MRSEC SEMINAR SERIES

Confined Flowable Materials: Principles at the Nano and Meso Scales

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Abstract:
The flow of materials, such as colloidal particles or aqueous solutions, in a channel or at an interface with a solid surface, is found at the heart of many technological applications. For example, in direct 2D and 3D printing, materials ranging in composition and size from nanoscale metal particles to microscale polymers must efficiently flow in a controlled way through a nozzle and arrange themselves on a solid surface with the highest spatial resolution. Furthermore, engineering applications utilizing new physics of nanoscale flow have been reported, for example nanofluidics technology for energy harvesting applications, DNA manipulation, ions separation, and lab-on-a-chip devices. The grand challenge question of this research is the following: "From the nano to the meso scales, how do the physical and chemical complexities of solid surfaces, the properties of flowable materials (such as particle size, shape, chemistry, and polarizability) and the presence of external gradients control flow at solid-fluid interfaces, and in highly confined geometries?" The combination of experiment and theory in this area will generate a blueprint for understanding material flow in interfacial layers and in nano-, meso-scale confinement where current models fail and effects are unknown. This acquired knowledge will be crucial to bring technologies such as 2D/3D printing and nanofluidics to a next level of development in terms of efficiency (what is the optimum flow rate), resolution (how small can the nozzle be), and control (external electrical, thermal, or chemical stimuli/gradients). Our research will also help to answer fundamental and long-standing questions about interfacial water (e.g. water structure and transport near chemically complex surfaces such as protein complexes and biological or fuel cells membranes).