Comparing the Optical and Magneto-optical Properties of $CuInS_2$ Nanocrystals to their II-VI Binary Analogs

W.D. Rice, S. A. Crooker (NHMFL, Los Alamos); H. McDaniel, V.I. Klimov (Chemistry Division, Los Alamos)

Introduction

I-III-VI ternary nanocrystals have attracted considerable attention as low-toxicity, bio-compatible alternatives to their II-VI binary analogs. $CuInS_2$ (CIS) nanocrystals are a particular focus for optical applications, since they have a bandgap lying in the visible regime that can be tuned with particle size across a wide, technologically relevant wavelength range (500-950 nm). Furthermore, it was recently demonstrated that CIS can be chemically synthesized with high efficacy to produce efficiently emitting nanocrystals. The high photoluminescence (PL) yield and visible bandgap tunability, as well as a large Stokes' shift of the PL emission inhibiting re-absorption, make CIS an alluring system for photovoltaic and lighting applications.

Despite the strong recent interest in CIS nanocrystals, the nature of the PL emission is not well understood. Early studies of bulk and thin-film CIS have established that PL arises from donor-acceptor (DAP) transitions, although the exact nature of these donors and acceptors is difficult to identify. Recent studies of nanocrystal CIS also attribute the broad PL emission to a DAP mechanism.

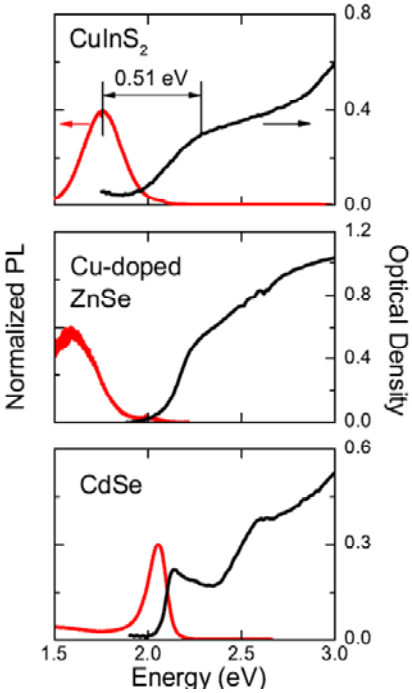

Fig. 1 Comparing photoluminescence and absorption from $CuInS_2$

Experimental

We compare the absorption, photoluminescence, and magneto-optical properties of colloidal CIS nanocrystals with two well-understood and closely related binary nanocrystal analogs: Cu-doped ZnSe nanocrystals and CdSe. In contrast to conventional CdSe nanocrystals, both CIS and Cu-doped ZnSe nanocrystals exhibit broad exciton absorption, a substantially Stokes'-shifted emission (see Figure 1), and a marked asymmetry in the low temperature, polarization-resolved magneto-PL; in CIS, this behavior increases with a decreasing Cu/In ratio.

Additionally, we find evidence in CIS nanocrystals of spin-exchange coupling between paramagnetic moments in the nanocrystal and the conduction/valence bands of the host lattice (see Figure 2), a behavior also observed in Cu-doped ZnSe.

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[1] W. D. Rice et al, *submitted*.

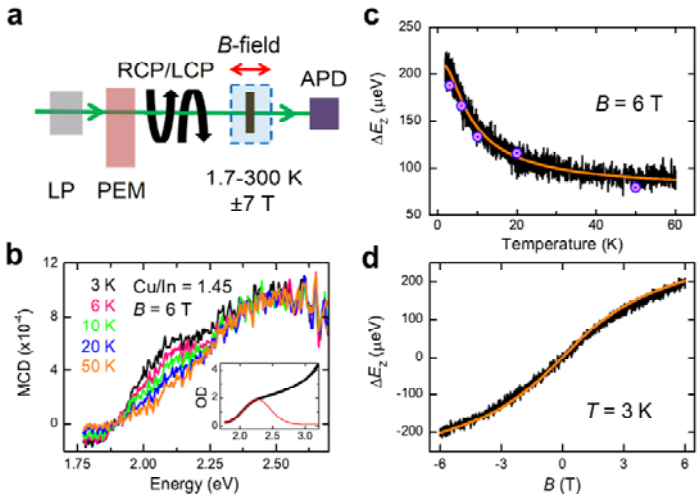

Fig. 2 Magnetic circular dichroism (MCD) studies of CIS nanocrystals reveal a temperature-dependent signal, indicative of a spin-exchange coupling between the conduction and valence bands of the host crystal with paramagnetic impurities in the nanocrystal. The MCD signals can be fit very well to a Brillouin-like paramagnetic magnetization.