稀土锆酸盐热障涂层的相稳定性和界面结合性能研究 *

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摘 要:采用电子束物理气相沉积(EB-PVD)工艺制备了 $La_2Zr_2O_7$(LZ)、$La_2Zr_2O_7$-3wt.%Y_2O_3(LZ3Y)、$La_2(Zr_{0.7}Ce_{0.3})_2O_7$(LZ7C3)和 6~8wt.%$Y_2O_3$ 部分稳定化的 ZrO_2(YSZ)四种陶瓷涂层,研究了稀土锆酸盐和 YSZ 热障涂层的高温相稳定性、涂层结合性能和热循环行为。借助 X-射线衍射仪(XRD)、扫描电子显微镜(SEM)、能谱仪(EDS)等表征手段分析了涂层的相组成、相结构稳定性、显微组织和化学成分。试验结果表明:经过 1300℃长时间热处理后,LZ、LZ3Y 和 LZ7C3 涂层粉末的 XRD 衍射峰均逐渐向 2θ 大角度方向偏移,涂层中共存的 La_2O_3、t-ZrO_2 和 CeO_2 物相也产生了固溶现象,YSZ 涂层则是出现了两个单斜相衍射峰且峰强度逐渐增大;在室温空气中放置 336h 后,LZ 涂层出现了明显的片层状脱落现象;YSZ 涂层的平均结合强度值最大,LZ 涂层则是最小。同样,三种稀土锆酸盐涂层的热循环寿命均比 YSZ 涂层短。这可能与三种涂层中含有过量的 La_2O_3 有关,La_2O_3 易于与空气中的 H_2O 或 CO_2 发生化学反应导致体积膨胀,从而削弱了陶瓷层与金属粘结层的界面结合性能,降低了陶瓷层的耐剥落寿命。

关 键 词:稀土锆酸盐;热障涂层;相结构;结合强度;热循环寿命

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Phase Stability and Interfacial Bonding Strength of Rare Earth Zirconate Novel Thermal Barrier Coatings

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Abstract: The four LZ, LZ3Y, LZ7C3 and YSZ thermal barrier coatings (TBCs)were fabricated via electron beam physical vapor deposition (EB-PVD). The high temperature phase stability, interficial bonding strength and cyclic oxidation behavior of three types of rare earth zirconates and YSZ TBCs were investigated. The phase constituent, phase structural stability, morphology and chemical composition of the four TBCs were systematically analyzed by XRD, SEM and EDS. The results indicate that the diffraction peaks belonging to the LZ, LZ3Y and LZ7C3 coating powders, which gradually shift to the larger 2θ-value after long-term thermal exposure at 1300℃. The excessive phases including of La_2O_3, t-ZrO_2 and CeO_2 coexisted in the ceramic coatings also have produced the solid solution phenomenon. The YSZ coating appears two monoclinic diffraction peaks and the intensities of these two peaks slightly increase to a certain extent. After 336h in room temperature air, the LZ coating exhibits lamellar delamination. The averaged interfacial bonding strength of YSZ coating is the highest, while that of LZ coating is the lowest. Meanwhile, the thermal cycling lives of three rare earth zirconates TBCs are lower than that of YSZ coating. It is proably related to the excess of La_2O_3 contained in the three new TBCs. La_2O_3 is easy to chemically react with H_2O or CO_2 in air, which further leads to volume expansion, weakens the inferfacial adhesion between the ceramic coat and bond coat and decreases the thermal cycling lifetime of the coaings.

Key words: rare earth zirconate; thermal barrier coatings; phase structure; bonding strength; thermal cycling lifetime

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