National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Environmental Barrier Coatings for Ceramic Matrix Composites

Protect high-performance components in extreme environments

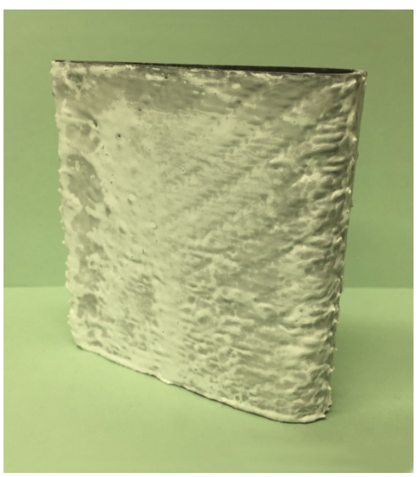
Innovators at NASA's Glenn Research Center have developed two durable environmental barrier coatings (EBCs) for use with ceramic matrix composite (CMC) components. CMCs are lightweight composites used to reduce fuel consumption in advanced gas turbines and other high-temperature, high-stress environments (up to 1482°C). Glenn's breakthrough EBCs are the only coatings that can withstand such temperatures, protecting CMCs from increased wear and corrosion, oxidation, and water vapor recession in extreme environments. In addition, these EBCs can be fabricated with simpler and lower-cost methods than conventional coating processes such as plasma spraying. Glenn's EBCs add reliability and lifespan to CMCs' advantages of lighter weight, higher temperature capability, and greater oxidation resistance. This innovation is poised to facilitate the upcoming CMC revolution, from hot components in next-generation, fuel-efficient jet engines to furnaces to nuclear reactors.

BENEFITS

- Durable: Maintains protection at unprecedented high temperatures
- Oxidation-resistant: Protects CMC components from most common causes of failure, water vapor and corrosive gases
- Easy to manufacture: Process allows liquid phase sintering to facilitate strong bonding
- Long-lasting: Proven steam oxidation life of at least 500 hours at 1482°C
- Cost-saving: Allows CMCs to remain in use for longer periods without replacement

THE TECHNOLOGY

CMCs are a game-changer for a number of applications because of their lighter weight, higher temperature capability, and resistance to oxidation. It has been estimated that aircraft designs relying on CMCs can decrease fuel consumption by 10% by 2020. EBCs are used to protect CMCs from water vapor and other corrosive gases inside engines and other extreme environments. The current state of the art for EBCS features a silicon bond coat that is not viable beyond its melting point of 1482°C. By contrast, Glenn's EBCs have demonstrated a steam oxidation life of at least 500 hours at 1482°C, making them ideal durable coatings for next-generation CMCs. These EBCs are slurries, with either a mullite-based bond coat or a rare earth disilicate-based bond coat comprising at least three and two layers, respectively. Mullite is often used as a refractory material for furnaces, reactors, etc. because of its high melting point (1840°C). Rare earth disilicates also have high melting points (~1800°C). These bond coats can be fabricated by preparing a mixture of a coating material, a primary sintering aid, at least one secondary sintering aid, and a solvent. The mixture is then processed (e.g., in a milling media) to form a slurry that can be deposited to a CMC substrate. The sintering aids have two primary functions: 1) densifying deposited slurry by generating liquid phases via reactions with the coating material and other sintering aids, so that the liquid fills gaps between particles of coated material; 2) enhancing bonding and performance of the coating by generating reaction products that enhance those qualities. One great advantage of this EBC is that it can be fabricated via various low-cost methods - including dipping, spinning, spin-dipping, painting, and spraying - in addition to plasma-spraying. Glenn's innovation rises to meet the need for a new class of EBCs that can keep up with CMCs' increasing ability to withstand higher temperatures and stresses than ever before.



Glenn's EBCs enable lightweight CMC engine vanes that are oxidation-resistant, reducing maintenance needs and extending life

These EBCs are proven to withstand high-temperature, high-stress environments such as continuous casting - up to 1482°C

APPLICATIONS

The technology has several potential applications:

- Aerospace
- Chemical manufacturing
- Heat exchangers
- Furnaces
- Power
- Thermal management
- Turbines (e.g. blades, vanes, combustor liners, bladetracks, shrouds, seals)

PUBLICATIONS

Patent No: 11,325,869

Patent Pending

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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More Information

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