Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Jagannathan Rajagopalan

Contact

Shen Yan
shen.yan@skysonginnovations.com

Refractory High-Entropy Alloy (RHEA) Protective Coatings with Ultra-Low Density, High Strength, Large Deformability, and Low Thermal Conductivity

Background

Thermal barrier coatings (TBCs) are used to protect structural alloys in extreme (temperature/stress/radiation) environments (e.g., space reentry/hypersonic vehicles, aero turbines). Porous ceramics are often used as the topcoat of TBCs because of their high strength and melting point, and low thermal conductivity. However, ceramic topcoats are brittle and can undergo catastrophic cracking or spallation, leading to sudden component failure. Therefore, there is a pressing need to develop new protective coatings that are lightweight, strong, resilient, and have extremely low thermal conductivity.

Invention Description

Researchers at Arizona State University have developed ultra-low density (< 1% bulk density) refractory high-entropy alloy (RHEA) protective coatings with an unprecedented combination of high-temperature specific strength (> 50 MPa·cm3 /g at ~1500 °C), deformability (> 10% macroscopic failure strain), good creep and oxidation resistance, and exceedingly low thermal conductivity (< 0.1 W/mK) for use in extreme environments such as space reentry, hypersonic vehicles, aircraft, power plant turbines, and automobile engines. The synthesis method uses common physical vapor deposition techniques such as sputtering and evaporation, and does not require any unconventional equipment or manufacturing techniques. Coating can be applied in two distinct ways: (a) direct deposition of the RHEA protective coatings on structural components, and (b) production of RHEA meshes for spray coating and 3D printing feedstock.

Potential Applications

- Heat shields
- High-temperature seals
- Wear-resistant coatings

Benefits and Advantages

- Superior Performance – Featured combination of high-temperature specific strength, deformability, and low thermal conductivity is unmatched by current TBCs
- Cost Effective – Production requires only established and commercially available equipment
- Simple – Coatings are made from a single material (unlike TBCs which consist of 2-3 distinct material layers and thus may require different deposition processes)
- Versatile – Mechanical, thermal, and functional properties of the coatings can be explicitly varied across thickness in order to accommodate desired adhesion, thermal shielding, oxidation, creep, and wear resistance

Research Homepage of Professor Jagannathan Rajagopalan