SEMINAR SERIES

Novel Ceramic Near-Net Shaped Processing

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Lisa Rueschhoff received a B.S. in Materials Engineering from Iowa State University in 2013. During her time at Iowa State she worked as an Undergraduate researcher at Ames National Laboratory (USDOE) on the production of nano-metallic powders for lithium-ion battery anodes. She obtained her Ph.D. in Materials Engineering from Purdue University in 2017. While at Purdue, Lisa was an NSF Graduate Fellow with her doctoral dissertation focused on complex shaping of ceramic materials using highly-loaded aqueous suspensions. As a graduate student she was involved in the American Ceramic Society (ACerS) as Chair of the President's Council of Student Advisors (PCSA), a group of world-wide student leaders that work to encourage and engage students in ceramics through programming and outreach. Dr. Rueschhoff is currently a National Research Council (NRC) Postdoctoral Fellow at the Air Force Research Laboratory in the Materials and Manufacturing DirectorateComposites Branch.

Ceramic materials offer great advantages over their metal counterparts, due to their lower density, higher hardness, wear resistance, and higher melting temperatures. However, ceramics are often unusable in high-stress applications due to low fracture toughness causing catastrophic brittle failure, as well as the high cost and difficulty of forming complex shapes. This research addresses these limitations through the preparation of highly-loaded aqueous ceramic suspensions that can be used with, and tailored to, multiple near-net shaping processes, including room-temperature injection molding and direct ink writing (DIW). The silicon nitride (Si3N4) system is of interest because of its inherently high fracture toughness due to interlocking and elongated β-Si3N4 grains, but it is difficult to stabilize in water due to complex surface and solution chemistry. Through this research, stabilization of Si3N4 was achieved via the novel use of commercially available comb-polymer water reducing admixtures (WRAs). These highly-loaded suspensions were used in a novel room temperature and low-pressure injection molding process, with parts sintered to high densities (up to 98% TD) and high flexural strengths of nearly 700 MPa. Finally, the additive manufacturing technique of DIW was used to deposit these, and other highly loaded ceramic suspensions, in a layer-by-layer format to product bulk dense ceramic parts. These novel processing routes are low-cost and viable means for producing robust ceramic parts, both of which can be tailored to many systems to expand the use of ceramics materials.

Additionally, preliminary results will be presented on the bottom-up synthesis of advanced ceramics and composites. Nanoscale controlled ceramics, and ceramic composites, exhibit extraordinary mechanical properties, including elastic deformation and high toughness, but they are currently difficult to fabricate using scalable production methods. The ability to control pre-ceramic polymer (PCP) patterning by using bottom-up approaches enables production of hierarchical ceramic components with potentially enhanced mechanical properties. BCPs contain two or more chemically-distinct blocks that phase separate into well-defined nanostructures (e.g. lamella). Subsequent pyrolysis of the material converts the PCP into a structural ceramic material and simultaneously removes the self-assembled BCP from the structure. Nanocomposite materials can then be created through backfilling these structures with a second polymer or ceramic phase. Preliminary results on process optimization of silicon carbide PCP and polystyrene-poly(methyl methacrylate) (PS-b-PMMA) lamellae forming BCP thin films will be presented.

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