Tkach, Colleen

From: Inform
Subject: EM: 5C Chemistry Seminar - Tues. 04/28 @ 11am

From: Lauran Soto

Hello!

Please join us for the final 5C Chemistry Seminar of the Spring 2026 Semester!

Prof. Matthew Law
University of California, Irvine

Tuesday, April 28, 2026
11:00am-12:00pm
Nucleus East - NS E208

"Connecting the Dots: Toward Colloidal Quantum Dot Superlattices with Fully Delocalized Charge Transport"

Abstract: Colloidal semiconductor quantum dots (QDs) are intriguing building blocks for next-generation solar cells, photodetectors, and other optoelectronic devices. Recently, PbX (X = Se, S) QDs that are epitaxially interconnected (necked, or partially fused) to form highly-ordered, highly-coupled 3D superlattices have gained attention as a particularly exciting class of QD solids for optoelectronics. These epitaxially-fused QD superlattices (epi-SLs), which are made by self-assembly and ligand exchange on a liquid surface followed by stamp transfer to a solid substrate (the Langmuir-Schaefer technique), may support the emergence of electronic minibands that enable high-mobility, bulk-like charge transport. The demonstration of coherent delocalized charge transport in a self-assembled colloidal solid would be a major achievement in fundamental mesoscale materials chemistry. Furthermore, a class of artificial crystals that combines the unique, size-dependent photophysics and solution processability of QDs with bulk-like electronic performance would create new opportunities in the design of electronic and optoelectronic devices (e.g., efficient multi-junction solar cells made from a single material).

In this talk, I will describe our progress in making 3D (multilayer) PbSe QD epi-SLs of sufficient spatial and energetic order to delocalize charge carriers into minibands. After discussing the basics of charge transport in QD solids and the crystallographic structure, physical formation mechanism, and chemical formation mechanism of the epi-SLs, I will present the use of electrospray deposition and contactless photobase-triggered QD fusion to fabricate much more uniform and structurally perfect epi-SLs than is possible with conventional deposition and ligand exchange techniques. Lattice-resolved electron tomography (@ ~2 Å resolution) has been developed to image the position, orientation, and necks of every QD in a sample, enabling a detailed statistical analysis of structural defects and the elaboration of processing/structure/property relationships needed to guide fabrication improvements. I will describe the air-free fabrication and electrical characterization of single-grain epi-SL field-effect transistors (FETs) made by multistep electron beam lithography. Variable-temperature electrical measurements of the single-grain FETs show a record-high hole mobility with a negative temperature dependence that is suggestive of bulk-like

transport, but definitive interpretation of this anti-activated region is complicated by the current-voltage hysteresis of the devices. The latest charge transport results and miniband studies will be presented. Near-term prospects for achieving miniband transport in individual epi-SL grains by incorporating the most perfect epi-SLs into smaller devices and employing strategies to suppress surface defects and device hysteresis will be discussed.

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Matthew Law

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Best,
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