Supplemental Information

Solution-Processed Copper Oxide Interlayer for Broadband PbS Quantum-Dot Photodiode

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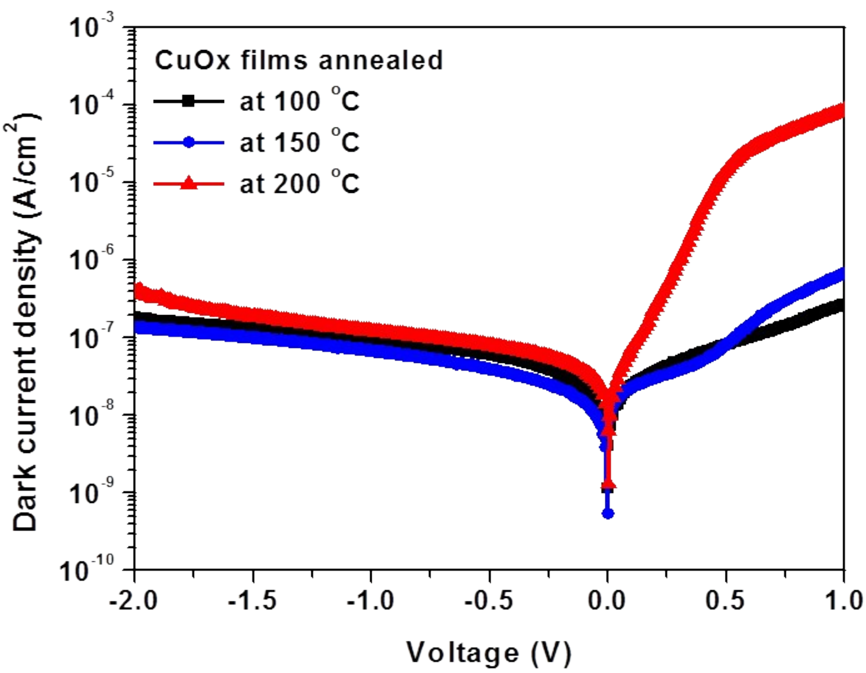

Figure S1. Dark current behaviors of the photodetector with CuOx HTL annealed at different temperatures.

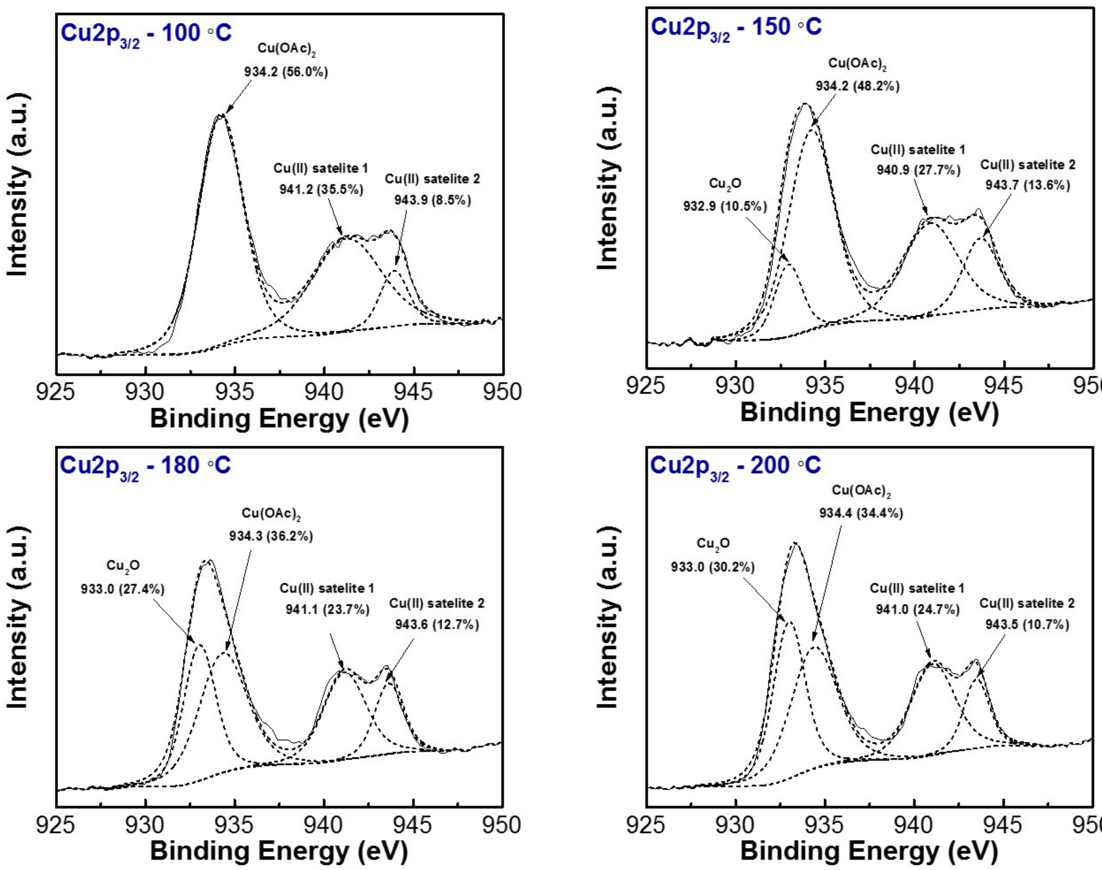

Figure S2. Cu2p$_{3/2}$ x-ray photoemission spectra of CuOx HTL annealed at different temperatures.

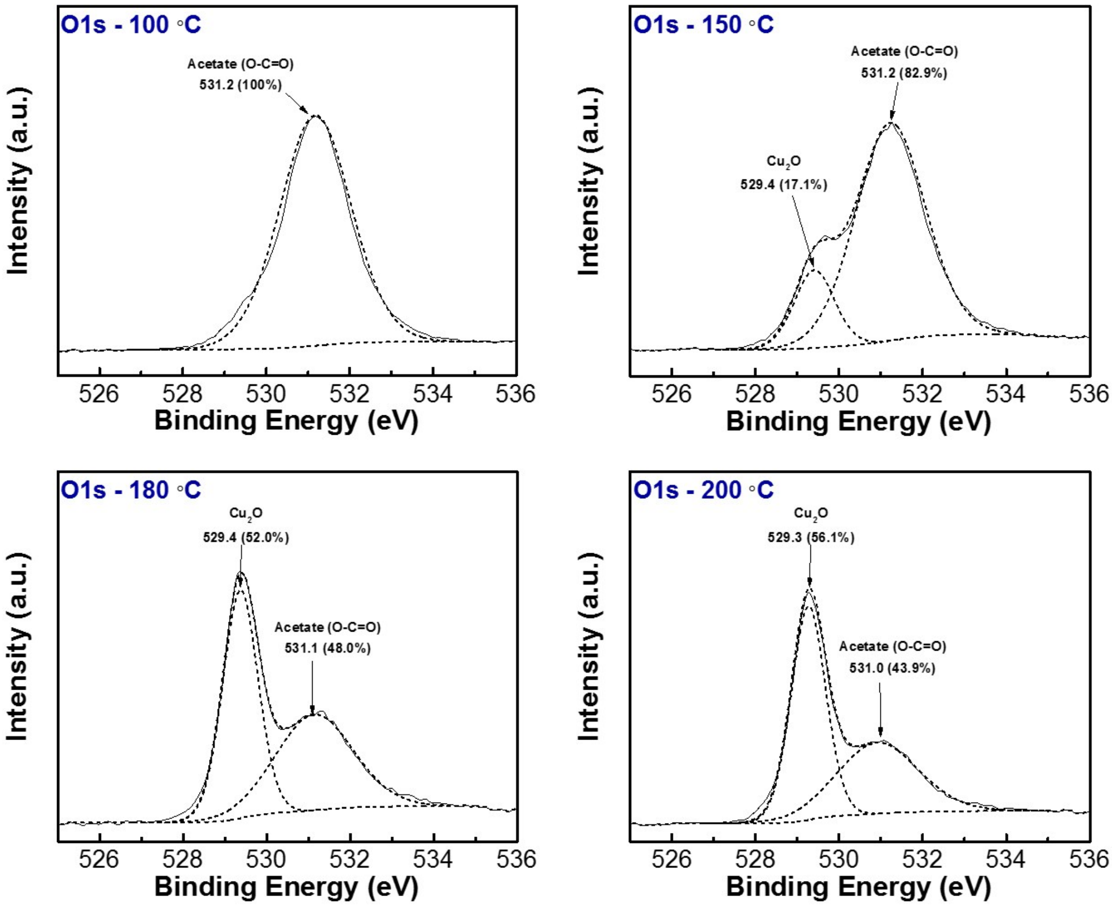

Figure S3. O1s x-ray photoemission spectra of CuOx HTL annealed at different temperatures.

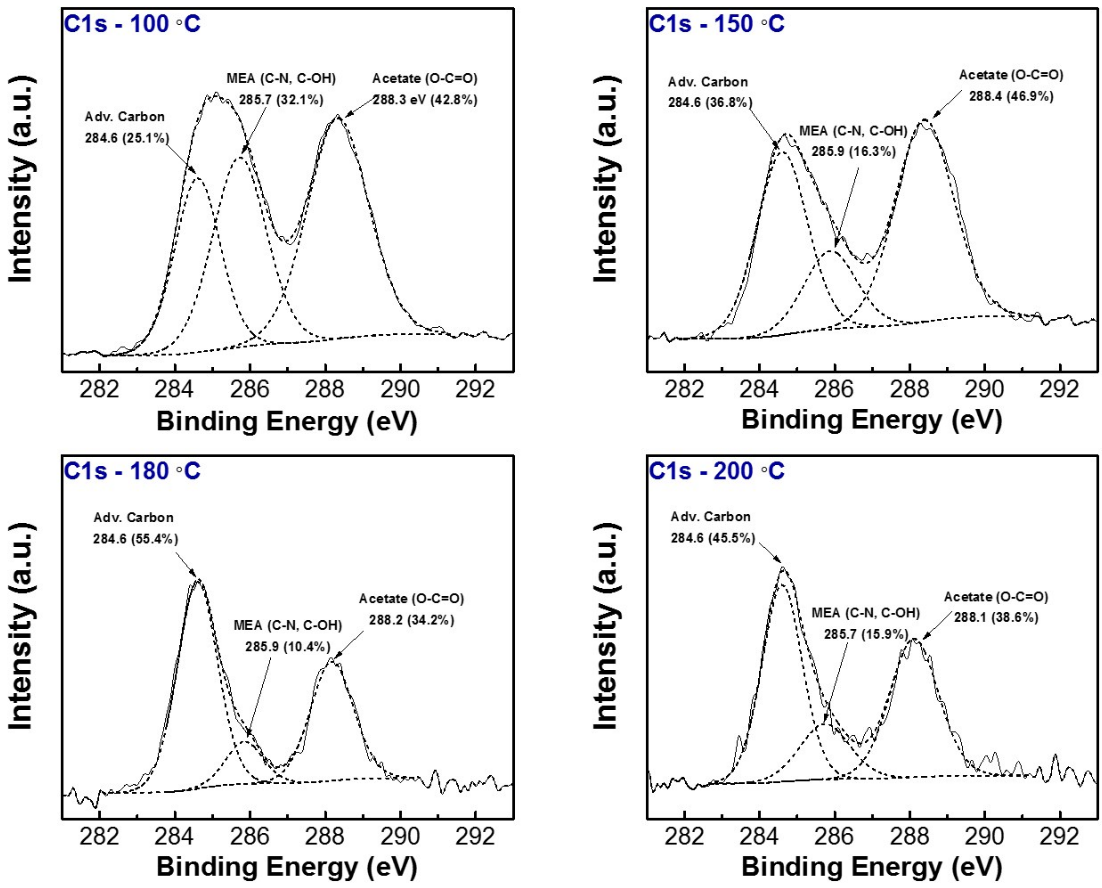

Figure S4. C1s x-ray photoemission spectra of CuOx HTL annealed at different temperatures.

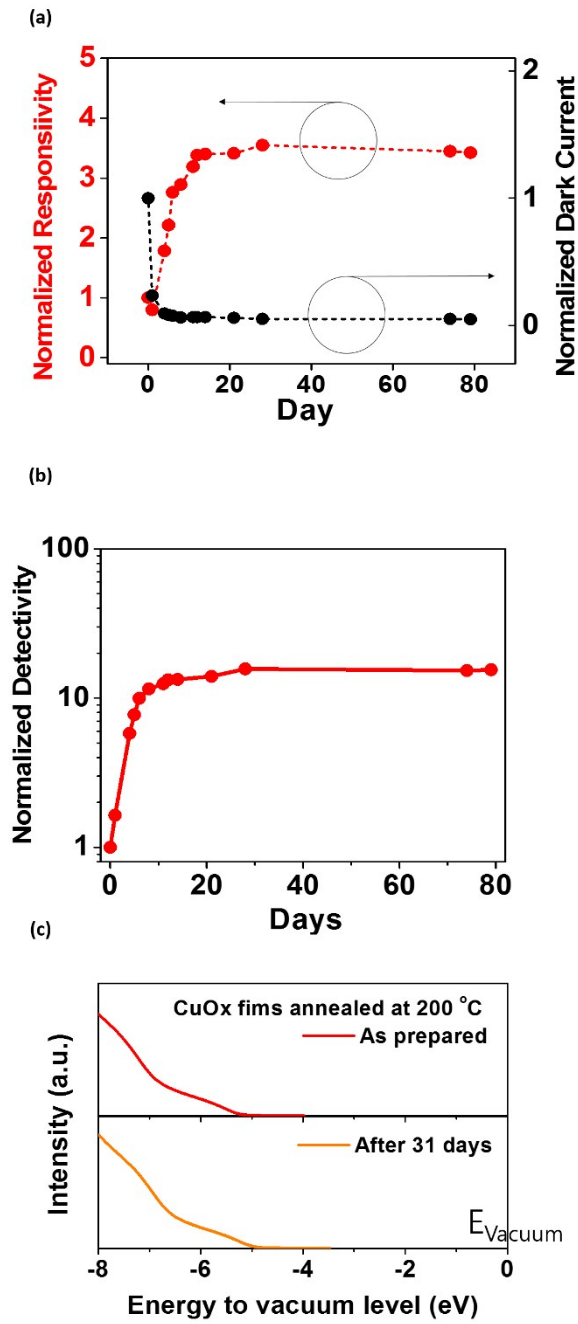

Figure S5. Air stability of the PbS photodetector annealed at 200°C degree. a) Normalized Response and normalized dark current trend up to 80 days, b) Normalized detectivity. c) UPS measurement of CuOx films annealed at 200°C degree before and after 31 days.

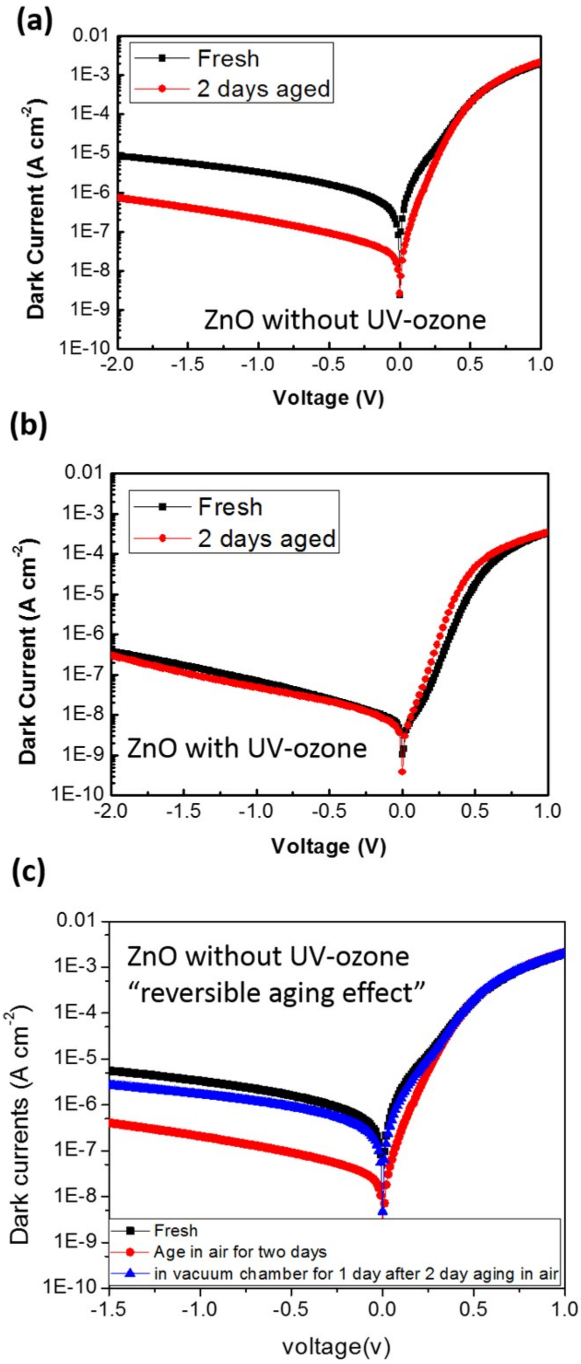

Figure S6. Dark current behavior of the photodiode a) without and b) with UV-ozone treatement on ZnO interlayer. c) Reversible dark current after de-oxidizing the sample in a high vacuum

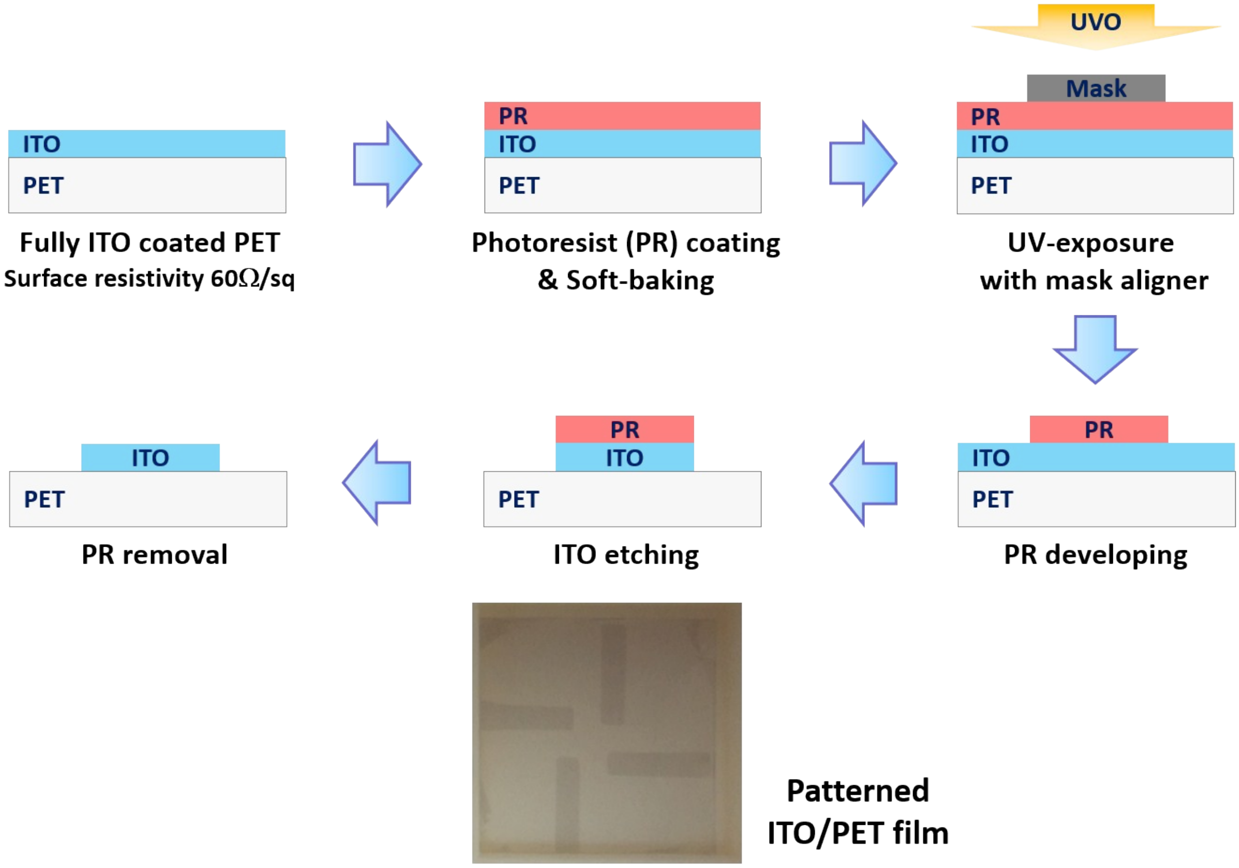

Figure S7. Fabrication of patterend ITO film on PET substrate by photolithography for flexible PbS photodetector.

■ Detectivity Measurement

In our detectivity measurement, only shot noise was considered because 1/f noise can be ignored at the low device operation voltage of -1 V[1]. Shot noise is defined as[2],

$$I_S = \sqrt{2qB(I_p + I_b + I_d)}$$

where B is bandwidth, I_p is photo current, I_b is noise current from background radiation and I_d is dark current.

Thermal noise is defined as,

$$I_t = \sqrt{\frac{4kTB}{R_{shunt}}}$$

where T is the temperature, k is Boltzman constant, and R_{shunt} is shunt resistance in the device.

Since I_p, I_b, and I_t are typically neglected at noise equivalent optical input power (NEP)[1-3], the detector's noise is dominated by the dark current noise (shot noise). Then, NEP is defined as,

$$NEP = \frac{\sqrt{2qI_dB}}{R}$$

where R is responsivity (A/W) of the device. Then, specific detectivity (D*) is defined as,

$$D^* = \frac{\sqrt{AB}}{NEP}$$

where A is the device area. Therefore, detectivity can be calculated from responsivity and dark current density as below,

$$D^* = \sqrt{AB} \times \frac{\mathrm{R}}{\sqrt{2qI_dB}} = \frac{\mathrm{R}}{\sqrt{2qJ_d}}$$

Reference

1. Manders, J. R.; Lai, T. H.; An, Y.; Xu, W.; Lee, J.; Kim, D. Y.; Bosman, G.; So, F. Low-Noise Multispectral Photodetectors Made from All Solution-Processed Inorganic Semiconductors. *Advanced Functional Materials* 2014**,** ***24***, 7205-7210.
2. Sze, S. M.; Ng, K. K. *Physics of semiconductor devices*. John wiley & sons: 2006.
3. Guo, F. Low Noise, High Detectivity Photodetectors based on Organic Materials. 2014.