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Method for Fabricating Robust Ceramics and Ceramic Composites for High-Temperature Device Applications

A novel reaction-based method converts easily-shaped preforms into complex, high-performance ceramic composites that offer superior high-temperature stiffness, fracture, and corrosion resistance for critical system components.

High-temperature systems are used in a wide range of applications associated with transportation, energy production and storage, waste heat recovery, propulsion, national defense, chemical processing, and chemical and waste storage. The performance of such high-temperature systems, e.g., aircraft, automobiles, and ship engines; fossil fuel, nuclear, and solar power plants; and hypersonic vehicles and missiles, is often limited by the properties of materials used in critical system components/devices. The drive for enhanced performance often means even more extreme conditions experienced by such components/devices, which in turn requires advanced materials with improved combinations of high-temperature mechanical, chemical, and thermal properties, e.g., resistance to distortion, fracture, melting, and corrosion at elevated temperatures. The cost-effective manufacturing of such advanced materials and devices in complex, tailorable shapes and chemistries is also of vital importance for widespread utilization.

Researchers at Purdue University have developed a reaction-based method for converting complex-shaped, three-dimensional preforms, which are generated by pressing, casting, 3-D printing, machining, etc., into high-melting, stiff, fracture-resistant, thermally-conductive, corrosion-resistant ceramic composites that retain the same shape and dimensions as the starting, easily-shaped preforms. The reaction process can be used to generate toughened ceramic composites that are chemically and structurally tailored for particular devices in high-temperature systems. The high-temperature components/devices that could benefit from this technology include, but are not limited to, combustion chambers, compressors, bearings, turbine blades, aerodynamic leading edges, heat exchangers, valves, bearings, piping, and storage containers for high-temperature fluids.

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Category

Aerospace & Defense/Thermal Management & Combustion Optimization

Materials Science & Nanotechnology/Advanced Functional Materials

Chemicals & Advanced Materials/Materials Processing & Manufacturing Technologies

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Advantages:

Manufacturing:

-Net-shape, net-size fabrication

-No sintering shrinkage and part distortion

-Lower cost manufacturing

Materials:

-High melting

-High temperature stiffness

-Fracture resistance

-Corrosion resistance

-High thermal conductivity

Devices:

-Higher operating temperatures

-Longer life

Potential Applications:

-Manufacturing of complex-shaped, ceramic-rich components

-Toughened ceramic composites with tailorable chemistries and properties

-More efficient, higher performance, high-temperature systems

TRL: 4

Intellectual Property:

Provisional-Patent, 2016-04-18, United States | PCT-Patent, 2017-04-18, WO | NATL-Patent, 2018-10-17, United States

Keywords: high-temperature systems, ceramic composites, reaction-based method, complex-shaped preforms, net-shape fabrication, fracture resistance, high thermal conductivity, corrosion resistance, advanced materials, high performance systems