OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY
FY 2005/06 Accomplishment

Slurry-Coated Materials Withstand Corrosive Turbine Engine Environment

Successful Environmental Barrier Coatings Formed by Low-Cost Process

Background

Monolithic silicon nitride (Si_3N_4) ceramics are the primary ceramic material currently used in combustion engine environments. These ceramics are also under consideration for use as hot-section structural materials in microturbines and other advanced combustion systems; however, Si_3N_4 typically forms a surface oxidation layer (silicate) in oxidizing conditions. The silicate layer rapidly degrades in the corrosive and erosive turbine engine environment, severely limiting life of the ceramic. Long-term use of Si_3N_4 material in advanced combustion engine applications will require the development of environmental barrier coatings (EBC) that can withstand high temperature, high pressure, high gas velocity, and the presence of water vapor.

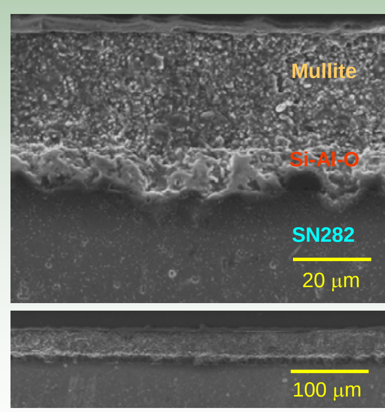
Technology

The slurry (dip) coating process is a promising, low-cost approach for the production of EBCs. For many years, slurry coatings have been used to produce protective barriers in the housing, marine, automotive, and aerospace industries. In contrast to most other coating techniques, slurry coating is a non-line-of-sight process, which coats all surfaces of the part.

Components with complex shapes can be dipped into a slurry (ceramic particles suspended in a solvent medium), and subsequently dried and heat treated at elevated temperatures to promote densification. Excessive shrinking of the coating upon sintering can cause cracking, and poor adhesion of the coatings to the substrate can dramatically effect the substrate strength. Successful EBCs for Si_3N_4 materials have been developed through the formulation of crack-free and adhesive slurry compounds.

During FY05, coatings of doped alumino- and rare-earth silicates were tested for use

Example of an as-coated, rare-earth silicate on silicon nitride



Micrographs of polished cross-sections of densified mullite on silicon nitride

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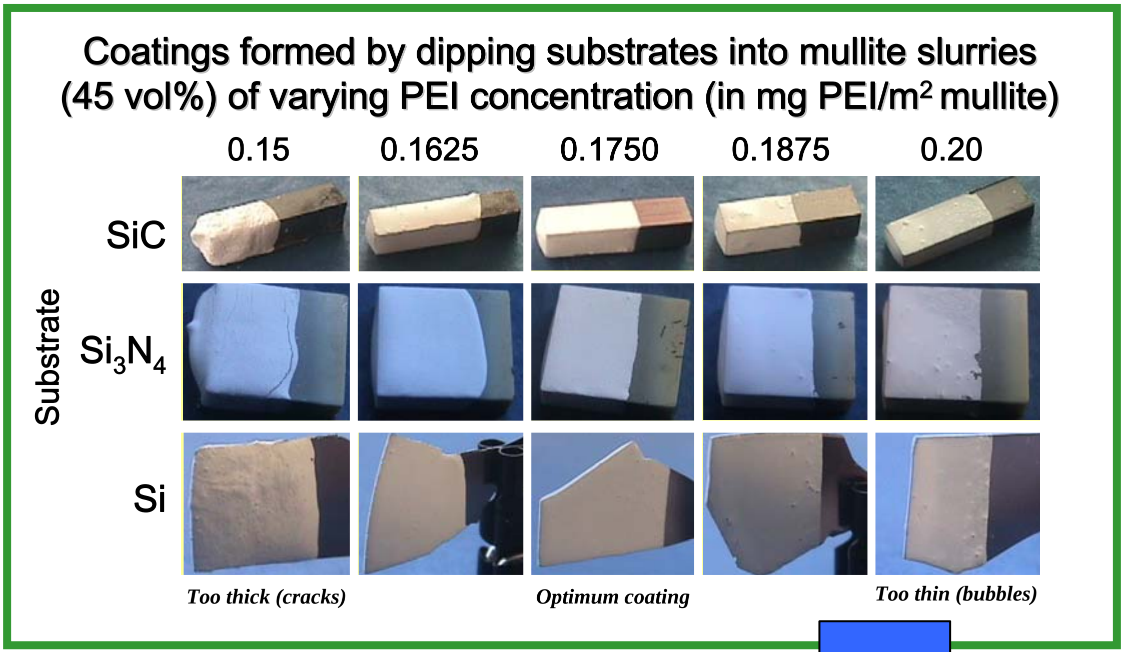
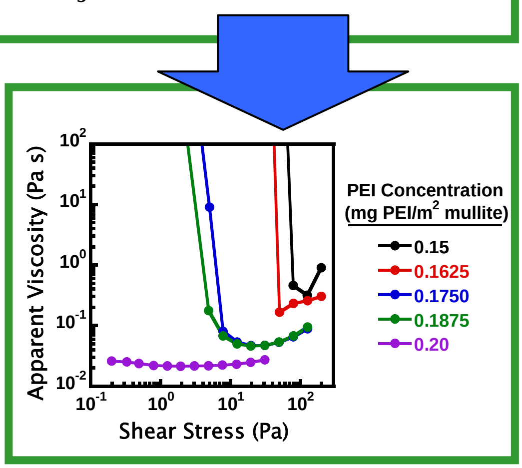
on silicon nitride substrates in simulated microturbine environments. A cationic poly-electrolyte, poly-ethylenimine (PEI), was used to tailor the rheological behavior of mullite, doped aluminosilicate, and rare-earth silicate suspensions. Latex emulsions were used to promote improved wetting, drying, and green strength of the ceramic layers. Uniform, crack-free layers were demonstrated on a wide variety of substrates.

ORNL has supplied coatings to collaborators such as NASA, Ceramatec, and Honeywell. Industrial partners are continuing to provide substrate materials, as well as ideas and suggestions for coating compositions, as the optimum processing conditions and best coating compounds are identified.



Benefits

- Non-line-of-sight process for uniform coatings on complex shapes
- No unique equipment required to establish coating capability
- Process flexibility – a variety of ceramic powders can be applied to various substrate compositions
- Technology can be easily transitioned to industrial production



Future Work

The durability and adherence of coatings on complex-shaped substrates exposed to a simulated and actual gas turbine engine environment will continue to be assessed as the slurry coating process is further refined.

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