Seminar Talk

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Title: Ice-Templated Hierarchical, Directionally Porous Ceramics: Understanding Dynamic Deformation Behavior and Structure Mechanical Property Relationships

Abstract:
Hierarchical materials design provides significant opportunities for developing engineering materials with novel architectures that are yet to be achieved in the traditional approach of materials processing. However, there are only limited techniques which allow to manipulate microstructure of materials at different length scales. Ice-templating is an emerging technique in which unidirectional solidification results in unique directionally porous materials, and this technique enables greater process control over different structural length scales providing novel avenues to tailor property and functionality that cannot be achieved in the conventional processing of porous ceramic. Ice-templating is a versatile, environment friendly manufacturing technique, and a unique advantage is that as a physical process the evolved morphology is not strongly influenced by the material system. Another novel advantage is that at a comparable level of porosity, ice-templated ceramic exhibits mechanical properties (along the ice-growth direction) which are superior relative to that of the open-cell porous ceramic processed through other techniques. Therefore, due to the directional porosity and significant strength advantage, ice-templating technique has gained major attention for a variety of fields ranging from aerospace, automotive, biomedical, energy, national security, and structural applications. Due to the wide spectrum of possibilities for the engineering endeavors, there is a growing interest in understanding the fundamentals of structure-mechanical property relationships in ice-templated ceramics, because mechanical performance of ice-templated sintered ceramic will have a direct implication to the device functionality, performance and reliability. In this talk, first we will discuss about the ice-templating process, and role of various variables in manipulating templated microstructure. Next, we will discuss our work on understanding the uniaxial compressive response of ice-templated sintered ceramics both in the quasistatic (lowstrain rate) and dynamic (high-strain rate) regimes of strain rate. We utilize ice-templated alumina ceramic as a model material system, and employ split-Hopkinson pressure bar (SHPB) to measure dynamic compressive response. A high-speed camera is employed to capture the deformation and failure characteristics. In the processed ice-templated ceramic materials, porosity, lamellar bridge density, microstructural morphology and other length-scale features are modified through the systematic variations of the intrinsic and extrinsic variables. We also utilize a custom-made setup

to conduct sphere impact tests on ice-templated ceramics, and study the response of the materials during impact using a high-speed camera. Our present work is potential in the design of mechanically robust lightweight structural materials for armor systems, anti-mining, impact protection, and nuclear warheads.

Bio:

Dr. Dipankar Ghosh is an Assistant Professor in the Department of Mechanical and Aerospace Engineering at Old Dominion University, Norfolk, VA. Dr. Ghosh directs the Laboratory for Extreme and Energy Materials (LEEM), and has significant experience in manufacturing of advanced materials and high-strain rate mechanical characterization. Currently. Dr. Ghosh is working on developing ice-templated ceramic and ceramic-polymer composite materials for structural and functional applications. Dr. Ghosh received his PhD in Mechanical Engineering from University of Florida (Gainesville, FL) in 2009. Dr. Ghosh received Best Ph.D. Dissertation Award from Department of Mechanical and Aerospace Engineering, University of Florida (2010), and Outstanding International Student Award from College of Engineering, University of Florida (2009). Before joining ODU, he has held postdoctoral positions at University of Florida and California Institute of Technology (Pasadena, CA). Dr. Ghosh has published 2 book chapters and 30 peer-reviewed journal articles in prestigious international journals. His research on ice templating of ceramic materials is currently funded by the National Science Foundation (NSF).