Monitoring excited state dynamics of nanocrystal thin films through time-resolved X-ray diffraction

Seminar

Monday, September 23, 2024

3:00 – 4:00 p.m.

Beaupre Center, Room 105

Colloidal semiconductor nanocrystals (NCs) are increasingly utilized in photonic and electronic applications due to their tunable size, shape, composition, and surface chemistry. Consequently, a comprehensive understanding of their nanoscale thermal properties is essential for ensuring device performance and stability during operation. Previous studies have reported that the thermal conductivity of nanocrystal films range from 0.1-0.6 W m^{-1} K^{-1}, which is nearly two orders of magnitude lower than their bulk counterparts. This slow thermal transport in NC thin films can negatively affect device performance, shortening the lifespan and efficiency of NC-based optoelectronics such as lasers or LEDs. Conversely, a deeper understanding of nanoscale thermal transport could also enhance the development of NC-based thermoelectrics, which harness thermal gradients as electrical power. Overall, real-time characterization of temperature changes as excited charges relax in device active layers is needed to help unlock these applications.

Here, we use time-resolved x-ray diffraction (TR-XRD) measurements of CdSe:CdS NC thin films, to directly measure thermal conductivity in samples that model a NC laser cavity. We compare experimental results with thermal transport models to extract thermal conductivity. Previous work using TR-XRD to measure thermal conductivity has been focused on bulk films or small flakes of 2D materials. Our work builds upon earlier studies of NC thin film thermal conductivity, which used conventional methods such as 3ω and time or frequency domain thermoreflectance. Now, we capture this information in a contact-less approach. The use of TR-XRD to study NC thin films will help facilitate direct monitoring of structural dynamics and thermal transport in photoexcited NC thin films and actual NC-based devices. Finally, recent results studying ultrafast symmetry changes in PbS NCs using both ultrafast electron diffraction and TR-XRD will also be discussed.

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Fall 2024 Seminar Series

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