Macromolecules Innovation Institute (MII) Seminar Series

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Prof. Xiaoyu (Rayne) Zheng

"Design and Additive Manufacturing of Ultralight, Scalable Materials"

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Abstract: It has been a long research and engineering pursuit to create lightweight and mechanically robust and energy efficient materials with interconnected porosity. These cellular materials are desirable for a broad range of applications including structural components, lightweight transportation, heat exchange, catalyst supports, battery electrodes and biomaterials. However, the required outstanding properties have remained elusive on lightweight materials (<10kg/m^3), constrained by the inherent coupling of material properties and the lack of suitable processes to generate these artificial materials. For example, graphene aerogels have among the lowest record densities ~1kg/m^3, but their strength have been degraded to tens to hundreds of Pascal (<10^{-8} of that of carbon nanotubes). The attainment of low density has come with a price --- significant reduction of bulk scale properties.

In this talk, I will present our recent efforts on design and manufacturing of multi-scale materials with controlled three-dimensional architectures from the macroscale to nanoscales. These 3D bulk metamaterials (polymer, metal, ceramic and combinations thereof) possess weight density comparable to that of carbon aerogel, but with over 10^5 higher stiffness and strength. By designing and studying their hierarchical architectures, material compositions and feature sizes spanning multiple length-scales, we create a wide range of decoupled material properties such as programmable stiffness, tunable strength, fracture toughness as well as programmable possion ratio. With the possibility of incorporating precise control of topological architectures across unprecedented disparate length-scale sets, we enter into a paradigm where nanoscale material properties can be harnessed and made accessible in large scale objects, opening a wide range of applications of these materials in energy, health care and flexible electronics.

Bio: Dr. Rayne X. Zheng is an assistant professor of Mechanical Engineering at Virginia Tech and directs Advanced Manufacturing and Metamaterials Laboratory. He is affiliated with the Macromolecules Innovation Institute at Virginia Tech. Dr. Zheng started his career as a Member of Technical Staff and Principle Investigator at the Engineering Directorate at Lawrence Livermore National laboratory, California. The aim of Zheng's research is to enable the design, analysis, and fabrication of advanced materials and systems with controlled architectures that possess extraordinary and unique capabilities inspired by nature and structural engineering. Zheng received his Ph. D in Mechanical Engineering with the Best Dissertation Award from Boston University in 2011 for his work on optical-mechanical microsystems for cellular force measurement. He is the recipient of Best Poster Award at 2012 Materials Research Society Spring Meeting, Best Paper Award at 2010 IEEE Sensor, Directorate Publication Excellence Award at Lawrence Livermore National Laboratory in 2013. His work on Ultralight, Ultrastiff Mechanical Metamaterials" was published on the June 20 2014 issue of Science and featured on cover and editorial highlights. In 2016, he was invited by National Academy of Science, Engineering and Medicine to present his work on scalable metamaterials.

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