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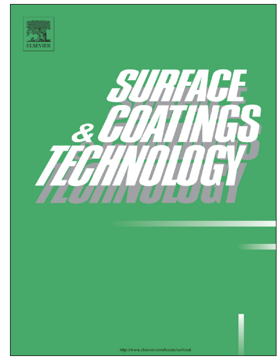

Plasma-assisted reactive high-rate vapor deposition of yttria-stabilized zirconia using electron beam evaporation and spotless vacuum arc

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Abstract

Some applications in energy technology will require large-area and dense coatings of yttria-stabilized zirconia (YSZ) while high coating rate is demanded for economic reasons. A combination process of co-evaporation of yttrium and zirconium by EB-PVD from a dual crucible, reactive processing procedure of introducing oxygen, and a spotless arc burning between zirconium as cathode and yttrium as anode were investigated experimentally. The YSZ layers were deposited at relatively high static coating rates (20 to 80 nm/s) in comparison to other PVD processes. The cubic crystal structure that was identified by means of XRD corresponds to the YSZ phase with the highest ionic conductivity and is therefore especially well-suited for use as a solid-state electrolyte.

Pores were evidenced in the microstructure of the layers deposited at a coating rate of more than 50 nm/s. Nevertheless, very dense YSZ layers could be obtained at a coating rate of 30 nm/s and a spotless arc current of 300 A. Specific leakage rates of YSZ layers on porous Ni/NiO-YSZ anode substrates measured using air are in the region of 1 Pa m s^{-1}. The investigations have shown that the intense plasma created with a spotless arc has a considerable influence on growth and microstructure of YSZ layers, even at high coating rates.

1. Introduction

On account of their high ionic conductivity of oxygen, coatings of yttria-stabilized zirconia (YSZ) have great potential for applications in energy technology [1]. Applications as a solid-state electrolyte in fuel cells (SOFC), as a gas-separation membrane for power stations, and for chemical process engineering require large-area coatings whose manufacture will in turn require inexpensive technologies for economic reasons in the future. YSZ coatings having columnar porous microstructures are being applied industrially as high-temperature thermal barrier coatings (TBC) on turbine blades using electron beam physical vapor deposition (EB-PVD) today. The porous microstructure is the basis for low thermal conductivity and high stability of the layers under highly varying thermal loading. Because quite high coating thicknesses are required for thermal insulation (on the order 100 µm), commensurately high coating rates of approximately 4 to 10 µm/min (67 to 167 nm/s) are necessary in practice for economical coating in industry. These high coating rates can be