单晶高温合金 CVD 铝化物涂层对热障涂层高温防护性能的影响 *

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摘 要:在镍基单晶高温合金 DD5 上依次采用化学气相沉积(CVD)法沉积铝化物涂层,使用真空电弧离子镀(ARC)原位沉积 NiCoCrAlYHf(HY5)金属粘结层,采用电子束物理气相沉积(EB-PVD)沉积氧化钇稳定的氧化锆(6~8YSZ)。对比了 DD5+(HY5+YSZ)及 DD5+(Al+HY5+YSZ)两种涂层试样在 1100℃下的静态氧化防护性能。采用 X 射线衍射仪、扫描电子显微镜、电子探针等方法分析了两种涂层在高温氧化过程中显微组织和成分的演变规律。结果表明:DD5+(Al+HY5+YSZ)涂层为多层结构,组织致密,与基体结合良好;250h 静态氧化后, 两种涂层外观状态整体完好;1100℃/250h 静态氧化条件下,DD5 合金、DD5+(HY5+YSZ)涂层和 DD5+(Al+HY5+YSZ)涂层的氧化速率常数分别为 0.415,0.410,0.354 $g^2\cdot m^4\cdot h^{-1}$;250h 静态氧化后,DD5+(HY5+YSZ)和 DD5+(Al+HY5+YSZ)涂层中铝元素含量最高分别为 5.8wt%和 16.7wt%,粘结层上表面铝元素含量分别为 3.7wt%和 6.0wt%,热生长氧化物(TGO)厚度分别为 6.6μm 和 9.4μm;两种涂层与基体间均发生了元素互扩散,出现了二次反应区(SRZ),DD5+(Al+HY5+YSZ)涂层中二次反应区更为明显、连续。

关 键 词:化学气相沉积;铝化物涂层;热障涂层;电子束物理气相沉积;静态氧化
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Influence of Aluminide Coating Prepared by Chemical Vapor Depositionon High-Temperature Protective Performance of Thermal Barrier Coating on Single Crystal Superalloy

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Abstract: Aluminide coating was deposited on the nickel-based single crystal superalloy DD5 by chemical vapor deposition (CVD), then NiCoCrAlYHf (HY5) metal bond coat was deposited in situ by vacuum arc ion plating (ARC), and yttria-stabilized zirconia (6~8YSZ) was deposited by electron beam physical vapor deposition (EB-PVD). The isothermal oxidation protection performance of DD5+(HY5+YSZ) and DD5+(Al+HY5+YSZ) samples at 1100℃ was compared. X-ray diffraction, scanning electron microscope and electron probe methods were used to analyze the evolution of microstructure and composition of the two coatings during high temperature oxidation. The results show that DD5+(Al+HY5+YSZ) coating has a dense multi-layer structure and combines well with the substrate. After isothermal oxidation for 250h, the appearance of the two coatings both keep intact. During the isothermal oxidation process at 1100℃ for 250h, the oxidation rate constants of DD5 alloy, DD5+(HY5+YSZ) coating, and DD5+(Al+HY5+YSZ) coating are 0.415, 0.410, 0.354$g^2\cdot m^4\cdot h^{-1}$, respectively. After isothermal oxidation for 250h, the highest Al contents in DD5+(HY5+YSZ) and DD5+(Al+HY5+YSZ) coatings are 5.8wt% and 16.7wt% respectively, which is in good accordance with Al content on the bond coat upper surface of 3.7wt% and 6.0wt%, and the thicknesses of thermal grown oxide (TGO) are 6.6μm and 9.4μm respectively. Element interdiffusion occurs between two coatings and the substrate, leading to the appearance of secondary reaction zone (SRZ). The SRZ in the DD5+(Al+HY5+YSZ) coating is more obvious and continuous than that in DD5+(HY5+YSZ).

Key words: CVD; aluminide coating; thermal barrier coating; EB-PVD; isothermal oxidation

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