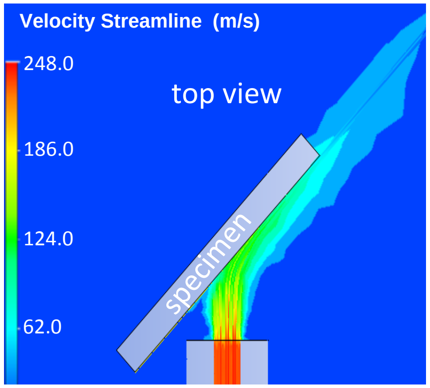
Opila Group



Our lab focuses on materials durability in extreme environments for energy, power, and propulsion applications. Current research interests include oxidation and corrosion of alloys, ceramics, and ceramic matrix composites, high temperature coating development, high temperature water vapor interactions with metals and ceramics, thermochemistry of gaseous metal hydroxides, and oxide defect chemistry.

Elizabeth Opila
Associate Professor
ejo4n@virginia.edu
www.virginia.edu/ms/faculty/opila.html

Dept. of Materials Science and Engineering
University of Virginia
Charlottesville, VA
434.243.7610

"Exploring high-temperature chemistry and the use of materials in extreme environments."

University of Virginia Engineering

Ultra-high Temperature Materials and their Interactions

Our research focuses on ceramics, which are proposed for use as nose and wing leading-edge materials for hypersonic aircraft. At high-speeds, plasma is formed around the aircraft, resulting in significant vehicle surface temperature increases. We are exposing ceramic materials to ultra-high temperatures to determine how fast they react and degrade. Ultimately, we aim to find ways to improve these ceramic materials as they endure extreme heat.

Entropy-stabilized ceramic systems are under development for use in ultra-high temperature extreme environments, however, they suffer from poor oxidation resistance. We are characterizing oxidation of ultra-high temperature ceramics using sample resistance heating and double oxidation exposures while taking advantage of state-of-the-art capabilities in isotopic mapping by Time-of-Flight Secondary Ion Mass Spectrometry.

Ceramic Matrix Composites for Combustion Applications

SiC-based Ceramic Matrix Composites are currently under development for turbine components in propulsion applications due to expected increased efficiencies relative to the currently used superalloys resulting from their lighter weight and potential higher temperature capability. In order to further the use of these composites, we are characterizing oxidation and deposit induced corrosion mechanisms for SiC-based composites. We are also investigating alternative composite matrix materials which will be more corrosion-resistant.

Environmental Barrier Coating Development

Coatings are needed to protect Ceramic Matrix Composites from the corrosive conditions found in turbine engine environments. We are studying the reactions between rare earth silicate-based coatings and water vapor found as a combustion product in the engine with the goal of predicting the useful life of the coatings. In addition we are developing novel coating compositions to better withstand reactions with molten deposits formed from ingestion of particles into the engine.

RECENT RESEARCH DEVELOPMENTS

- We have demonstrated that short–time high-temperature UHTC oxidation significantly impacts long-term variability in material degradation. Understanding these sources of variability is essential for developing robust life-prediction models.
- A steam jet furnace has been developed that simulates the temperature, gas chemistry, and gas velocity of turbine engines. This capability allows rapid and quantitative testing of materials durability for turbine engine applications.

RECENT GRANTS

- DOD/ONR Multi University Research Initiative - The Science of Entropy Stabilized Ultra-High Temperature Materials
- Rolls Royce- Matrix Development for High-Temperature Water Vapor Resistant SiC- Based Ceramic Matrix Composites
- NASA-Ceramic Matrix Composite Environmental Barrier Coating Durability Model

SEAS Research Information
Pamela M. Norris,
Executive Associate Dean for Research
University of Virginia
Box 400232
Charlottesville, VA 22903
pamela@virginia.edu
434.243.7683

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