Supplementary Information

Engineered s-SWCNT Network/a-Ga_2O_3 Heterointerface for Enhanced Deep Ultraviolet Photodetection

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Materials and Methods

Materials: The semiconducting single-walled carbon nanotubes (s-SWCNTs) dispersed in toluene (~20 μg mL^{-1}, the semiconductor purity > 99.9%) were prepared using a previously reported method[1] and were purchased from Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO).

Device Fabrication: Gold interdigitated electrodes (IDEs) were patterned onto 4 mm × 6 mm × 1 mm glass substrates via conventional photolithography and wet etching. The fabrication process comprised seven steps: spin-coating, pre-baking, exposure, development, hard baking (post-baking), etching, and resist removal. The IDEs consisted of 20 pairs of digits, each with a width and spacing of 30 μm. Subsequently, s-SWCNT thin films were deposited onto the IDE-patterned substrates via spin-coating at varied speeds [0 rpm, 50s -> 500 rpm, 15s -> 2000/3000/4000/5000 rpm, 60s]. The resulting films were then thermally annealed at 100 °C in air for 1 min to evaporate the toluene solvent. Finally, amorphous gallium oxide (a-Ga_2O_3) films were grown on the s-SWCNT films via radio frequency (RF) magnetron sputtering at room temperature. Sputtering conditions were: power of 120 W, pressure of 4 Pa, Ar flow rate of 40 sccm (O_2:Ar = 0:40 sccm), background vacuum of 5×10^{-4} Pa, and a deposition time of 30 min.

Characterization: The morphology of the s-SWCNT/a-Ga_2O_3 films was examined using a Zeiss Supra 55 scanning electron microscope (SEM). The crystal structure was analyzed using a Rigaku Ultima VI X-ray diffractometer (XRD). The elemental composition and chemical states were determined by X-ray photoelectron spectroscopy (XPS, Thermo Scientific ESCALAB 250Xi) and Raman spectroscopy (Horiba LabRAM HR Evolution). Absorption spectra were acquired using a PerkinElmer Lambda 950 testing system. Photoluminescence (PL) spectroscopy (Edinburgh FLS1000) was employed to investigate the material's band alignment. The optoelectronic properties of the as-prepared photodetectors, including responsivity and *I-V* characteristics were measured using a Zolix DR800-CUST spectral response measurement system which has been widely used in our previous studies[2,3], and the schematic diagram of the test equipment is displayed in Fig. S3. The wetting process between the spin-coated solution and the substrate was recorded using a contact angle meter (USA KINO SL200KS).

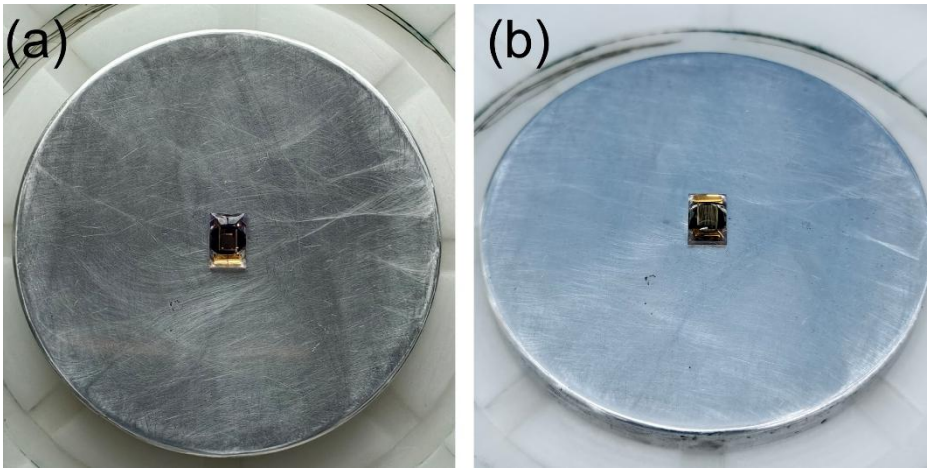

Fig. S1 (a) Bird's eye view and (b) high-angle shot of the s-SWCNT solution dripping and completely wetting the glass substrate with pre-patterned IDEs.

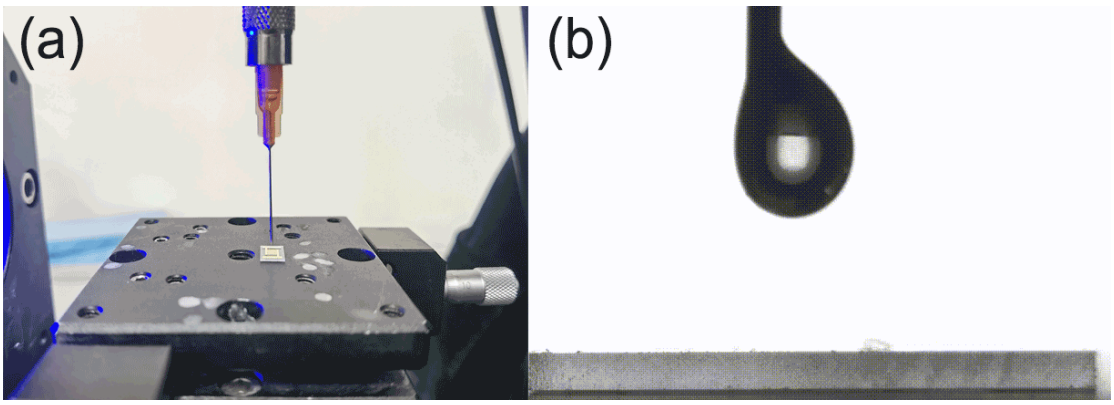

Fig. S2 (a) Photograph of the contact angle measurement setup. (b) Dynamic process of the s-SWCNT solution dripping onto the glass substrate with pre-patterned IDEs (the square test area). If the GIF image cannot be played, the dynamic process can be viewed in the mp4 video attachment.

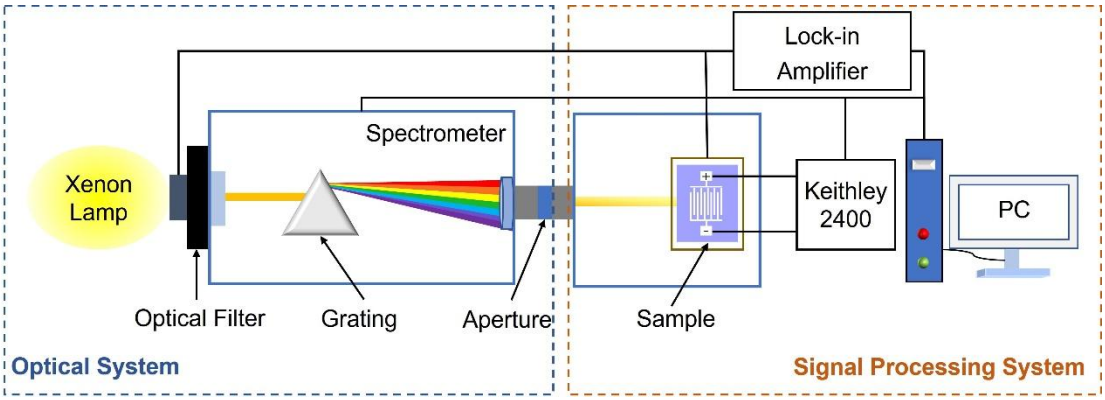

Fig. S3 Schematic diagram of the spectral response measurement system.

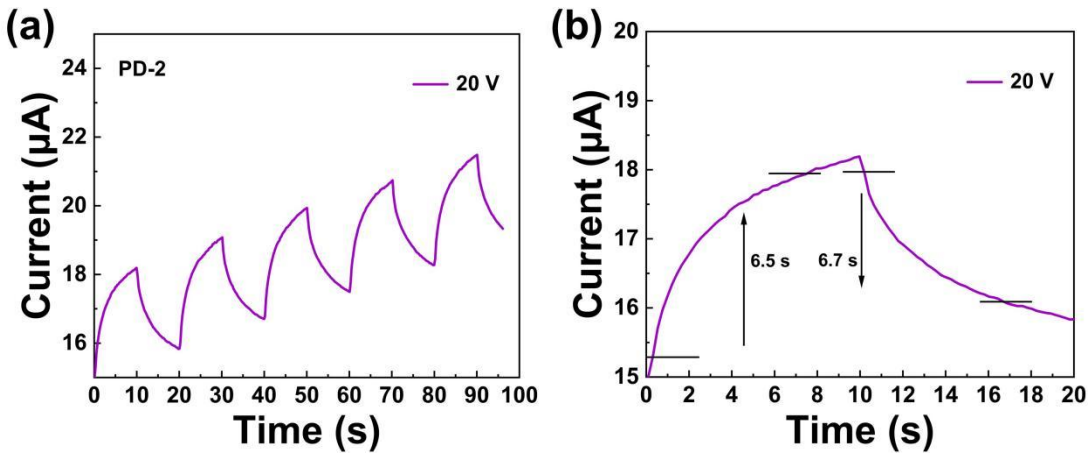

Fig. S4 (a) Current-time (*I-t*) curve of the PD-2 under 260 nm illumination. (b) Rise/decay edges of the photocurrent stimulated by a single light pulse.

Table S1. Comparison of the main parameters with the reported Ga_2O_3 DUV photodetectors based on different heterojunctions.

Heterojunction Materials	Device Structure	Bias (V)	Light Intensity ($\mu W/cm^2$)	λ (nm)	R (A/W)	EQE (%)	Ref.
SWCNT/Ga_2O_3	MSM	5-25	80	260	1.405	670.5	Our work
NSTO/Ga_2O_3	Vertical	0	45	254	2.6×10^{-3}	1.3	4
GaN/Ga_2O_3	MSM	0	480	254	4.4×10^{-2}	21.5	5
NiO/Ga_2O_3	Vertical	0	2500	254	5.6×10^{-6}	0.0027	6
Sprio-MeOTAD/ Ga_2O_3	Vertical	0	80	254	6.5×10^{-2}	31.8	7
SMHTMs/Ga_2O_3	Vertical	0		254	1.41×10^{-3}	0.7	8
$CsCu_2I_3$/Ga_2O_3	Vertical	5	200	254	2×10^{-2}	9.8	9
V_2O_5/Ga_2O_3	Vertical	5	1	254	1.98×10^{-2}	9.7	10
Laser-induced Graphene/Ga_2O_3	MSM	10		254	4.31×10^{-2}	21.1	11
Diamond/Ga_2O_3	Vertical	0		235	2×10^{-4}	0.1	12
$BiFeO_3$/Ga_2O_3	Vertical	2	100	254	1.2×10^{-2}	5.9	13

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