

GdPO₄: CMAS-phobic and infiltration-inhibiting protective layer material for thermal barrier coatings

Lanxin Zou¹, Lei Guo^{1*}, Shijun Meng¹, Yuanpeng Wang¹, Fuxing Ye¹, Hongbo Guo²

¹*School of Materials Science and Engineering, Tianjin University, Tianjin 300072, China*

²*School of Materials Science and Engineering, Beihang University, Beijing 100191, China*

E-mail address: glei028@tju.edu.cn (L. Guo).

Abstract Calcium–magnesium–alumina–silicate (CMAS) which wets, spreads and infiltrates into thermal barrier coatings (TBCs) at high temperatures during the operation of aero engines, seriously jeopardizes the performance and lifetime of TBCs. Here, we proposed a promising protective layer material of GdPO₄ for TBCs, which has excellent CMAS-phobicity and infiltration-inhibiting ability. The CMAS wetting behavior and its interfacial reaction with GdPO₄ were investigated and compared to Gd₂Zr₂O₇ and YSZ. The results showed that the contact angle between CMAS and GdPO₄ was the highest, indicating the best CMAS-phobicity of GdPO₄. An apatite reaction layer with a bilayer structure was formed at the interface between CMAS and GdPO₄ after corrosion at 1250 °C for 1 h, effectively inhibiting CMAS wetting and infiltration, mainly attributable to the fact that the needle-like structure of the upper sublayer helps pin the three-phase contact line of molten CMAS, which can inhibit CMAS wetting, and the compact lower sublayer inhibits CMAS infiltration. First-principles calculations revealed that GdPO₄ and its interfacial reaction layer had lower surface energy and smaller adhesion work between the interfacial reaction layer and CMAS, and these material properties all favor the CMAS-phobicity of GdPO₄. It is thus concluded that GdPO₄ is of excellent CMAS-phobicity and infiltration-inhibiting ability.

Keywords Thermal barrier coatings (TBCs); calcium–magnesium–alumina–silicate (CMAS)-phobicity; GdPO₄; interface reaction layer; first-principles calculation