Tuneable photoluminescence emission from exfoliated InSe nanocrystals

G.W. Mudd[1], S. A. Svatek[1], O. Makarovsky[1], L. Eaves[1], A. Patanè[1], P. H. Beton[1], Z. D. Kovalyuk[2], G. V. Lashkarev[2], A. I. Dmitriev[2]

[1] *School of Physics and Astronomy, The University of Nottingham, Nottingham NG7 2RD, UK*
[2] *Institute for Problems of Materials Science, Ukrainian Academy of Sciences, Kiev, Ukraine*

The discovery of single-atomic layer graphene has led to a surge of interest in other anisotropic crystals with strong in-plane bonds and weak, van der Waals-like coupling between the atomic layers [1-2]. Here we report strong quantization effects and tuneable photoluminescence emission in mechanically exfoliated Bridgman-grown crystals of γ-rhombohedral InSe [3]. Figs.1a-c show scanning atomic force microscopy (AFM) and optical images, and height z-scans of a typical thin exfoliated flake. RT photoluminescence (PL) maps and corresponding spectra of the flakes are shown in Fig. 1(d-e). The near-band edge PL peak exhibits a strong blue-shift to higher photon energies *hν* with decreasing layer thickness *h*, consistent with 2-D quantum confinement of photo-excited carriers by the external surfaces of the flakes, see solid line fit in Fig. 1f obtained from a model based on the band parameters of InSe. The persistence of intense PL down to *h* ~ 6 nm and over periods of several weeks following exfoliation indicates that surface defects do not significantly impair radiative recombination. We exploit the high optical quality of exfoliated InSe layers to realize infrared photodetectors. Also, we discuss how nanoflakes of InSe could be used in combination with graphene electrodes to make novel optoelectronic nanodiodes.

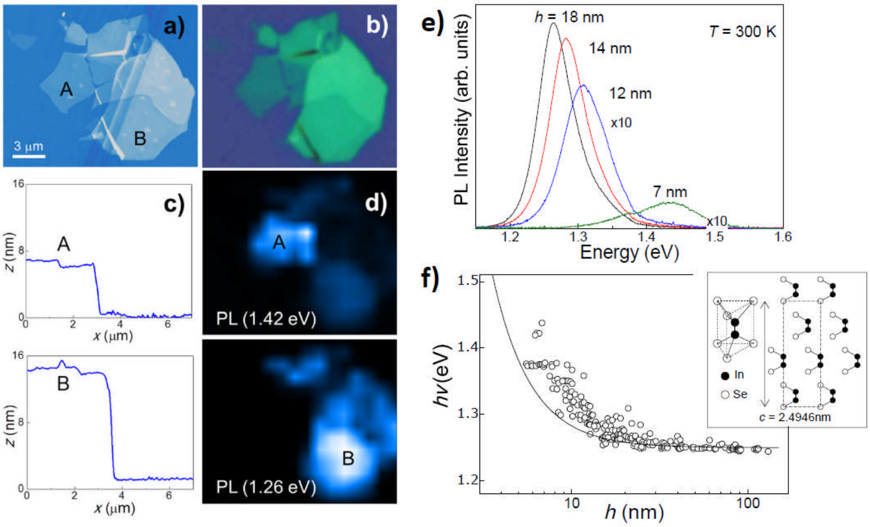

Figure: AFM **(a)** and optical image **(b)** of exfoliated InSe. The AFM z-profiles **(c)** and corresponding confocal micro-PL maps (**d**) reveal flat nanometer thick layers A and B. **(e)** Typical micro-PL spectra of InSe layers at *T* = 300K with peak energy strongly dependent on the layer thickness *h* **(f)**. The inset in (f) shows the crystal structure of γ-rhombohedral InSe.

[1] K.S. Novoselov et al., PNAS **102**, 10451 (2005).
[2] P.A. Hu et al., ACS Nano **6**, 5988 (2012).
[3] A. I. Dmitriev et al., Phys. Stat. Sol. (b) **162**, 213 (1990).