for thermal insulation in TBC systems. Coatings with 7 to 8 weight percent yttria added to zirconia provide thermal shock resistance due to its metastable transformation phase.

SUMMARY

[0004] The present disclosure relates to a powder that forms a thermal barrier coating when thermally sprayed. In one example, the powder is a ceramic powder. Ceramic powder is advantageous due to its resistance to high temperatures reaching above 1000°C, but the generally higher hardness of this material may also lead to wear damage on, e.g., the nickel superalloy-based turbine blades (turbine section of aerospace engines or gas).

[0005] Severe wear damage may arise from inefficient cutting processes, leading to excessive friction-heating of blade materials under severe rubbing contact conditions in a turbine and/or if the thermally sprayed abradable coating is too hard. Examples of damage mechanisms to the blades include bulk plastic deformation and fracture, oxidation of material arising from frictional heating, and cracking of the material due to extreme cutting forces.

[0006] Thermal barrier coatings (TBCs) may improve the thermal insulation and erosion resistance properties of a coated component and may maintain these properties over the service life of the component by reducing sintering due to the use of ceramic powder. The thermal spray material for TBCs of the present disclosure differs from typical TBCs due to the multiphase nature of the coatings.

[0007] Within the present disclosure, the disclosed examples and claims, the term "phase" refers to attributes of each component in the thermal spray material.

[0008] In one aspect, the present disclosure relates to a thermal spray material for thermal barrier coatings, comprising: component (A) having erosion resistance; and component (B) having thermal conductivity. The present disclosure relates to a thermal spray material that includes at least one erosion resistant phase and at least one thermal conductivity

phase. In examples, the crystallographic phase of either the thermal conductivity phase or the erosion resistant phase is a tetragonal phase. The erosion resistant phase and the thermal conductivity phase have been found to be thermally stable as demonstrated by being in nearly identical proportions after more than

300 hours of exposure to high temperatures of at least 1250°C. The erosion resistant phase is in a range of 60-80 wt% and the thermal conductivity phase is in a range of 20-40 wt% after 300 hours of exposure to high temperatures. Thus, the ratio of the erosion resistant phase to the thermal conductivity phase is about 2:1. In a preferred example, the erosion resistant phase is about 70 wt% and the thermal conductivity phase is about 30 wt% after 300 hours of exposure to high temperatures. Thus, the ratio of the erosion resistant phase to the thermal conductivity phase is about 7:3. The multiphase structure of the components in the thermal barrier coating of the present disclosure provides improved erosion and thermal conductivity properties as compared to typical TBCs that contain only one of these phases.

[0009] In examples, the at least one erosion resistant phase includes a partially stabilized zirconium oxide that includes primary stabilizers, such as ytterbium oxide and/or dysprosium oxide. In examples, the at least one erosion resistant phase includes a ytterbium-oxide stabilized zirconium oxide that includes 84-86 wt% ZrO_2 and 14-16 wt% Yb_2O_3. In other examples, the at least one erosion resistant phase includes a ytterbium-oxide stabilized zirconium oxide that includes 82-86 wt% ZrO_2 and 14-18 wt% Yb_2O_3.

[0010] In examples, the amount of the primary stabilizers in the erosion resistant phase is in a range of 0.1-6.0 mol%. In other examples, the amount of the primary stabilizers in the erosion resistant phase is in a range of 5.0-6.0 mol%.

[0011] In examples, the at least one lower thermal conductivity phase includes a partially or a fully stabilized zirconia (or zirconates) that includes stabilizer oxides. In examples, the at least one lower thermal conductivity phase includes a cubic-zirconium oxide that includes 78-81 wt % ZrO_2, 9-10 wt% Y_2O_3, 5-6 wt% Gd_2O_3, and 5-6 wt% Yb_2O_3. In other examples, the at least one lower thermal conductivity

phase includes a dysprosium-oxide stabilized zirconium oxide that includes 88-92 wt% ZrO_2 and 9-11 wt% Dy_2O_3.

[0012] In examples, the stabilizer oxides can be one or more of the following oxides: yttrium, gadolinium, dysprosium, or ytterbium. In examples, the total amount of the stabilizer

oxides in the thermal conductivity phase is in a range of 3-35 mol%. In other examples, the total amount of the stabilizer oxides in the thermal conductivity phase is in a range of 3-10 mol%.

[0013] In non-limiting examples, the thermal spray material includes a high erosion resistant material at a concentration in a range of 50-90 wt%. In examples, the thermal spray material includes a high erosion resistant material at a concentration in a range of 60-80 wt%. In other examples, the thermal spray material includes a high erosion resistant material at a concentration in a range of 68-72 wt%. In a preferred example, the thermal spray material includes a high erosion resistant material at a concentration of about 70 wt%.

[0014] In non-limiting examples, the at least one erosion resistant phase and the at least one low thermal conductivity phase are present in the thermally stable coating material as a composite, a blend, or a cladded powder. In other examples, the blend or cladded powder provides improved coating performance, particularly erosion resistance.

[0015] In another aspect, the present disclosure relates to a method for manufacturing a thermally stable multiphase coating material for thermal barrier coatings comprising: blending component (A) having erosion resistance with component (B) having thermal conductivity to obtain a thermal spray material; and plasma spraying the thermal spray material to obtain the thermally stable multiphase coating material comprising at least one erosion resistant phase and at least one thermal conductivity phase. In non-limiting examples, a method for manufacturing a thermally stable coating composition includes combining at least one erosion resistant phase with at least one low thermal conductivity phase to obtain a thermal spray material, as a composite, blend, or clad. Then, plasma spraying the thermal spray material to obtain the thermally stable coating material.

[0016] In another aspect, the present disclosure relates to a thermally stable multiphase coating material obtained from the thermal spray material as described herein, comprising: at least one erosion resistance phase; and at least one thermal conductivity phase. In other examples, the at least one erosion resistant phase and the at least one low thermal conductivity phase are not alloyed together prior to plasma spraying. The method for manufacturing the thermally stable coating composition provides the advantage of maintaining a coating with improved erosion resistance.

[0017] The resultant thermally stable coating material of the present disclosure provides a lower thermal conductivity and a comparable or greater solid particle erosion resistance as compared to typical yttria-stabilized zirconia (YSZ) coatings having 7 to 8 weight percent yttria added to zirconia with similar coating microstructure. Also, the resultant thermally stable coating material of the present disclosure provides thermal stability as shown by the volume fractions of the phase present in the coating being nearly identical after a long heat treatment/high temperature exposure of at least 1250°C.