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Emission Tail of Indium Phosphide Quantum Dots

Semiconductor quantum dots (QDs) have unique tunable photoluminescence properties which lend them to a range of important technological applications including solid-state lighting, displays, photovoltaics, and biomedical imaging. Indium phosphide (InP) QDs have attracted significant interest as an environmentally friendly and non-toxic alternative to traditional heavy metal based QDs containing cadmium and lead. In this article Edinburgh Instruments investigates the emission tail of indium phosphide quantum dots using their FS5 Spectrofluorometer.

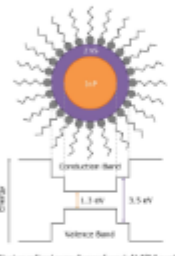
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APPLICATION NOTE
Emission Tail of Indium Phosphide Quantum Dots Investigated using the FS5 Spectrofluorometer
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Introduction
Semiconductor quantum dots (QDs) have unique tunable photoluminescence properties which lend them to a range of important technological applications including solid-state lighting, displays, photovoltaics, and biomedical imaging. Indium phosphide (InP) QDs have attracted significant interest as an environmentally friendly and non-toxic alternative to traditional heavy metal based QDs containing cadmium and lead.

QDs composed solely of InP are non-toxic due to non-radiative recombination occurring at trap states on the surface of the InP. To obtain emission QDs the InP core is coated with a layer of a higher bandgap semiconductor such as the wurtzite (WZ) to form a core-shell heterostructure which passivates the trap states and greatly increases the photoluminescence quantum yield (Figure 1). In order to further improve photophysical stability semiconductor layered InP/ZnS QDs, relationships between the composition and photoluminescence properties need to be established. In this application note, the FS5 Spectrofluorometer is used to carry out a steady state and time-resolved characterization of novel InP/ZnS QDs.



Materials & Methods
A solution of InP/ZnS QDs in toluene was prepared with an absorbance of 0.15 at 380nm. The absorption and photoluminescence properties were characterized using an FS5 Spectrofluorometer equipped with an SC-05 Quartz Halide Module and PL-400 pulsed diode laser, time-correlated single-photon counting (TCSPC) electronics and a PMT 980 detector.



Results & Discussion
The absorption and photoluminescence spectra were measured using the FS5 and are shown in Figure 2. The FS5 contains an absorption detector as standard which enables the photoluminescence and absorption spectra to be quickly measured using a single instrument. The spectra reveal that the InP/ZnS QDs have a pronounced band-edge photoluminescence peak at 620 nm with a FWHM of 65 nm. In addition to the primary band edge peak, there is also a broad low energy tail extending out into the NIR. In order to detect this tail, the FS5 was equipped with an extended range photomultiplier tube detector (PMT 980) which has good sensitivity out to ~950 nm. The PMT 980 provides an extra 80 nm of detection range over the standard PMT 980 and is ideal for materials with long emission tails. The broad low energy tail has been observed previously in InP/ZnS QDs and is relative to trap emission.¹

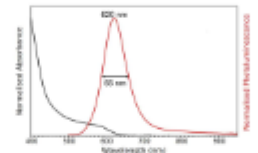


Figure 1: Diagram of band energy diagram of core and InP/ZnS quantum dots.

Figure 2: Absorption (black) and photoluminescence (red) spectra of the InP/ZnS QDs. Absorption parameter $\lambda_{max} = 380$ nm, $\lambda_{0.5} = 400$ nm, $\lambda_{0.1} = 5$ nm, $\lambda_{0.01} = 1$ nm.

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