MATERIALS SCIENCE IN EXTREME ENVIRONMENTS UNIVERSITY RESEARCH ALLIANCE

Seminar

Engineering Energetic Materials

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Traditionally, energetic materials (propellants, explosives and pyrotechnics) have been mostly CHNO molecules synthesized chemically and mixed with polymers to form composites that are cast or pressed into final form. This continues to be an exciting area and many new materials are being developed and characterized. However, the focus of this presentation is an overview of our efforts at engineering new energetic materials rather than by chemical approaches. This includes fabricating piezoelectric energetic materials, developing scalable methods to introduce nanoscale features in full density micron-scale particles, blending pyrotechnic elements into propellants to achieve unique combustion, and assembling complex structures with additive manufacturing to enable function. Some fluoropolymer materials can be poled, and when combined with fuels, such as aluminum become energetic. Our recent work has explored how these multifunctional materials might be exploited to enable external control of burning rate and ignition. Mechanical activation or arrested ball milling is an example of engineering particles in traditional sizes, but with nanoscale features. We have also formed engineered crystalline materials by controlled encapsulation of particles and by subtractive methods (microscale machining and femtosecond laser machining). Likewise, we are exploring the interaction of fast burning pyrotechnics, or reactives, into propellant materials to tailor output. We term this "reactive wires", in contrast to the inclusion of inert wires into propellants to enhanced the effective burning rate. Additive manufacturing (AM) of energetic materials represents an attractive avenue to tailoring the properties and performance of energetic systems by enabling precise control of the microstructure of additively manufactured components. Examples of recent results in each of these areas will be presented, and future directions will be discussed.

Steven F. Son is the Alfred J. McAllister Professor of Mechanical Engineering at Purdue University and is affiliated with Purdue's Maurice J. Zucrow Laboratories. He received his Ph.D. from the University of Illinois at Champaign-Urbana in 1994. Prof. Son's research is in the field of combustion with an emphasis on energetic materials combustion. Dr. Son has given hundreds of invited presentations at national and international scientific meetings and is an author of over three hundred scientific publications. Prof. Son was Associate Editor for AIAA's Journal of Propulsion and Power and is the Editor in Chief of the JANNAF Journal of Propulsion and Energetics. Before his academic career, beginning in 2006, he was a Technical Staff Member, J. R. Oppenheimer Fellow, and Project Leader at Los Alamos National Laboratory in the High Explosives Sciences Group. Dr. Son has current support as PI or co-PI from ARO, ONR, AFOSR, DTRA, NASA, NSF, and DOE.

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