Supporting Information

1T′-$MoTe_2$/GaN Van der Waals Schottky Junction for Self-powered UV Imaging and Optical Communication

Lenan Gao[a], Bangbang Yang[a], Junli Du[b, *], Cheng Zhang[c], Shihong Ma[a], Zhaowei Guo[a], Yu Wang[a], Jian Wang[a], Xinjian Li[a], Di Wu[a], Pei Lin[a, *]

[a] *Key Laboratory of Materials Physics, Ministry of Education, School of Physics, Zhengzhou University, Zhengzhou 450001, China*

[b] *State Grid Henan Electric Power Research Institute, Zhengzhou 450052, China*

[c] *National Joint Engineering Research Center for Abrasion Control and Molding of Metal Materials, School of Materials Science and Engineering, Henan University of Science and Technology, Luoyang 471003, China*

* Corresponding authors.

E-mail addresses: linpei@zzu.edu.cn (Pei Lin), 17801052606@163.com (Junli Du)

Table S1. Electrical properties of as-purchased GaN film

Thickness	4.5± 0.5 μm
Substrate	Sapphire
Orientation	C-plane (0001)
Conduction type	n-type
Resistivity (300 K)	< 0.5 Ω·cm
Carrier concentration	< 5×10^{17} cm^{-3}
Mobility	~300 $cm^2V^{-1}s^{-1}$

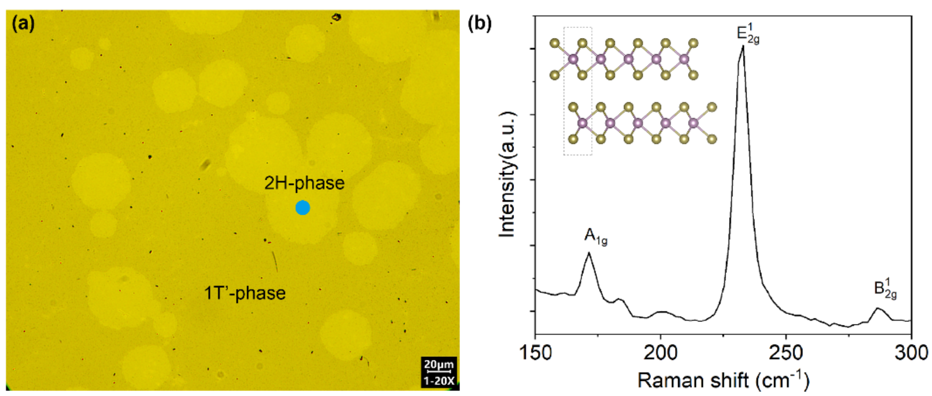


Fig. S1. (a) Optical image of $MoTe_2$ film prepared at 550 °C for 30 min, showing the coexistence of polymorphic 2H and 1 T′ phase. (b) Typical Raman spectrum of 2H-$MoTe_2$.

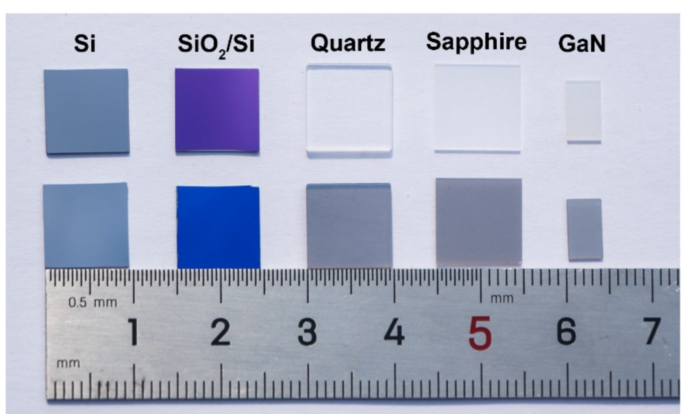


Fig. S2. Photographs of the sapphire, quartz, Si, and GaN substrates before (up) and after (bottom) the growth of 1T′-$MoTe_2$ films.

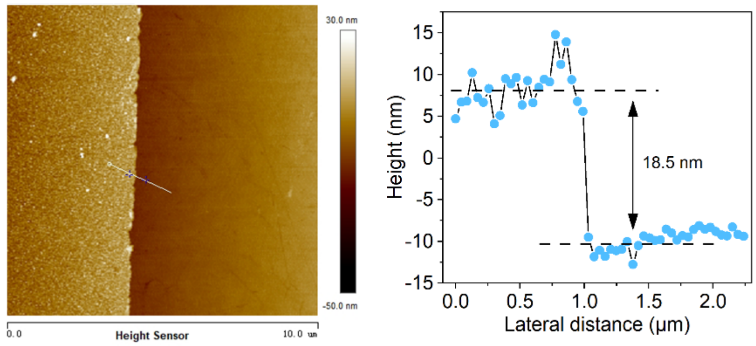


Fig. S3. Atomic force microscopy image of the 1T′-$MoTe_2$ used for device fabrication. The thickness is ~18.5 nm.

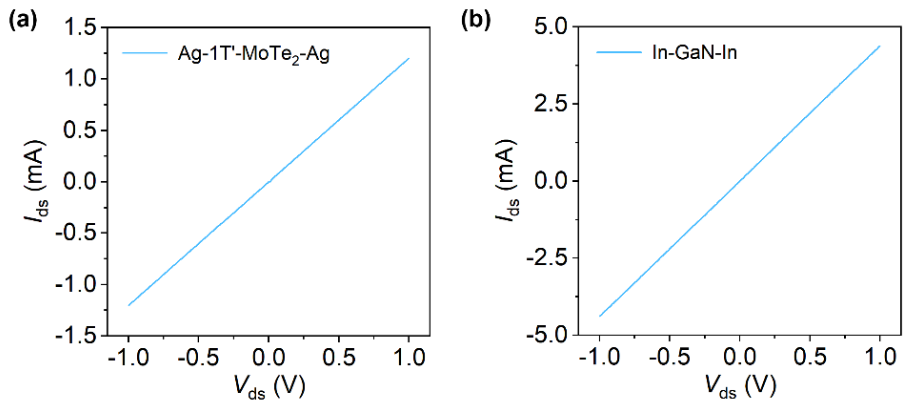


Fig. S4. I_{ds}-V_{ds} curves of Ag-1T′-$MoTe_2$-Ag (a) and In-GaN-In (b) devices, presenting typical Ohmic contact behavior.

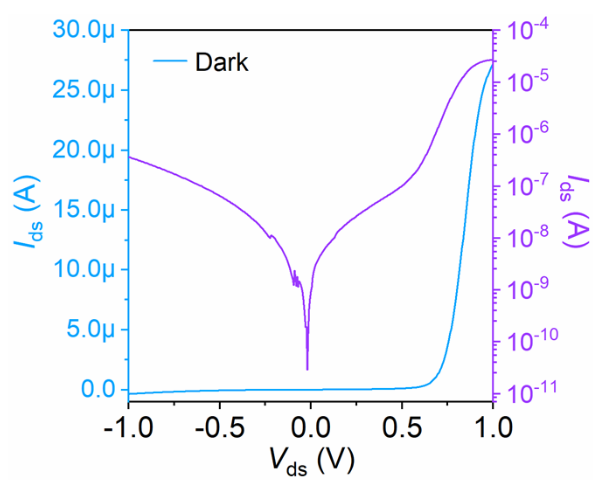


Fig. S5. The linear and logarithmic scale plots of I_{ds}-V_{ds} of the 1T′-$MoTe_2$/GaN heterojunction device under dark.

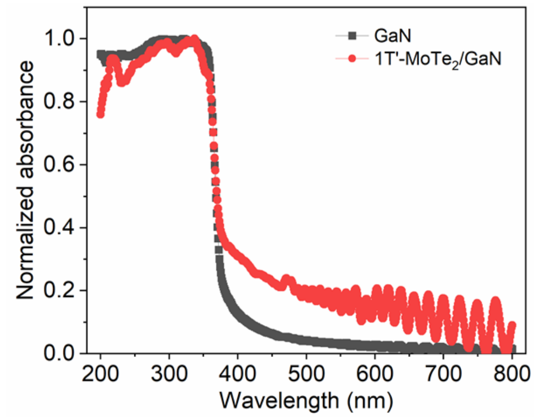
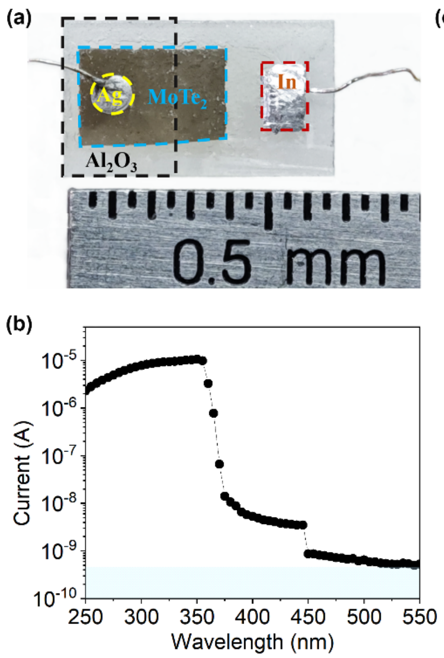


Fig. S6. Normalized absorption spectra of GaN and 1T′-$MoTe_2$/GaN heterostructure.



(c)

Wavelength (nm)	Intensity (mW)
250	0.08
260	0.114
270	0.152
280	0.197
290	0.239
300	0.262
310	0.279
320	0.284
330	0.294
340	0.307
350	0.32
360	0.188
370	0.208
380	0.221
390	0.236
400	0.224
410	0.218
420	0.245
430	0.289
440	0.304
450	0.384
460	0.467
470	0.485
480	0.413
490	0.383
500	0.34
510	0.322
520	0.308
530	0.295
540	0.279
550	0.266

Fig. S7. (a) Photograph of the fabricated 1T′-$MoTe_2$/GaN photodiode. (b) The wavelength-dependent I_{ds} of the 1T′-$MoTe_2$/GaN photodiode at zero bias and (c) the corresponding light intensity for each wavelength.

Here, we take the illumination density of 0.384 mW/cm^2 as an example to calculate the responsivity R. The laser power is ~153.7 μW with a spot area of ~0.4 cm^2, yielding a power density P_{in} of ~0.384 mW/cm^2. The effective junction area A is ~0.03 cm^2. From the

I_{ds}-V_{ds} curves in Figure 3e, the short-circuit current I_{ph} is ~5.72×10^{-7} A. The R is calculated by $R= I_{ph}/(P_{in}\times A)$ = (5.72×10^{-7} A) / (0.384 mW/cm^2 × 0.03 cm^2) = 49.6 mA/W

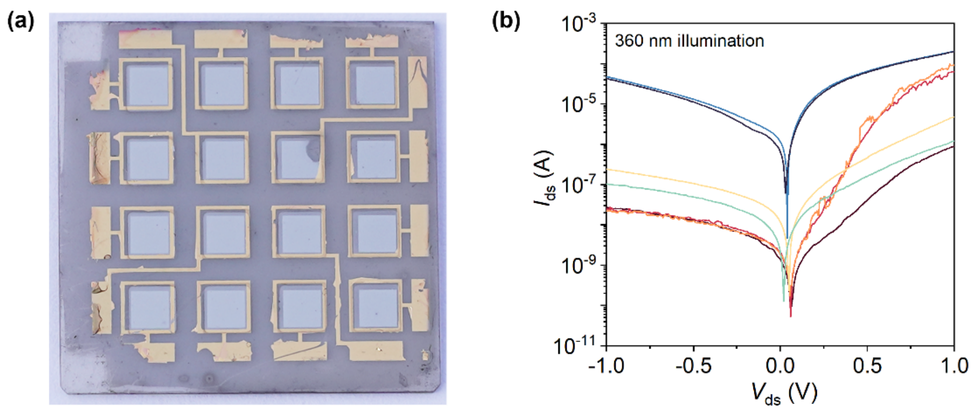


Fig. S8. (a) Photograph of the 1T′-$MoTe_2$/GaN heterostructure arrays through the in-situ growth of 1T′-$MoTe_2$ directly onto GaN substrates. (b) I_{ds}-V_{ds} curve of seven devices under the illumination of 360 nm light. It shows that most of these devices exhibit either no response or significantly reduced photocurrent compared to devices that the 1T′-$MoTe_2$ layer is transferred onto GaN.

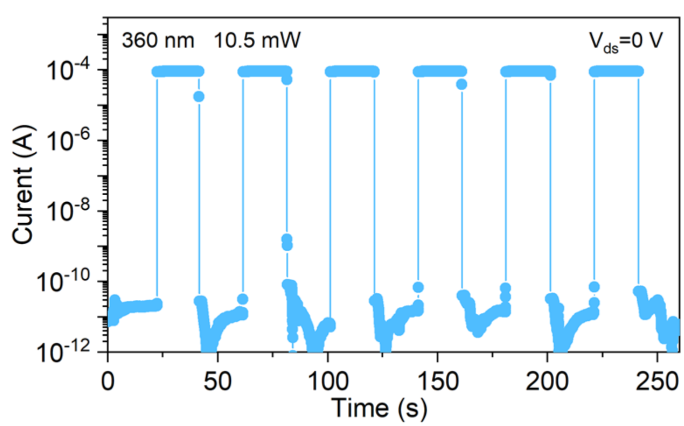


Fig. S9. *I-t* characteristics of the device under 360 nm irradiation of 10.5 mW (V_{ds}=0 V), which shows favorable repeatability and a high I_{light}/I_{dark} of ~4.9×10^6.

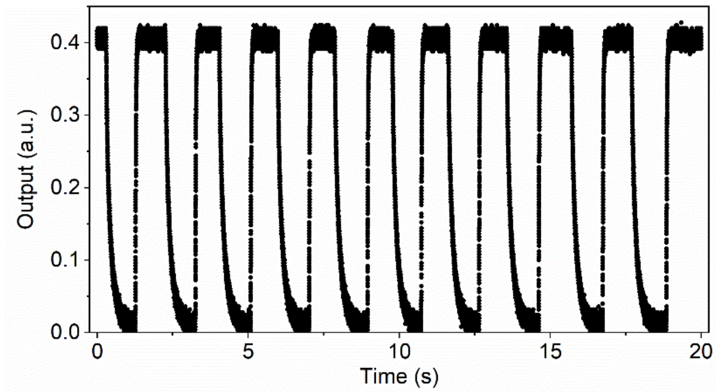


Fig. S10. *I-t* characteristics of the device measured with an oscilloscope to evaluate the response speed.

Table S2. Comparison of the figures-of-merit of 2D material/GaN heterostructure-based UV photodetectors

Device structure	**λ (nm)**	**Power (mW/cm²)**	I_{on}/I_{off}	R **(A/W)**	D **(Jones)**	τ_{rise}/τ_{decay}	R_{UV}/R_{Vis}	**Ref.**
ReS_2/WS_2/p-GaN	365	0.069	~30 (1V)	3.78 (1V)	2.1×10^{12} (1V)	259/374 µs (1V)		[1]
MoS_2/p-GaN	532	0.8		0.13 (0 V)	3.8×10^{10} (0 V)	18.5/123.2 ms (4 mW/cm²)		[2]
Bi_2Se_3/GaN	366	20		5.9×10^{-3} (0 V)		63/43 ms		[3]
MoS_2/GaN	365	0.5		10.1	2.3×10^{13}	0.5/4.2 ms		[4]
MoS_2/p-GaN	416 365 520	1.46 mW		35.6 19.6 8.4 (4 V)	5.5×10^{11} 2.9×10^{11} 1.2×10^{11}	350 ms/2.21 s		[5]
MoS_2/GaN	532 365	56.5 46.9	4 5.4	328 (5 V) 27.1(5 V)	2×10^{11} 1.7×10^{10}	0.4/2.6 s 0.3/3.9 s		[6]

MoS_2/GaN	365	1		1.8×10^{4} (1 V)	7.5×10^{12} (1 V)	~0.1/0.6 s		[7]
MXene/GaN	355	0.03		0.284 (0 V)	7.1×10^{13} (0 V)	7.55 μs/1.67 ms	R_{355}/R_{500} =532	[8]
$PtSe_2$/GaN	265	2.4	10^{8}	0.193 (0 V)	3.8×10^{14} (0 V)	0.14/7.75 ms		[9]
WS_2/GaN	375	10^{-3}	~10^{3}	0.226	4×10^{14}	10.1/2.55 ms (10 Hz)		[10]
MoS_2/GaN	265	2.4	10^{5}	0.015 (0 V)	1.5×10^{12} (0 V)	0.3/3.6 ms (100 Hz)		[11]
MoS_2/h-BN/GaN	560	8		1.2×10^{-3} (9 V)		0.5/0.3 s		[12]
1T'-$MoTe_2$/GaN	360 nm	10.5	4.9×10^{6}	5×10^{-2} (0 V)	3.5×10^{12} (0 V)	0.04/0.45 s	R_{350}/R_{400} $=1.6\times10^{4}$	This work

References

1. Q. Zheng, Z. Qiu, Q. Zhang, M. Yang, J. Lei, L. Han, L. Tang, Z. Zheng, X. Wang and J. Li, *ACS Applied Nano Materials*, 2023, **6**, 15490-15497.
2. B.-W. Liang, W.-H. Chang, C.-S. Huang, Y.-J. Huang, J.-H. Chen, K.-S. Li, K. B. Simbulan, H. Kumar, C.-Y. Su, C.-H. Kuan and Y.-W. Lan, *Nanoscale*, 2023, **15**, 18233-18240.
3. Z. Zeng, D. Wang, X. Fang, C. Zhao, B. Zhang, D. Liu, T. Chen, J. Pan, S. Liu, G. Liu, T. Liu, H. Jin, S. Jiao, L. Zhao and J. Wang, *Materials Today Nano*, 2023, **23**, 100372.
4. Y. Zheng, B. Cao, X. Tang, Q. Wu, W. Wang and G. Li, *ACS Nano*, 2022, **16**, 2798-2810.
5. Y. Yang and W. Sun, *ACS Applied Nano Materials*, 2024, **7**, 84-91.
6. X. Zhang, J. Li, Z. Ma, J. Zhang, B. Leng and B. Liu, *ACS Applied Materials &*

Interfaces, 2020, **12**, 47721-47728.

7. S. K. Jain, M. X. Low, P. D. Taylor, S. A. Tawfik, M. J. S. Spencer, S. Kuriakose, A. Arash, C. Xu, S. Sriram, G. Gupta, M. Bhaskaran and S. Walia, *ACS Applied Electronic Materials*, 2021, **3**, 2407-2414.
8. W. Song, J. Chen, Z. Li and X. Fang, *Advanced Materials*, 2021, **33**, 2101059.
9. R. Zhuo, L. Zeng, H. Yuan, D. Wu, Y. Wang, Z. Shi, T. Xu, Y. Tian, X. Li and Y. H. Tsang, *Nano Research*, 2019, **12**, 183-189.
10. Z. Zhao, D. Wu, J. Guo, E. Wu, C. Jia, Z. Shi, Y. Tian, X. Li and Y. Tian, *Journal of Materials Chemistry C*, 2019, **7**, 12121-12126.
11. R. Zhuo, Y. Wang, D. Wu, Z. Lou, Z. Shi, T. Xu, J. Xu, Y. Tian and X. Li, *Journal of Materials Chemistry C*, 2018, **6**, 299-303.
12. H. Jeong, S. Bang, H. M. Oh, H. J. Jeong, S. J. An, G. H. Han, H. Kim, K. K. Kim, J. C. Park, Y. H. Lee, G. Lerondel and M. S. Jeong, *ACS Nano*, 2015, **9**, 10032-10038.