Nanotechnology Preeminent Team Faculty Seminar

February 23, 2017 @ 10:30am

BRK, ROOM 1001

Dr. Carolin M. Sutter-Fella

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Title: Thin Film Semiconductors for Efficient Energy Conversion

Bio: Carolin M. Sutter-Fella received her Ph.D. from ETH Zürich, Switzerland, in 2014, where she worked in Prof. Ayodhya N. Tiwari's laboratory for Thin Films and Photovoltaics. Later in 2014, she joined the Electrical Engineering and Computer Science Department at UC Berkeley as a postdoctoral researcher working on a novel materials growth platform with Prof. Ali Javey. Currently, she is a postdoc in the Chemical Sciences Division at the Lawrence Berkeley National Laboratory, Berkeley, and a Swiss National Science Foundation Fellow, supervised by Dr. Ian Sharp. Her interests lie in the synthesis, characterization, and functionalization of inorganic and hybrid thin film semiconductors, and in the photon-matter interactions to understand charge carrier transport and recombination in these material systems. Carolin's ultimate goal is to contribute to an accelerated transition towards novel electronic materials for scalable, high efficiency, and low cost energy generation and utilization.

Abstract: New semiconductor materials show immense potential as building blocks in emerging optoelectronic devices. Therefore, the quest continues for semiconductors that possess suitable bandgaps for efficiently capturing the solar spectrum, are composed of abundant elements, and can be deposited over large areas at low cost. In this seminar, I will present on the synthesis, functionalization, and characterization of emerging material systems such as chalcogenides and hybrid organic-inorganic perovskites.

The compound semiconductor $Cu_2ZnSn(S,Se)_4$ (CZTSSe) consists of earth abundant and non-toxic elements. It is a direct bandgap semiconductor with tunable bandgap between 1.0 - 1.5 eV that ideally matches the solar spectrum. Direct coating of metal salt solutions is a facile and scalable non-vacuum method for depositing copper-zinc-tin-sulfur precursor layers for CZTSSe photoabsorbers, which offers a homogeneous intermixing of constituent elements on the molecular level. Incomplete sintering or poor film morphology are commonly observed when using such chemical precursor based synthesis routes. The non-vacuum synthesis and reactive sintering of CZTSSe thin films with NaF interlayers presents a way to overcome these limitations. Elemental depth profiling and visualization of charge carrier collection confirms the importance of Na impurities in CZTSSe thin film solar cells.

Recently, organometal halide perovskite semiconductors have emerged as promising candidates for optoelectronic applications because of their outstanding charge carrier transport properties achieved with low temperature synthesis. One open question in the field, that I addressed was the influence of bromine on the optoelectronic properties of wide bandgap lead halide perovskites. Photoluminescence quantum yield measurements present a suitable method to gain insights in the dominating recombination mechanisms and showed very high intrinsic material quality over the full $CH_3NH_3Pb(I_{1-x}Br_x)_3$ composition space. Similarly, using highly sensitive sub-bandgap external quantum efficiency (EQE) measurements of Au/spiro-OMeTAD/$CH_3NH_3Pb(I_{1-x}Br_x)_3$/$TiO_2$/FTO/glass photovoltaic devices revealed exponential band tails with a sharp onset characterized by low Urbach energies (15 - 23 meV), lower than most semiconductors with similar bandgaps (especially with E_g > 1.9 eV). Interestingly, sub-bandgap EQE spectra exhibit an extended band of sub-gap electronic states that can be fit with one or two point defects for pure $CH_3NH_3PbI_3$ or mixed $CH_3NH_3Pb(I_{1-x}Br_x)_3$ compositions, respectively. In-depth understanding of material properties and charge transport presents an inevitable prerequisite for future materials discovery.