## Electronic Supplementary Information

## Highly Stable and Spectrum-Selective Ultraviolet Photodetectors Based on Lead-Free Copper-Based Perovskites

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Fig. S1 EDS spectra of the  $Cs_3Cu_2I_5$  films.

Fig. S1 presents the EDS spectrum of the as-prepared  $Cs_3Cu_2I_5$  films. No other chemical impurities were detected in the resulting sample except for the well-known compositions, and the corresponding atomic ratio is close to the stoichiometric ratio of  $Cs_3Cu_2I_5$  material.



Fig. S2 (a) XPS results of  $Cs_3Cu_2I_5$  films and the high-resolution spectra of (b) Cs 3d, (c) Cu 2p, and (d) I 3d.



Fig. S3 Transmission spectrum of the  $Cs_3Cu_2I_5$  films.



Fig. S4 Absorption spectra of the  $Cs_3Cu_2I_5$  films, GaN layer, and the  $Cs_3Cu_2I_5$ /GaN hybrid.



Fig. S5 (a) PL decay curves of the  $Cs_3Cu_2I_5$  films as a function of temperature. (b) Temperaturedependent PL lifetime of the  $Cs_3Cu_2I_5$  films.



Fig. S6 Heating/cooling cycling PL measurements of the Cs<sub>3</sub>Cu<sub>2</sub>I<sub>5</sub> films (cycle 3).



Fig. S7 Thermogravimetric analysis data of the  $Cs_3Cu_2I_5$  films.



Fig. S8 Steady-state PL spectra of the  $Cs_3Cu_2I_5$  films recorded under continuous UV light excitation (265 nm, 3.0 mW/cm<sup>2</sup>) for 8 h.



Fig. S9 UPS data of the  $Cs_3Cu_2I_5$  films.

UPS measurements were performed to determine the valence band maximum of  $Cs_3Cu_2I_5$  films, and the value can be obtained by the following formulas

$$E_{VBM} = hv - E_{cutoff} + E_{Fermi} \tag{1}$$

$$E_{CBM} = E_{VBM} + E_g \tag{2}$$

in which hv is the ultraviolet radiation energy (21.22 eV),  $E_{\text{cutoff}}$  is the binding energy of the secondary cutoffs in the spectra, and  $E_{\text{Fermi}}$  is the difference between the VBM and the Fermi level. The calculated value of  $E_{\text{VBM}}$  is 5.65 eV, and the value of  $E_{\text{CBM}}$  is 1.85 eV.



Fig. S10 *I*–*V* characteristics of In and Au electrodes on GaN and Cs<sub>3</sub>Cu<sub>2</sub>I<sub>5</sub>, respectively.



Fig. S11 Two thousand response cycles showing the good reversibility of the  $Cs_3Cu_2I_5/GaN$  heterojunction device.



Fig. S12 Noise current of the photodetector as a function of frequency measured by a lock-in amplifier.



**Fig. S13** (a) Schematic illustration of the photodetector to measure the photoresponse speed. Photoresponse characteristics of the Cs<sub>3</sub>Cu<sub>2</sub>I<sub>5</sub>/GaN heterojunction device to pulsed light irradiation at the frequencies of (b) 1 Hz, (c) 800 Hz, and (d) 5 kHz under a voltage of 0 V. (e) The relative balance  $[(I_{max}-I_{min})/I_{max}]$  versus switching frequency. (f) Rising and falling edges for estimating the rise time ( $t_r$ ) and the fall time ( $t_f$ ) at 5 kHz.



Fig. S14 (a, b) SEM images of the  $Cs_3Cu_2I_5$  films before and after heating at 373 K for 12 h. (c) XRD patterns of the  $Cs_3Cu_2I_5$  films before and after heating at 373 K for 12 h. (d) PL spectra of the  $Cs_3Cu_2I_5$  films before and after heating at 373 K for 12 h.



**Fig. S15** (a) Temporal photoresponse curves of the device after aging for 12 h at 293 and 353 K, and after naturally cooling to 293 K. (b) Temporal photoresponse curves of the device after aging for 12 h at 293 and 393 K, and after naturally cooling to 293 K.

| Samples   | $	au_{\mathrm{ave.}}\left(\mathrm{ns} ight)$ | $\tau_1$ (ns) | $\tau_2$ (ns) | Percent $(\tau_1)$ | Percent $(\tau_2)$ |
|---|--|---------------|---------------|--------------------|--------------------|
| Cs <sub>3</sub> Cu <sub>2</sub> I <sub>5</sub>      | 794.2  | 80.5          | 815.5         | 23.2%              | 76.8%              |
| Cs <sub>3</sub> Cu <sub>2</sub> I <sub>5</sub> /GaN | 502.6  | 38.7          | 517.6         | 30.2%              | 69.8%              |

Table S1 Fitting parameters of the PL decay curves for  $Cs_3Cu_2I_5$  and  $Cs_3Cu_2I_5$ /GaN hybrid

| Material                                       | Conductivity<br>type | Resistivity<br>(Ω·cm) | Carrier concentration<br>(cm <sup>-3</sup> ) |
|--|----------------------|-----------------------|--|
| Cs <sub>3</sub> Cu <sub>2</sub> I <sub>5</sub> | р                    | $5 \times 10^3$       | $4.3 	imes 10^{15}$                          |
| GaN  | n                    | 0.01                  | $5.9 \times 10^{18}$                         |

Table S2 Electrical properties of the  $Cs_3Cu_2I_5$  films and GaN