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Supplementary Information for

Low-powered photodetector based on two-dimensional $InS_{0.3}Se_{0.7}/WS_2$ heterostructure

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1. Raman spectra of the $InS_{0.3}Se_{0.7}$ flakes

Fig. S1 show the Raman spectra of the $InS_{0.3}Se_{0.7}$ flakes measured at room temperature. The photoluminescence spectra were collected on micro Raman/Photoluminescence system (InVia, Renishaw) using an argon green laser at 514 nm. As can be seen, four typical Raman active modes at about 41 cm^{-1}, 119 cm^{-1}, 180 cm^{-1}, and 220 cm^{-1}, respectively are observed in both areas, which corresponding to the E, A_{1g}^1, E_{2g}^1, and A_{1g}^2 modes. Such observation is also consistent with the previous reports [Cryst. Growth Des. 18, 2899-2904 (2018)].

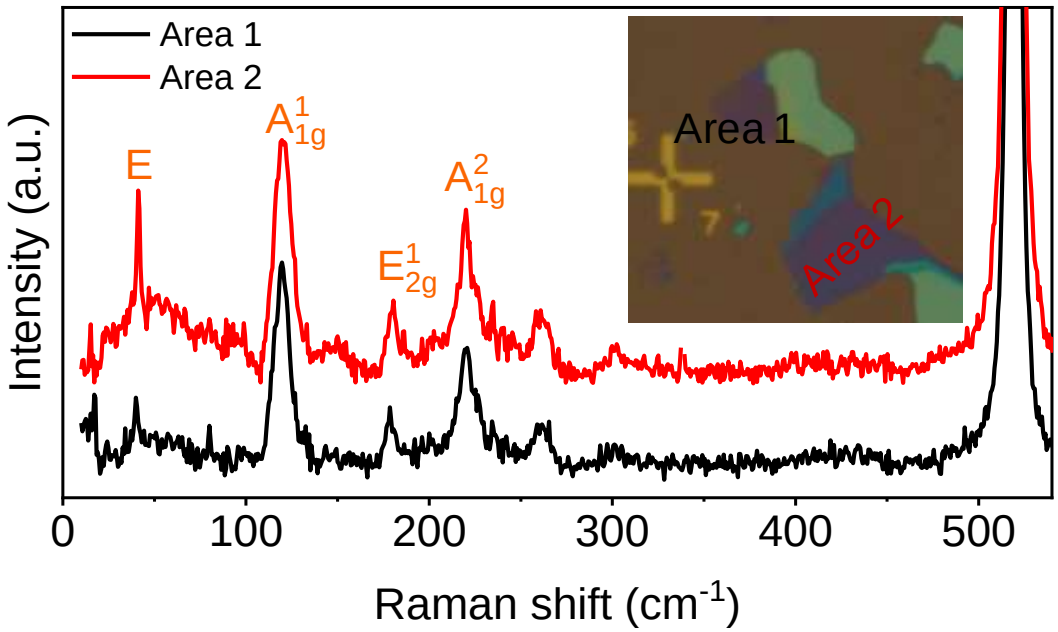

Fig. S1. Raman spectra of the $InS_{0.3}Se_{0.7}$ flakes.

2. Estimation of the stoichiometry of the as-synthesized $InS_{0.3}Se_{0.7}$ crystals

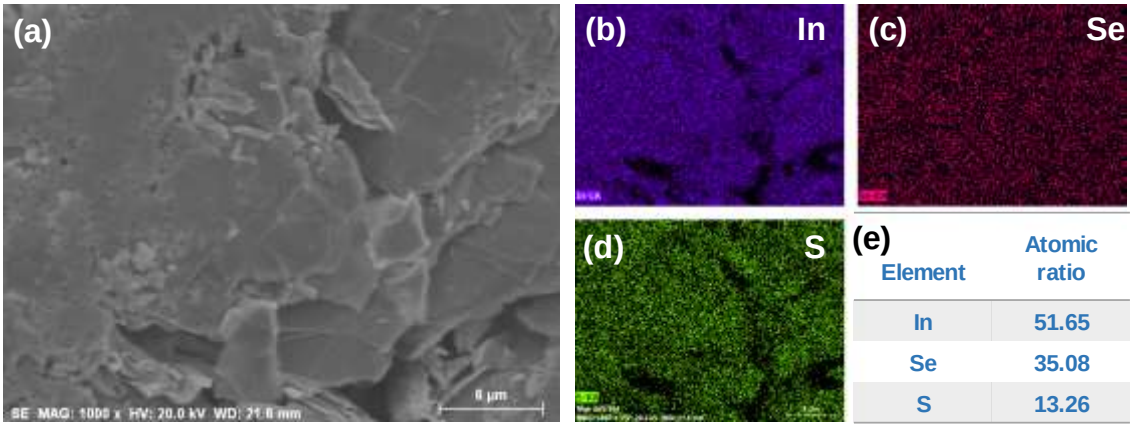

Fig. S2. SEM image (a) and EDS mapping spectra (b-e) of the as-synthesized $InS_{0.3}Se_{0.7}$ crystals.

Fig. S2 show the scanning electron microscopy (SEM) image and Energy-dispersive X-ray spectroscopy (EDS) of the as-synthesized $InS_{0.3}Se_{0.7}$ crystals. As can be seen, the as-synthesized $InS_{0.3}Se_{0.7}$ crystals are of layered structures (Fig. S2(a)), and are composed of In, Se and S from the EDS mapping spectra (Fig. S2(b-d)). The atomic ratio of In, Se and S elements is estimated to be about 1:0.7:0.3 from the quatitantive analysis of the EDS mapping spectra (Fig. S2(e)).

3. Photoluminescence spectra of the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures

Fig. S3 show the photoluminescence (PL) spectra of the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures at different temperatures. The photoluminescence spectra were collected on micro Raman/Photoluminescence system (InVia, Renishaw) using an argon green laser at 514 nm. As can be seen, the PL peak of the WS_2 flakes and $InS_{0.3}Se_{0.7}$ flakes locate at about 622 nm and 869 nm, respectively. With increasing temperature, the PL peak gradually shifts to long wavelength, i.e. red shift, for both WS_2 flakes and $InS_{0.3}Se_{0.7}$ flakes.

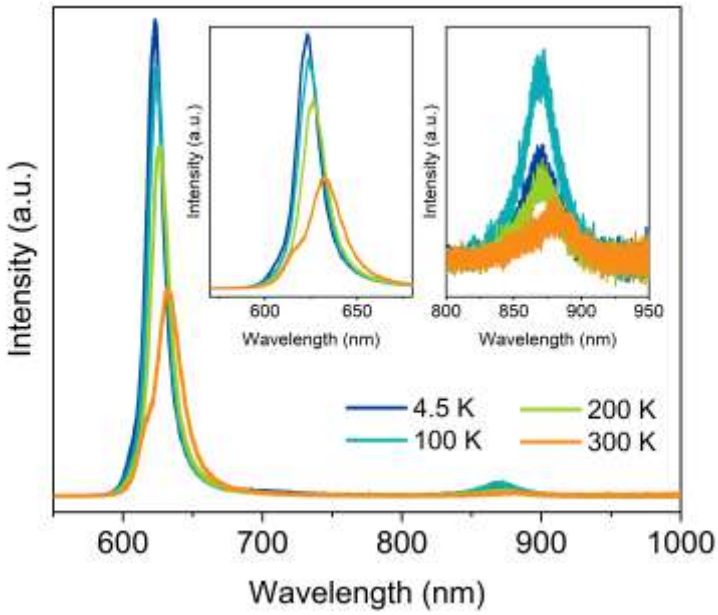

Fig. S3. Photoluminescence (PL) spectra of the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures measured at indicated temperatures.

4. Band diagram of the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures

Fig. S4 show the schematic drawing of the band diagram of the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures. As can be seen, the depletion zone (as indicated by the green area) is formed at the interface of the $InS_{0.3}Se_{0.7}$ flakes and WS_2 flakes. When the light is irradiated on the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures, the photo-induced electron-hole will be separated at the interface and finally lead to the detection of the photocurrent.

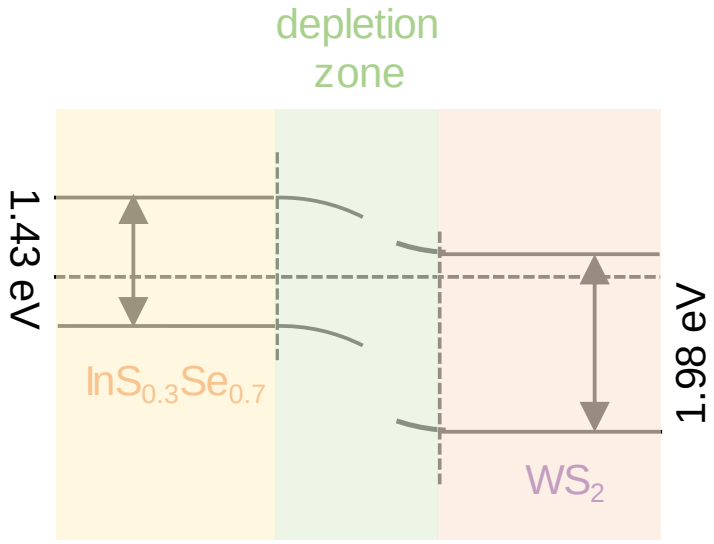

Fig. S4. Band diagram of the $InS_{0.3}Se_{0.7}/WS_2$ heterostructures