (TBCs), different Eu-doping ratios of $La_2Zr_2O_7$ with pyrochlore structure, which are more stable in thermodynamics, were synthesized by coprecipitation-calcination method. Phase structure, grain growth kinetics, bond strength, thermo-physical properties of the doped $La_2Zr_2O_7$ were investigated under different doping ratios. The results show that nano-sized doped $La_2Zr_2O_7$ grains (<100 nm) grow rapidly under elevated synthesis temperature. Meanwhile the increasing Eu^{3+} ions lead to more imperfects, changes of bond strength, and slight disorder of the lattice. The coefficient of thermal expansion (CTE) of Eu-doped $La_2Zr_2O_7$ is notably improved as Eu^{3+} ions increase. The thermal conductivity decreases at initial period and increases afterwards, which reaches the lowest value for the composition of $(La_{0.6}Eu_{0.4})_2Zr_2O_7$.

Keywords: Eu-doped lanthanum zirconate; thermal barrier coatings; phase structure; thermo-physical properties

1 Introduction

The operation efficiency and thrust-to-weight ratio of gas-turbine engines is directly related to the inlet gas temperature, which is much higher than the melting point of superalloy used in the turbines. Thermal barrier coatings (TBCs), composed of refractory oxide ceramics, are applied to the surface on hot parts of gas-turbine engines for thermal insulation and other protections of superalloy, thus enabling modern engines to operate at higher inlet gas temperature. Adding TBCs to turbine engines has the potential to increase operating temperature roughly as high as 150 °C, equivalent to the improvement of Ni-based superalloy and cooling technology in the last 20 years [1].The TBCs have emerged as one of the most critical materials for the next generation of gas turbine technology [2].

The conventional TBC is Y_2O_3-stabilized ZrO_2 (YSZ), which is widely used for its low thermal conductivity, high melting point, and long service life [3-5], and its deposition technology is well established [6, 7]. But YSZ coatings could not be used at the temperature above 1200 °C for long-term application due to its relatively low sintering resistance and phase structure stability, which impose restrictions on the improvement of gas temperature and are less effective at higher temperature for the next generation of advanced engines [8, 9]. So it is urgently needed to develop new TBCs materials with better phase stability, greater sintering resistance and lower thermal conductivity than YSZ.

Among the candidates of ceramic materials in recent studies, rare earth zirconates

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