Controlling the photoluminescence of liquid phase exfoliated γ-InSe nanosheet thin films by centrifugation-based size selection

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ABSTRACT

Indium selenide (γ-InSe) is a layered III-VI semiconductor with a thickness dependent direct bandgap in the near-infrared region. In this project we performed liquid phase exfoliation of phase-pure γ-InSe in *N*-Methyl-2-pyrrolidone (NMP) and aqueous surfactant dispersions. With the aid of liquid-cascade centrifugation, we isolate nanosheets of different sizes and thicknesses. We establish quantitative metrics for layer number and lateral size based on optical spectroscopy in combination with a statistical evaluation of the nanosheet dimension and study the thickness-dependent photoluminescence in dispersion and in thin films (Figure 1B). While we find that the nanosheets are stable in NMP, some degradation occurs in the aqueous surfactant solution. In order to prevent reaggregation effects during film deposition, nanosheets were assembled at liquid-liquid interfaces prior to the deposition on glass substrates. Film morphologies were studied *via* optical microscopy and AFM. Using a TCSPC setup, we investigate the PL lifetime and find two contributions to the radiative decay which we attribute to intrinsic emission and defect-induced photoluminescence. Also lifetime parameters show size-dependent trends. The herein utilized protocol allows for a straight forward, large scale production of homogenous InSe thin-films from nanosheet dispersions with defined mean thicknesses, and thereby allows to control their PL emission in the n-IR.

FIGURES

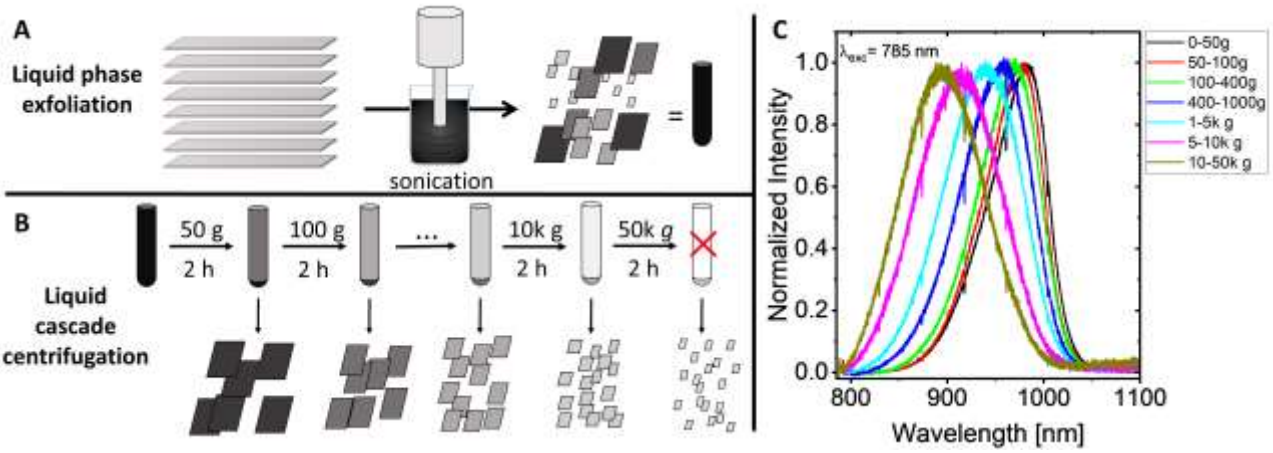

Figure 1: A): Schematic of Liquid-Phase Exfoliation of layered materials using tip sonication, followed by liquid cascade centrifugation (B) for size selection of nanosheets. C): Dispersions of γ-InSe show a thickness dependent shift in their photoluminescence upon excitation with a 785 nm laser.