Supplementary Information (SI) for Journal of Materials Chemistry C.

Supplementary Materials for

High-performance visible-to-near infrared phototransistor based on $SnSe/SnS_2$ van der Waals heterostructure

Supporting Information

High-performance visible-to-near infrared phototransistor based on SnSe/SnS_2 van der Waals heterostructure

Gaoning Fan [a], Weishuai Duan [a], Mengjiao Dong [a], Xueting Luo [a], Pengyu Zhou [c,*], Chun Sun [a], Yonghui Zhang [a], Mengjun Wang [a], Chao Fan [a,b,*]

a. State Key Laboratory of Reliability and Intelligence of Electrical Equipment, Hebei University of Technology, Tianjin, 300401, China.
b. CNOOC RAIBORN(Tianjin)Technology Co.,Ltd, Tianjin, 300450, China.
c. School of Science, Northeast Electric Power University, Jilin, 132012, China.

Contents list

1. OM images of the SnS_2 and SnSe single crystals.

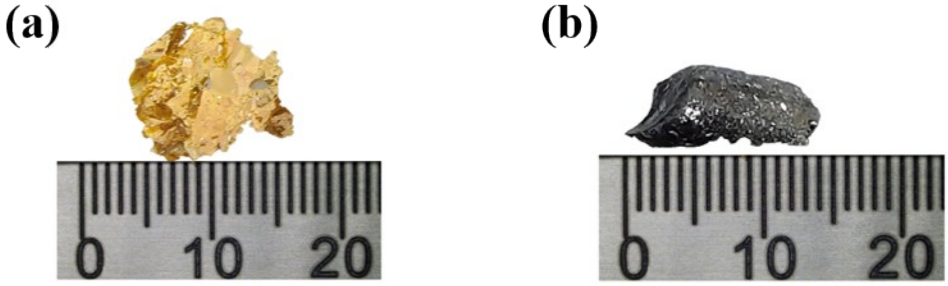

Fig. S1. OM images of the (a) SnS_2 and (b) SnSe single crystals

SnS_2 and SnSe single crystals have been grown via a CVT technique. Fig. S1 shows optical microscopy (OM) images of the (a) SnS_2 and (b) SnSe single crystals. Fig. S1 (a) shows a golden-yellow SnS_2 single crystal, which has a lateral dimension of approximately 12 mm. Fig. S1 (b) demonstrates SnSe single crystals, which can be seen to have transverse dimensions up to 11 mm and exhibit a dark grey metallic luster.

2. Preparation of $SnSe/SnS_2$ heterostructure.

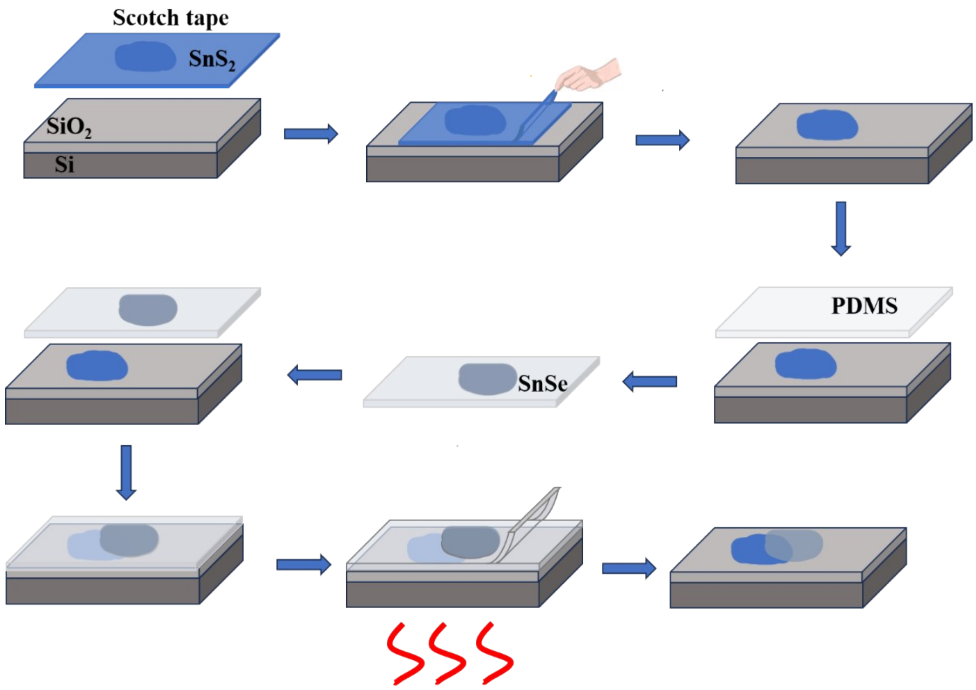

Fig. S2. Processes of the mechanical exfoliation and PDMS-assisted dry-transfer method of the $SnSe/SnS_2$ heterostructure

As shown in Fig. S2, SnS_2 and SnSe thin layers were mechanically exfoliated from the bulk crystals with a Scotch tape. Then the $SnSe/SnS_2$ heterostructure was prepared using a PDMS-assisted dry-transfer method. Firstly, a SnS_2 thin layer was exfoliated and transferred onto a SiO_2/ Si (SiO_2: 300 nm thick, Si: 400 μm thick) substrate. Secondly, a SnSe thin layer was transferred onto the above of the SnS_2 thin layer with assistance of a PDMS layer. Finally, after releasing the PDMS layer, a SnS_2/ SnSe heterostructure was formed.

3. Transfer characteristic of the SnS_2-based and SnSe-based phototransistor.

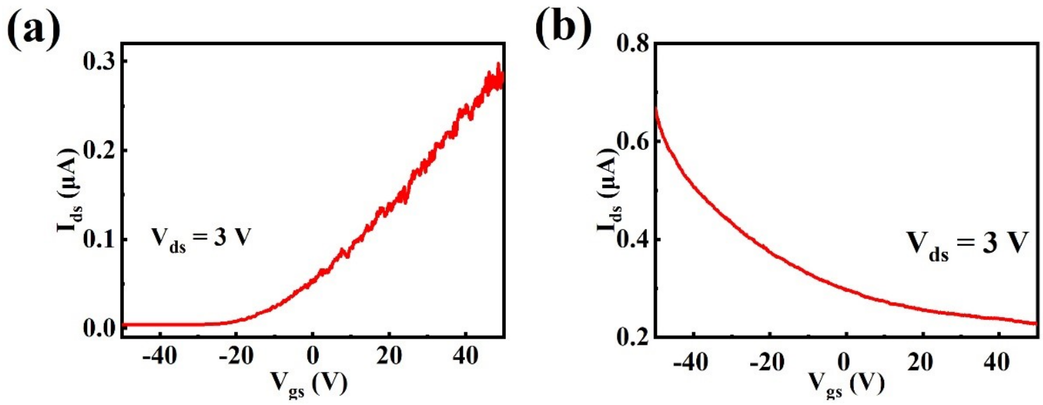

Fig. S3. Transfer characteristic of the (a) SnS_2-based and (b) SnSe-based phototransistor at V_{ds}=3 V

The mobility (μ) of the SnS_2-based and SnSe-based phototransistor can be determined using the following formula:

$$\mu = \frac{dI_{ds}}{dV_{gs}} \times \frac{L}{W \times C_{ox} \times V_{ds}}$$

Where the channel length L and width W are 6 and 4 μm, respectively. C_{ox} is the capacitance of the SiO_2 (11.51×10^{-5} F m^{-2}). The calculated mobilities of the SnS_2-based and SnSe-based phototransistor are 0.18 cm^2 V^{-1} s^{-1} and 0.37 cm^2 V^{-1} s^{-1}, respectively.

4. Response time of SnS_2 phototransistor under the illumination of a 405 nm laser.

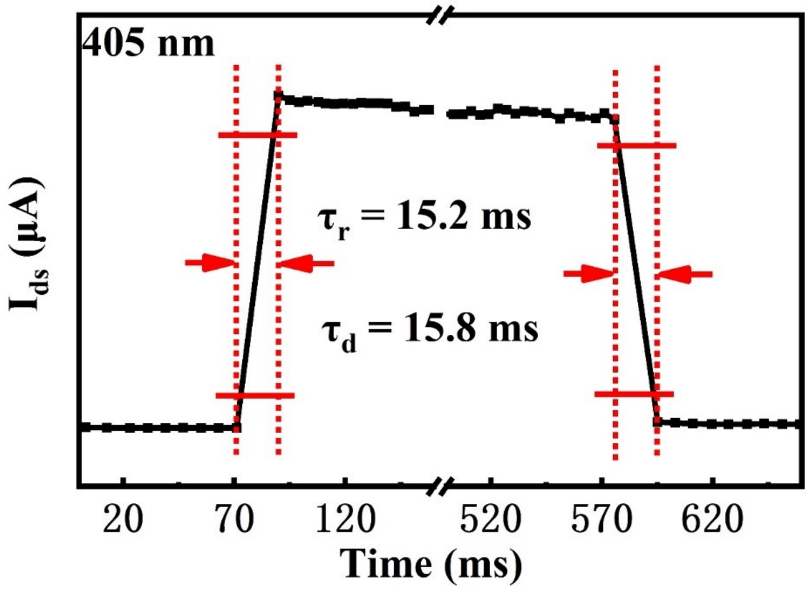

Fig. S4. Rise and decay time of SnS_2 phototransistor under 405 nm laser

As shown in Fig. S4, the rise time and decay time of the tin disulfide phototransistor under 405 nm laser illumination are 15.2 ms and 15.8 ms, respectively.

5. Enlarged I_{ds}–V_{ds} curves of the $SnSe/SnS_2$ phototransistor.

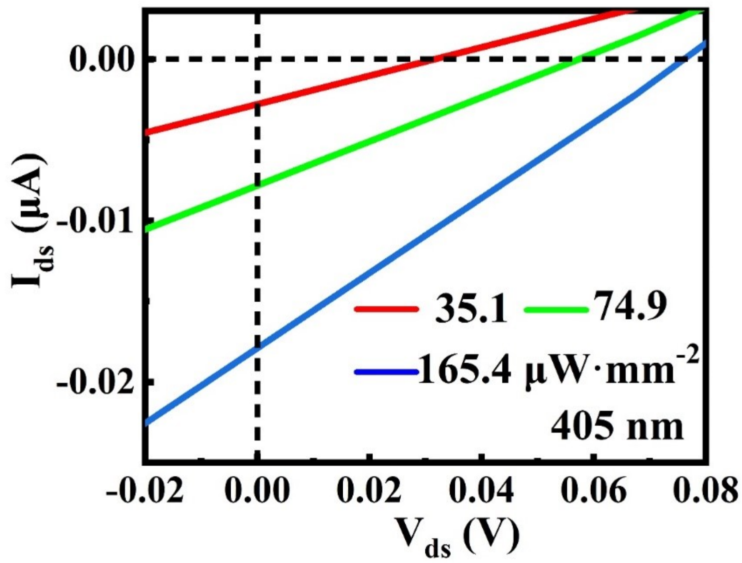

Fig. S5. Enlarged I_{ds}–V_{ds} curves of the $SnSe/SnS_2$ phototransistor under 405 nm illumination with different light power densities.

Fig. S5 zooms in the I_{ds}–V_{ds} curves of the $SnSe/SnS_2$ phototransistor under 405 nm illumination with different light power densities, which shows a remarkable photovoltaic behavior. I_{sc} and V_{oc} increased with the increase of light power density. Moreover, when the light power density reaches 165.4 μWmm^{-2}, the phototransistor exhibits a maximum I_{sc} and V_{oc} of 17.6 nA and 75 mV.