Seminar announcement

Wednesday, February 1, 2023
2 pm
WSI, Seminar room S 101
Exclusively in person

"Following and controlling formation and function of bottom-up assembled nanomaterials"

Design advances for the bottom-up assembly of highly ordered functional nanomaterials have generated a wide range of fundamental questions that must be answered to continue to advance material properties, such as strong electronic and mechanical coupling. Compared to the microscale realm of self-assembling soft matter, nanoscale building blocks are generally more challenging to manipulate with a high degree of tunability to achieve different desirable outcomes. This challenge is predicated on scale itself – that it is difficult to specify the interparticle interactions of nanoscale building blocks in the solution phase because the different attractive and repulsive contributions are non-additive, especially because of the finite size of solvent molecules relative to the building blocks themselves. We nevertheless focus on colloidal nanocrystal advances that incorporate electrostatics to promote the formation of ordered superlattice structures from nanocrystals with high dielectric constants.1 Through a multiscale suite of hard X-ray scattering experiments ranging from small- to wide-angle, incoherent to coherent, and storage ring to free electron laser, we characterize the phases, their fluctuations, and the dynamic interconversion between phases of this enigmatic system, non-invasively and in real-time, identifying the helpful role of a liquid-like intermediate phase that admits an unusually high degree of control over product yield, size, and order. We find that controlled, ordered assembly requires a balance of screening and surface charge that is facilitated by moderate to high dielectric ratios between the nanocrystals and their surroundings. We also find that laser absorption reversibly suppresses growth of the ordered superlattice phase and intend to leverage these finding to infer strategies to self-assemble more common low-dielectric nanocrystals into ordered structures by driving them far from equilibrium with optical excitation.

Energy transport in these and other materials is an important emergent property to also characterize at the nanoscale, especially since the solids created often still contain nanoscale heterogeneities. I will therefore also share recent advances in tracking the motion of ions and photogenerated charge carriers, excitons, and heat using time-resolved optical elastic scattering.2 I will not only show how these forms of energy navigate through heterogeneous landscapes but also how we sensitively measure dynamic temperature changes over the course of photogenerated energy transduction in conducting and semiconducting materials, introducing a unique form of nanoscale non-contact thermometry.

1. Coropceanu, I. et al. Self-assembly of nanocrystals into strongly electronically coupled all-inorganic supercrystals. Science 375, 1422–1426 (2022).
2. Delor, M., Weaver, H. L., Yu, Q. & Ginsberg, N. S. Imaging material functionality through three-dimensional nanoscale tracking of energy flow. Nat. Mater. 19, 56–62 (2020); Utterback, J. K. et al. Nanoscale Disorder Generates Subdiffusive Heat Transport in Self-Assembled Nanocrystal Films. Nano Lett. 21, 3540–3547 (2021).

For a bio, please page to the bottom of the following URL (photo is at the top):
http://www.cchem.berkeley.edu/nsggrp/ginsberg.html

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