Supplementary Information

Detection of Wavelength in the Range from Ultraviolet to Near Infrared Light Using Two Parallel $PtSe_2$/Thin Si Schottky Junctions

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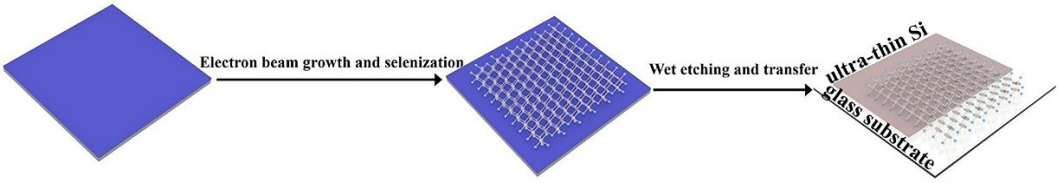

Fig. S1. Flow chart procedure for fabricating the 2D $PtSe_2$/thin Si Schottky heterojunction device.

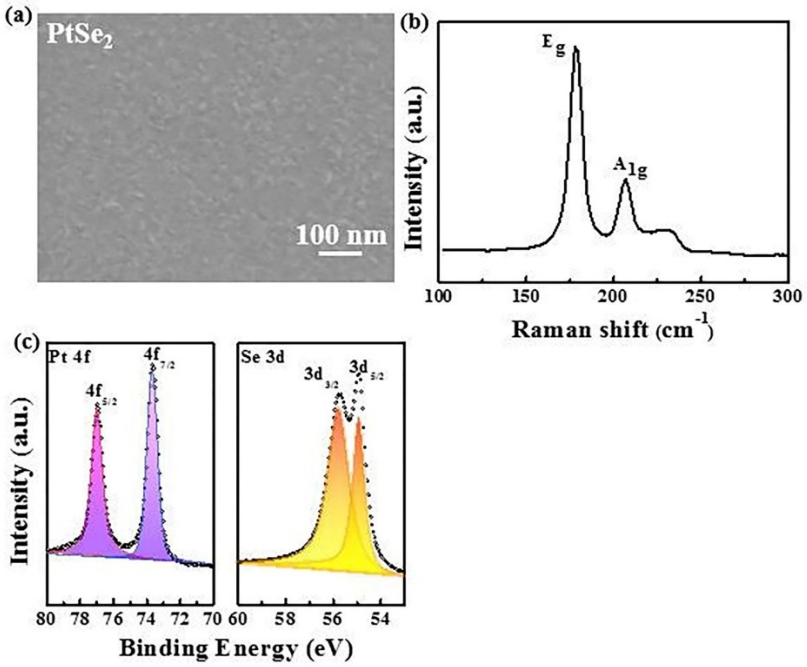

Fig. S2. (a) SEM image of an as-prepared $PtSe_2$ layer on the SiO_2 substrate. (b) Raman spectrum of the $PtSe_2$ layer. (c) High-resolution XPS spectra of Pt 4f and Se 3d.

Calculation of both responsivity and specific detectivity:

The responsivity (R) is defined as the photocurrent generated per unit power of the incident light on the effective area and is calculated by the expression (1) based on the experimental data [1]:

$$R(AW^{-1}) = \frac{I_p - I_d}{P_{in}S} \qquad (1)$$

where I_p is the photocurrent, I_d is the dark current, P_{in} is the incident-light intensity, and S is the effective illuminated area (S = 0.18 cm^2). On the other hand, specific detectivity (D*) represents the ability of a photodetector to detect weak optical signals, which can be calculated from the expression (2):

$$D* = \frac{A^{1/2}R}{(2qI_d)^{1/2}} \qquad (2)$$

where A is the effective area of device (A = 0.18 cm^2), R is the responsivity, and q is the electronic charge, respectively.

Calculation of the width of the diffusion region:

$$L = \sqrt{\frac{kT\mu\tau}{q}}$$

Where k is the Boltzmann constant, T is temperature, q is the elementary charge, μ is the n-Si mobility (500 cm^2/Vs), and τ is the lifetime of the carriers.

Study of the $PtSe_2$/thin Si Schottky Junction photodetector:

For the single $PtSe_2$/thin Si heterojunction, we have also studied the device performance in detail. Fig. S3a shows the *I-V* characteristics under 660 nm illumination with varying light intensities (6.14 μW cm^{-2} -5.66 mW cm^{-2}). Apparently, the photocurrent increases gradually with increasing light intensity due to the increased number of carriers at a higher light intensity. It is also observed that photocurrent monotonically decrease as the bias voltage gradual decrease in Fig. S3b. Meanwhile, for the single device exhibits excellent switching properties with a fast response speed, we have calculated the response speed from the photoresponse curve magnified at 5.5 kHz in Fig. S3c. In the time domain, the rise (or fall) time is defined as the time required for the photoresponse to increase (or decrease) from 10% (or 90%) to 90% (or 10%) out of the peak value [2]. As a result, the rise and fall time (τ_r and τ_f) is estimated to be 71 μs and 16 μs, respectively. It should be noted that the response speed of a single device is comparable to that of γ-In_2Se_3/Si heterojunction, graphene/Si [3, 4] heterojunction and other 2D material based photodetectors [5, 6]. To study the stability of photodetectors in the air, $PtSe_2$/thin Si heterojunction photodetectors were exposed to air for 6 months. No significant performance degradation was observed in the time-dependent light response (see Fig. S3d), which indicates the good air stability of the device. This good air stability of the device is attributed not only to the excellent stability of $PtSe_2$ nanofilm, but also to the dense film morphology, which prevents the oxidation of heterojunction interface.

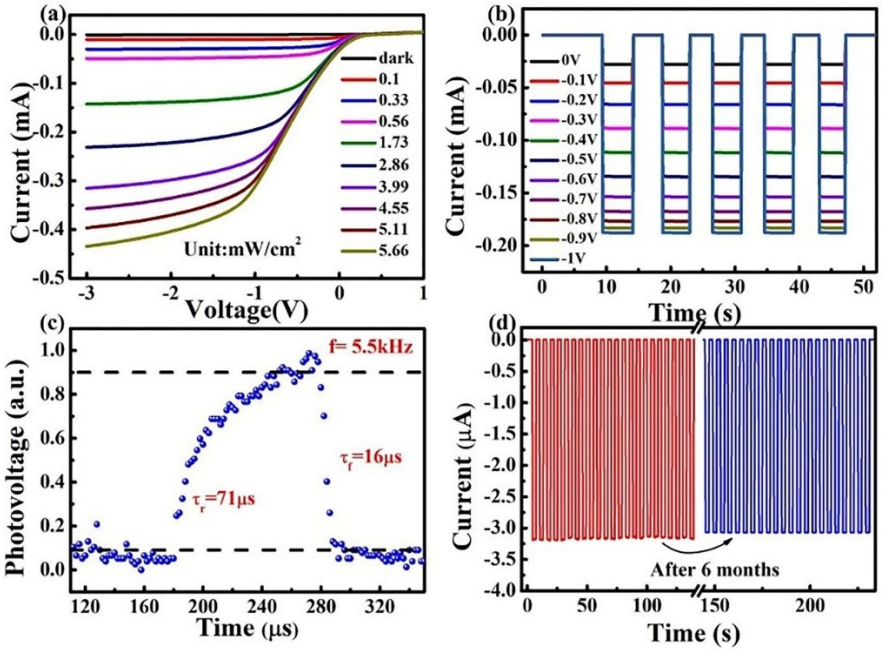

Fig. S3. (a) *I–V* characteristics of the heterojunction under 660 nm illumination at different light intensities. (b) Time-dependent photoresponse of the device under different biases. (c) Individual magnified photoresponse for estimating the rise and fall times. (d) Time-dependent photoresponse before (red) and after (blue) air-storage for six months.

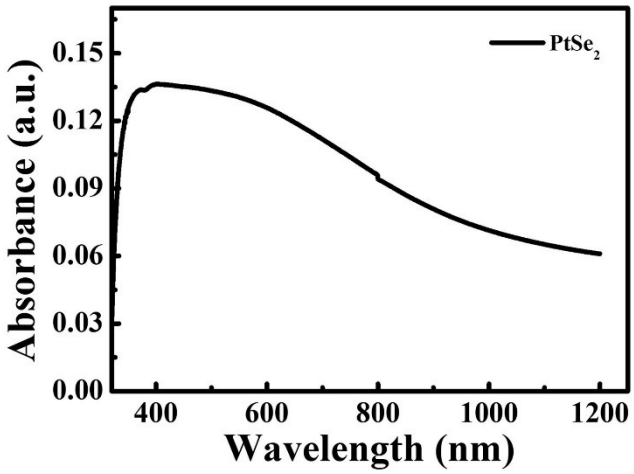

Fig. S4. Absorption spectrum of the $PtSe_2$ film.

The Expression of the wavelength:

The wavelength can be described by the following expression:

$$\lambda = A\ln\left(\frac{B}{\frac{I1}{I2}+C}-1\right)+D \quad (3)$$

Where the values of *A*, *B*, *C*, and *D* at several specific light intensities and temperatures were given in **Table S1**.

Table S1 The values of A, B, C, and D at several specific light intensities and temperatures.

T(°C)/Light intensity(μW/cm^2)	**A**	**B**	**C**	**D**
T=25, P=50	123	19518	113	283
T=25, P=75	126	19908	112	282
T=25, P=100	129	20668	110	274
T=25, P=125	133	21396	153	270
T=25, P=150	139	22768	176	258
T=5, P=100	138	571898	22	-318
T=45, P=100	133	18826	215	387

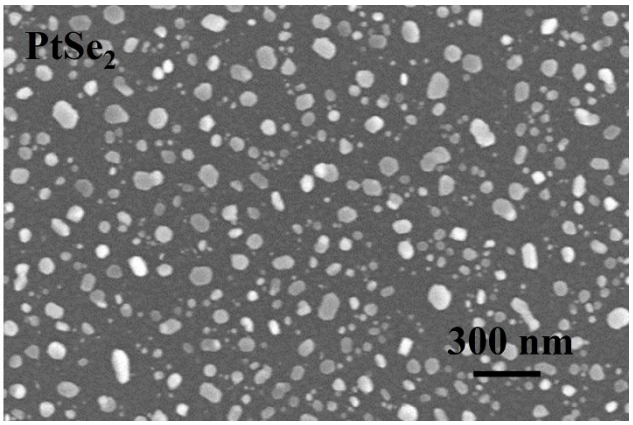

Fig. S5. SEM image of $PtSe_2$ layer with thickness 15 nm.

Notes and references

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