Electronic Supplementary Information

Integration of $H_2V_3O_8$ nanowires and GaN thin film for self-powered and visible-blind UV photodetectors

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Experimental section

Preparation of the devices

First, the GaN thin film was cleaned by acetone, ethanol, and deionized water. Meanwhile, 0.14 mmol HVO NWs was dispersed in 5 mL ethanol, and then the solution was sonicated for more than 30 min. Secondly, the GaN thin film was immersed into the homogeneous alcoholic solution of the dispersive HVO NWs at about 5 mm/sec. After dip-coating, the sample was annealed on a hot plate for 5 minutes at 80 °C. This process was repeated 1, 3, 5, 7 times, respectively. Consequently, the HVO/GaN heterojunction was successfully fabricated. The Ag pastes with an area of about 0.1 cm × 0.1 cm were added on the surface of GaN and HVO layer respectively. Then, the sample was baked on a hot plate at 80 °C for more than 1 hour. The HVO/GaN heterojunction with two Ag electrodes was successfully fabricated, which is labelled as “Ag/HVO/GaN/Ag device”. Similarly, the dispersive HVO NWs were dip-coated on the ordinary glass 3 times. The Ag pastes were added on the surface of HVO layer. The HVO/ordinary glass with two Ag electrodes is labelled as “Ag/HVO/Ag device”. The GaN film with two Ag electrodes is labelled as “Ag/GaN/Ag device”.

Characterization

Powder X-ray diffraction (XRD) data of the all samples were collected on an X-ray diffractometer (D8-FOCUS, Bruker, Germany) with Cu Kα radiation (λ = 1.5418 Å). Scanning electron microscopy (SEM) images were recorded with a field emission

scanning electron microscope (FE-SEM, SU8010, Hitachi, Japan). The energy-dispersive X-ray spectroscopy (EDS) spectra and elemental mapping images were measured in an EDAX Genesis, which was attached to the FE-SEM. The UV-Vis spectra with the range of 200-800 nm were obtained by an UV-27001 spectrophotometer (Shimadzu Corporation, Japan). All optoelectronic measurements were taken by using a semiconductor parameter analyzer system (Keithley 4200 SCS). The device was placed on a probe station with a LED supplying 365 nm UV light and a time conditioner controlling the 6 s ON and 6 s OFF state of the LED. The measurements were performed on the device via two tungsten probes. The light intensity of the LED was controlled by an independent power supply, and the light intensity was measured by a 365 nm UV light meter. The Mott-Schottky plots of as-synthesized samples were collected on CHI760E. All measurements were performed in ambient conditions at room temperature.

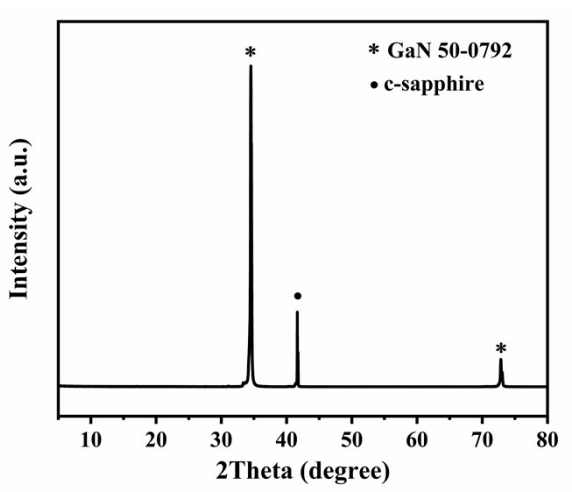

Fig. S1 The XRD pattern of the GaN thin film.

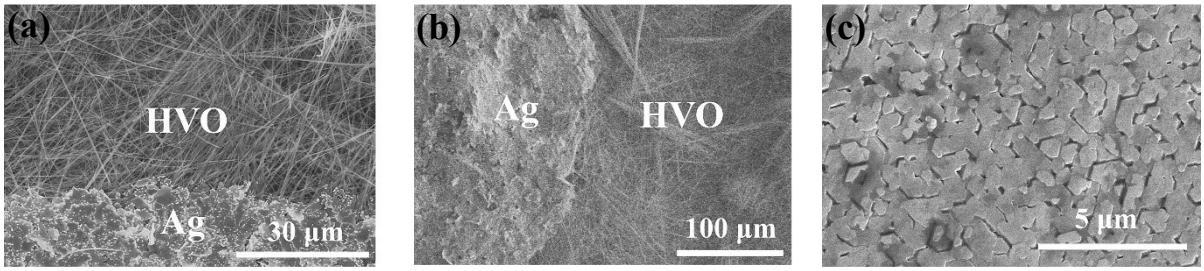

Fig. S2 (a, b) FE-SEM images of the HVO/GaN heterojunction and (c) GaN at different magnifications.

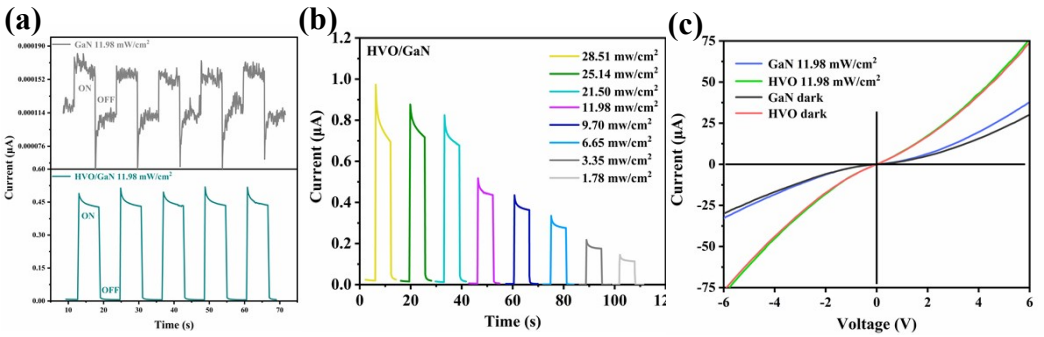

Fig. S3 (a) The I-t characteristics of the electrode-free pure GaN and electrode-free HVO/GaN PD in the 365 nm illumination under 0 V bias. (b) The I-t characteristics of the electrode-free HVO/GaN PD in the 365 nm illumination with variable intensities under 0 V bias. (c) The I-V curves of electrode-free pure GaN and HVO.

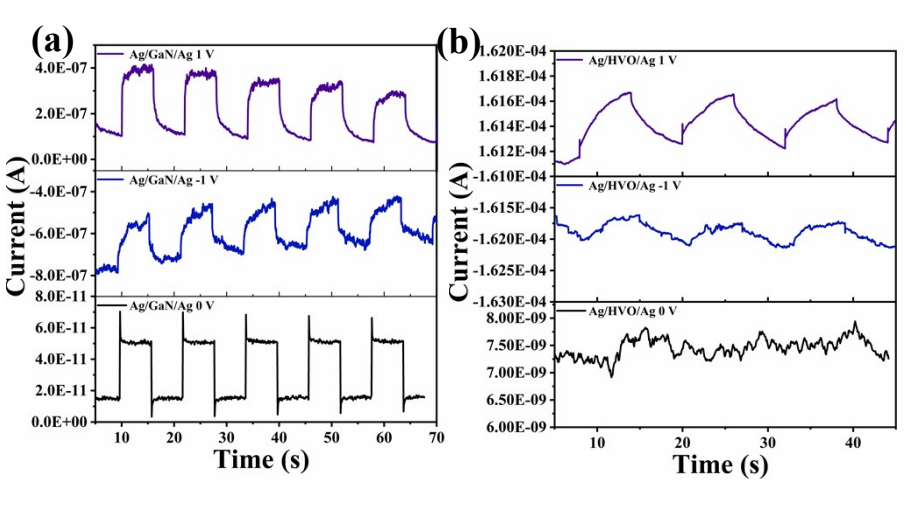

Fig. S4 (a) The I-t characteristics of the Ag/GaN/Ag and (b) Ag/HVO/Ag device under 0 V, -1V, 1V bias and 12.08 mW/cm^2.

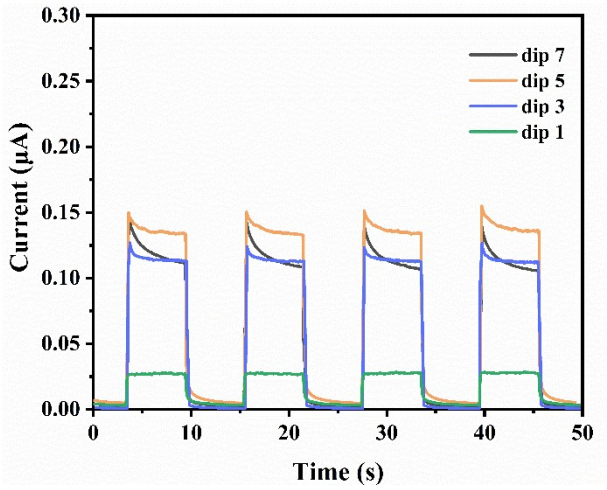

Fig. S5 The I-t characteristics of the Ag/HVO/GaN/Ag device that the HVO NWs were dipped 1, 3, 5, 7 times under 0 V bias and 12.08 mW/cm^2.

The photocurrent of the device drops when the HVO NWs are dipped only once. A small part of HVO NWs is distributed on GaN, so we cannot accurately calculate the coverage area of scattered HVO NWs. And because the HVO NWs cannot completely cover the GaN, the silver electrode on HVO may also partially contact GaN. There is

no significant change in the optical response of the devices that the HVO NWs are dipped 5 and 7 times.

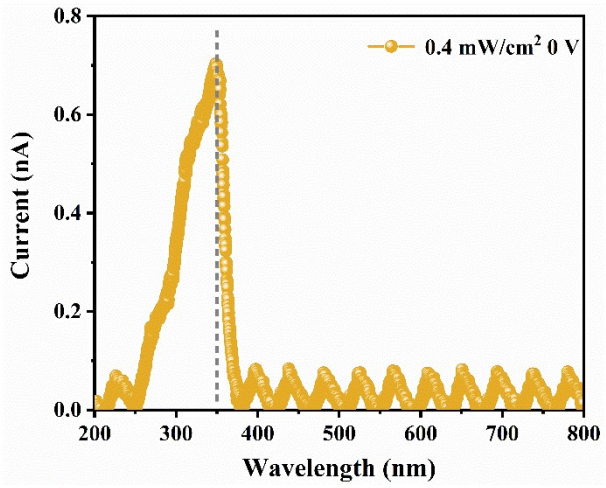

Fig. S6 The spectral responsivity of the Ag/HVO/GaN/Ag PD at zero bias.

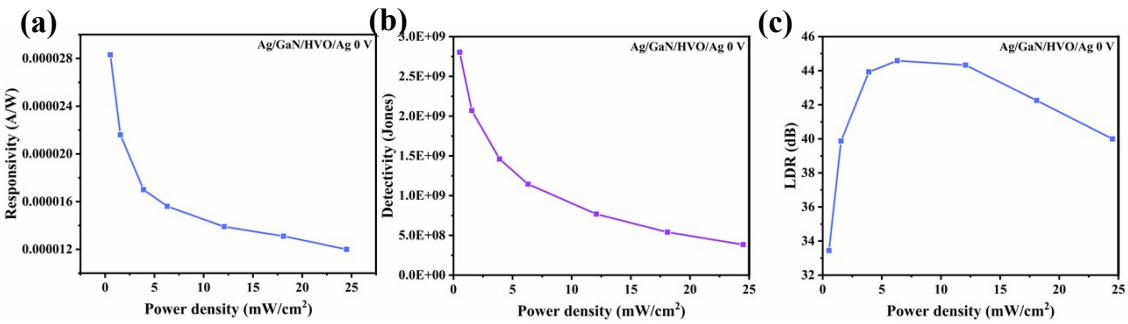

Fig. S7 (a) The responsivity, (b) specific detectivity and (c) linear dynamic range of the Ag/HVO/GaN/Ag PD in the 365 nm illumination with variable intensities under 0 V bias.

The responsivity, specific detectivity and linear dynamic range were calculated using the following formula[1, 2]:

$$R = \Delta I/PS \quad (1)$$

$D^* = R_\lambda / (2 e I_d / S)^{1/2}$ (2)

$LDR = 20 \log (I_{ph}/I_d)$ (3)

where $\Delta I = I_{ph} - I_d$, $V_{bias} = 0$ V, P = 24.50, 18.10, 12.08, 6.31, 3.90, 1.55, 0.53 mW/cm^2, P is the intensity of the light corresponding to that photocurrent, and S = 0.7 cm^2 is the effective area of the device, which is taken as the area of the heterojunction, in this case. e is the electronic charge.

Table S1 Characteristic parameters of PDs in the literature.

Devices	Wavelength (nm)	bias (V)	Response speed	On/Off ratio or LDR (dB)	R (A/W)	D* (Jones)	θ	Ref.
2D g-C_3N_4/GaN nanorods	392	0	0.14s/0.21s	20	2.00E-02	5.16E+12	0.76	3
MoS_2/GaN	405	5	0.11s/0.08s	186	1.00E+05	1.00E+14	-	4
ZrO_2/GaN	325	4	0.03s/0.18s	-	2.7E+01	1.00E+10	-	5
p-GaN thin film/n-ZnO nanowire arrays	360-400	0	9.3s/0.8s	5.07E+02	1.71E-04	1.11E+08	-	6
Graphene/GaN	360-400	10	5.05ms/5.11ms	-	3.61E-01	1.50E+10	-	7
GaN Microwires/PANI (361nm)	325	0	1.1ms/1.8ms	40−51 dB	6.90E-02	8.45E+13	0.51	8
NiO nanosheet/GaN	365	0	40 ms/40ms	3.40E+03	5.00E-04	-	0.7	9
VO_2/Si	950	0	70ms/150ms	58	2.00E-05	-	-	10
V_2O_5/MoS_2	UV vis NIR	1	-	-	6.50E-02	-	-	11
Fe-doped ZnO/$BiVO_4$	365	0.1	0.17s/0.17s	-	7.35E+00	3.66E+09	-	12
V_2O_5/ZnO	455	-1.5	4.90ms/9.79ms	58dB	2.00E-02	1.45E+12	-	13
$H_2V_3O_8$/GaN	365	0	<0.3s	170	2.83E-05	2.80E+09	0.79	This work

Notes and references

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