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

Supplementary Information

Superior-performance InSe/CdS van der Waals heterojunction photodetector for self-powered imaging

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Synthesis of CdS Nanoribbons via PVD: SiO_2/Si substrates were cut into 1×2 cm^2 strips and sequentially cleaned in acetone, anhydrous ethanol, and deionized water for 15 minutes each. Residual moisture was removed using a nitrogen gun. A gold film was deposited on the cleaned substrates via a 90-second gold sputtering process using a compact ion sputtering instrument. A quartz tube (2.5 cm diameter) was employed for the synthesis. A ceramic boat containing an appropriate amount of CdS powder (99.999 %, Shanghai Macklin Biochemical Co., Ltd.) was positioned at the center of the quartz tube. The gold-coated substrates were placed approximately 6-8 cm upstream and downstream of the ceramic boat. The quartz tube was then transferred to a three-temperature zone tube furnace. The chamber underwent three cycles of evacuation and purging with inert gas to ensure complete air removal, followed by maintenance under vacuum. The temperature was subsequently ramped to 820°C over 55 minutes and held for 20 minutes, after which the system cooled naturally to room temperature. Throughout the process, an Ar/H_2 mixture (5% H_2) was continuously supplied at a flow rate of 15 sccm. A schematic diagram of the process is shown in Fig. S1a. The synthesized CdS nanoribbons were dispersed in anhydrous ethanol for storage.

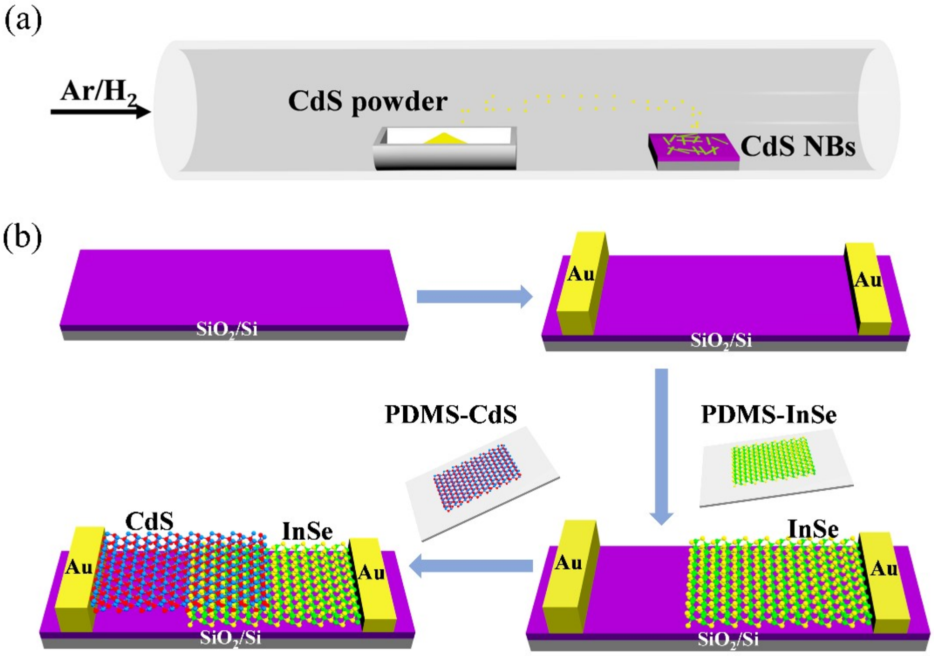

Fig. S1 (a) Schematic diagram of the PVD method for synthesizing CdS nanoribbons. (b) The preparation process of InSe/CdS heterojunction.

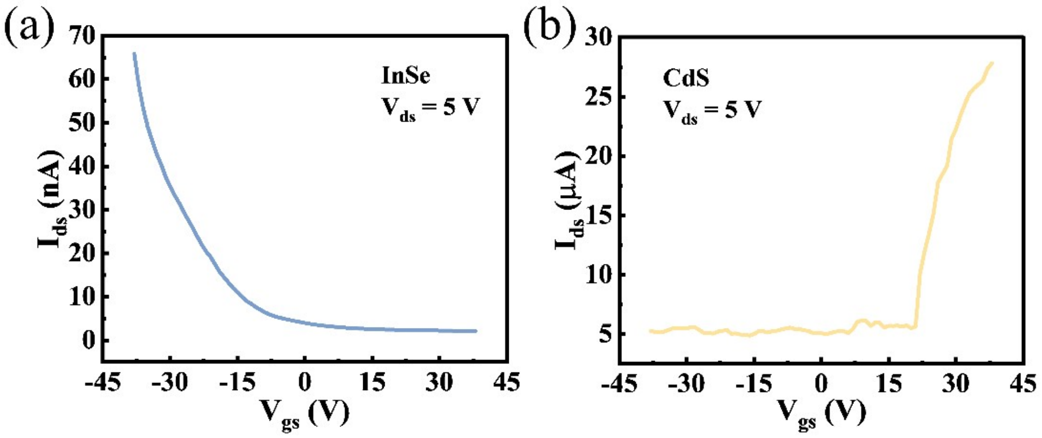

Fig. S2 (a) I_{ds}-V_{gs} curve of pristine InSe. (b) I_{ds}-V_{gs} curve of pristine CdS.

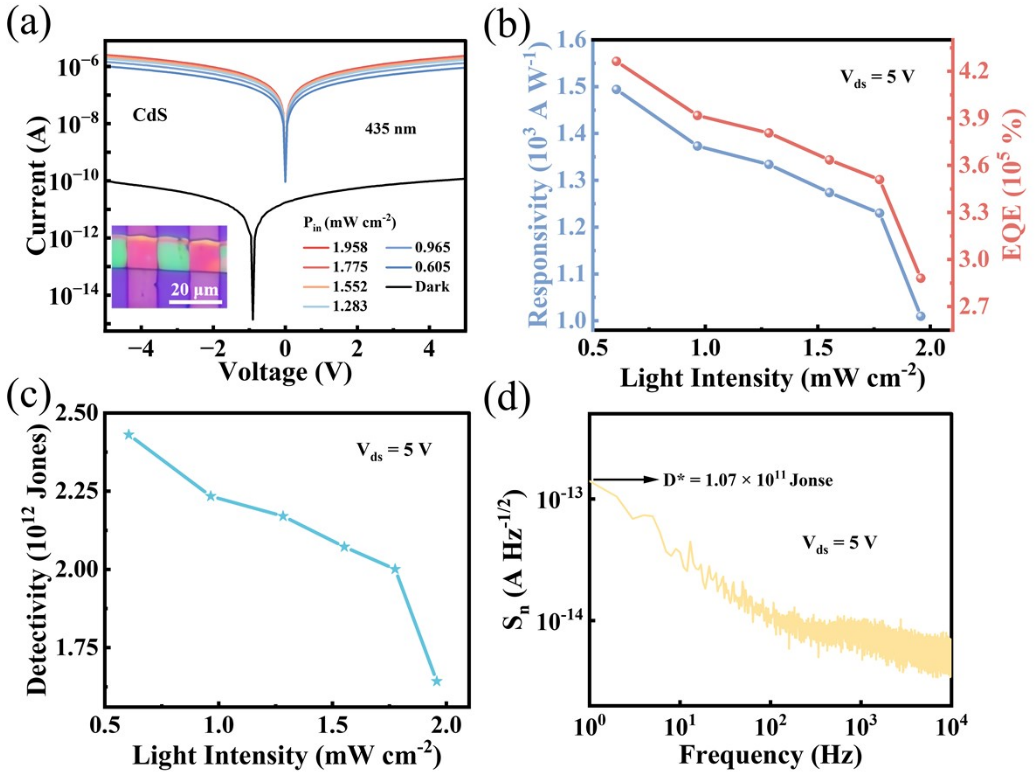

Fig. S3 Photovoltaic performance of CdS device. (a) Logarithmic I-V characteristic curves. (b-c) R and EQE versus P. (d)Sn.

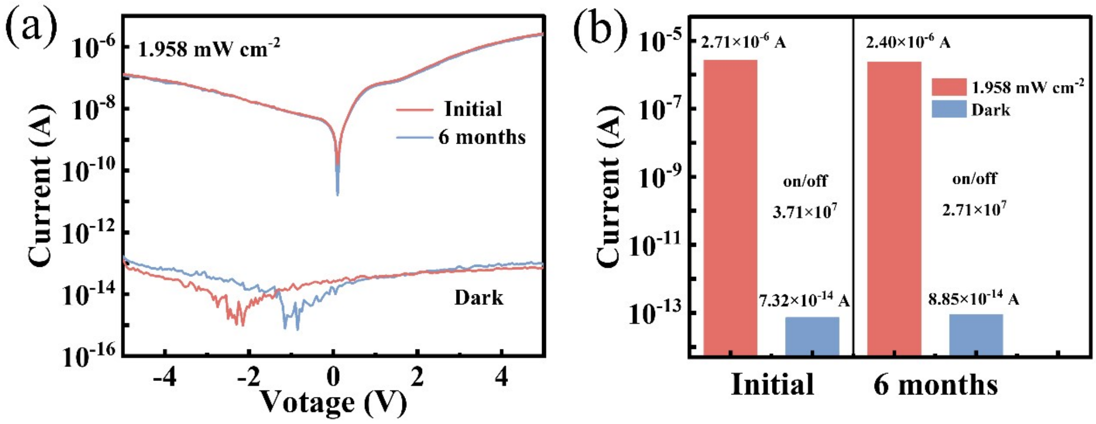

Fig. S4 Long-term stability of the InSe/CdS vdWH photodetector. (a) Logarithmic I-V curves at initial and 6 months. (b) Initial current and current after 6 months at 5 V.

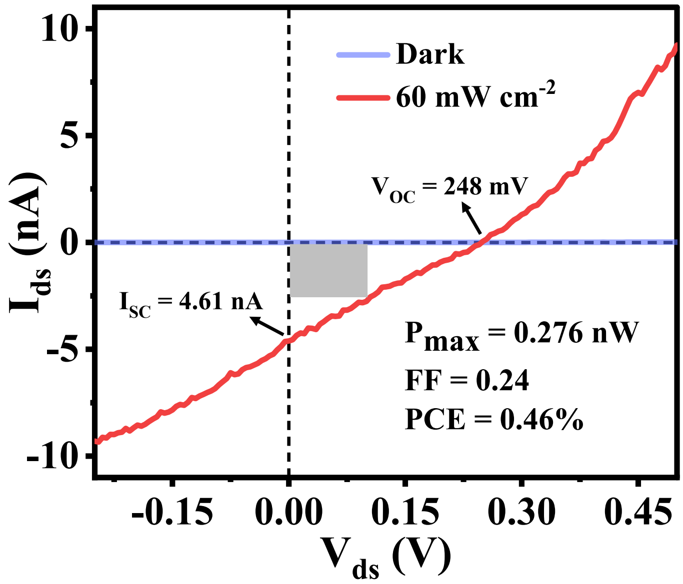

Fig. S5 I-V curves at different incident light intensity at a wavelength of 460 nm.

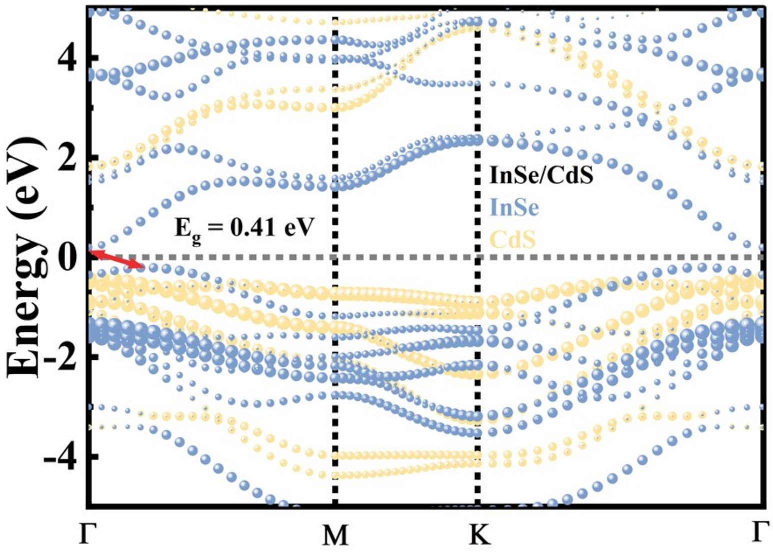

Fig. S6 Projected band structure of CdS/InSe.

Table S1 Comparison of the performances of InSe-based vdWH photodetectors.

Device Type	Active Materials	Wavelength [nm]	Responsivity	EQE [%]	Detectivity [Jones]	On/Off	Response time	Ref.
PCD	GaSe/InSe	410	350 A/W	/	3.7×10^{12}	10^3	/	1
	BP/InSe	655	53.80 A/W	1020	/	/	22/48 ms	2
	BP/InSe/h-BN/DDAB	365	10^3 A/W	3.5×10^5	10^{11}	/	0.96/2.97 ms	3
	InSe/CdS	435	2160 A/W	6.17×10^5	1.41×10^{14}	10^7	45/392 µs	This work
SPPD	InSe/Se	460	32 mA/W	8.7	/	/	30/37 ms	4
	GaSe/ InSe	410	21 mA/W	9.3	/	/	~2 µs	3
	InSe/GaTa	405	13.8 mA/W	4.2	/	/	0.02 ms	5
	$MoTe_2$/CdS	470	~ 11 mA/W	/	/	/	50 ms	6
	InSe/CdS	460	58.23 mA/W	15.71	/	/	76/69 µs	This work

References

1 F. Yan, L. Zhao, A. Patanè, P. Hu, X. Wei, W. Luo, D. Zhang, Q. Lv, Q. Feng, C. Shen, K. Chang, L. Eaves and K. Wang, Nanotechnology, 2017, 28, 27LT01.

2 R. Cao, H. D. Wang, Z. N. Guo, D. K. Sang, L. Y. Zhang, Q. L. Xiao, Y. P. Zhang, D. Y. Fan, J. Q. Li and H. Zhang, Adv. Opt. Mater., 2019, 7, 1900020.

3 Y. Wang, H. Wang, S. M. Gali, N. Turetta, Y. Yao, C. Wang, Y. Chen, D. Beljonne and P. Samorì, Adv. Funct. Mater., 2021, 31, 2103353.

4 H. Shang, H. Chen, M. Dai, Y. Hu, F. Gao, H. Yang, B. Xu, S. Zhang, B. Tan, X. Zhang and P. Hu, Nanoscale Horiz., 2020, 5, 564-572.

5 W. Feng, Z. Jin, J. Yuan, J. Zhang, S. Jia, L. Dong, J. Yoon, L. Zhou, R. Vajtai, J. M. Tour, P. M. Ajayan, P. Hu, J. Lou, 2D Mater., 2018, 5, 025008.

6 M. Y. Lu, Y. T. Chang, H. J. Chen, Small, 2018, 14, 1802302.