Supporting Information

Piezo-phototronic effect regulated broadband photoresponse of a-Ga_2O_3/ZnO heterojunction

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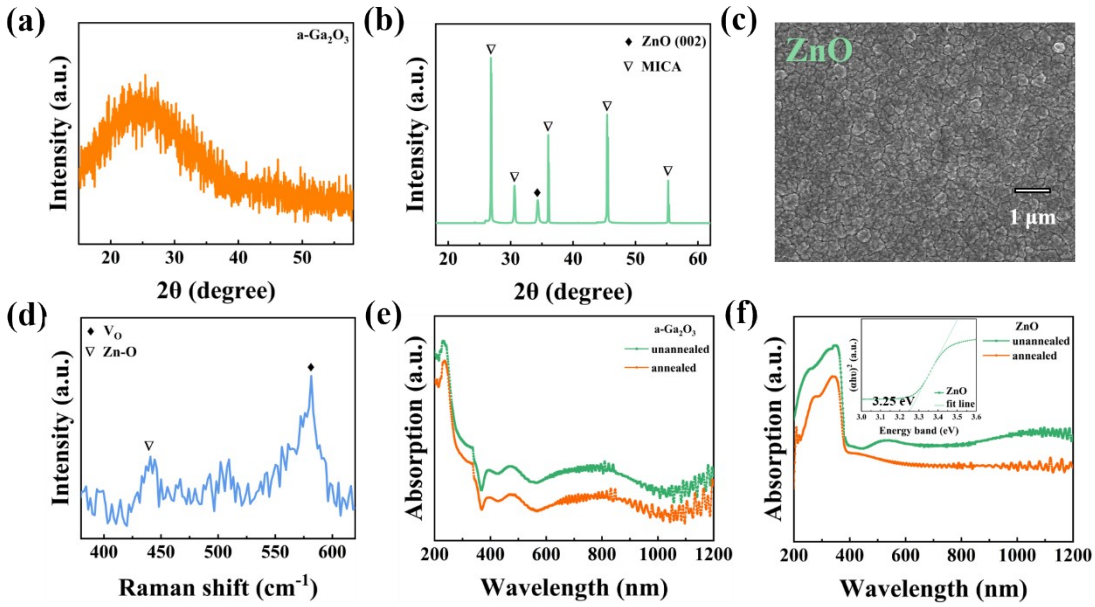

Fig. S1 XRD patterns of (a) a-Ga_2O_3 and (b) ZnO films. (c) The top view SEM image of the ZnO film. (d) Room-temperature Raman spectrum of ZnO film. (e) The absorption spectra of as-grown (unannealed) Ga_2O_3 and annealed sample. (f) The absorption spectra of as-grown (unannealed) ZnO and annealed sample.

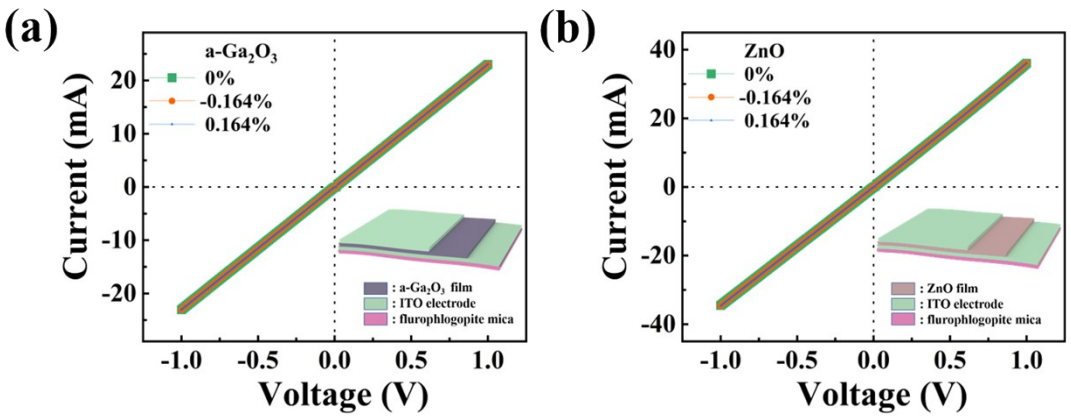

Fig. S2 The dark *J-V* curves of the (a) a-Ga_2O_3 and (b) ZnO films under different strains. The insets are the schematics of the devices.

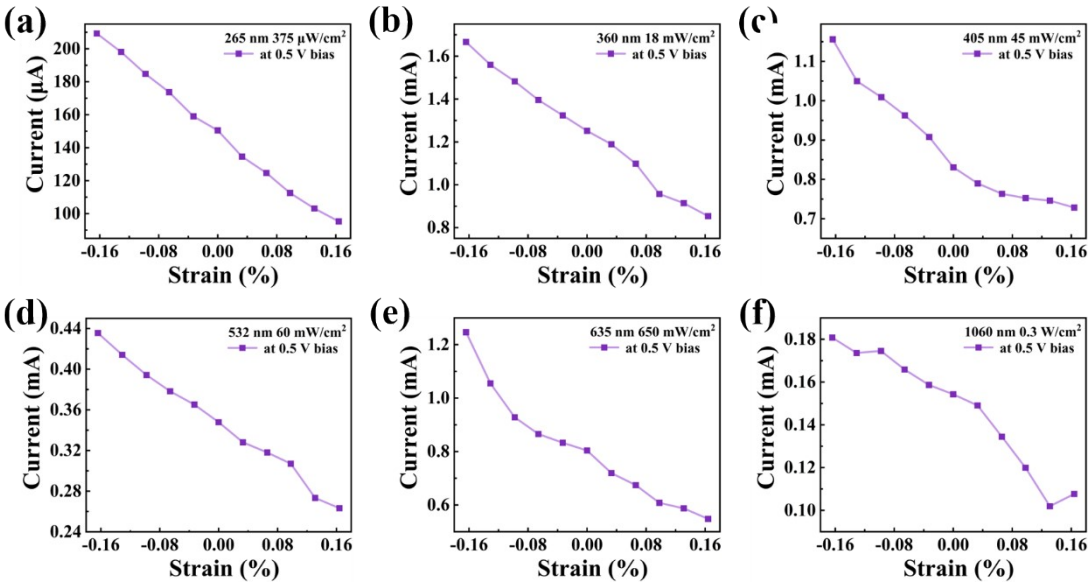

Fig. S3 The output photocurrent as a function of strain state under (a) 265, (b) 360, (c) 405, (d) 532, (e) 635, (f) 1060 nm illumination and 0.5 V bias

Table S1. A comparison of photoresponse properties for various Ga_2O_3 or ZnO-based heterojunction photodetectors.

Materials and structure	Bias [V]	Wavelength [nm]	R [A/W]	*D** [Jones]	Refs
Ga_2O_3/ZnO	0.5	265	7.27	2.83×10^{11}	This work
		360	2.10	8.16×10^{10}	
		405	0.542	2.11×10^{10}	
		532	0.150	5.84×10^{9}	
		635	36.2×10^{-3}	1.41×10^{9}	
		1060	9.49×10^{-3}	3.69×10^{8}	
Ga_2O_3/ZnO	20	254	2.49	2.75×10^{13}	1
		365	0.27	1.97×10^{12}	
Ga_2O_3/ZnO	0	266	7.97×10^{-3}	1.16×10^{11}	2
$(TmGa)_2O_3$/Au	10	240	0.447	2.26×10^{12}	3
ZnO/Ga_2O_3	0	251	9.7×10^{-3}	6.29×10^{12}	4
$CH_3NH_3PbI_3$/ZnO	1	380	4.00	1.74×10^{9}	5
		760	0.75	3.27×10^{8}	

Note S1: Calculation method of the strain values.

When an h_1-thick film on an h_2-thick substrate is bent to a radius r under external strain, the bending strain can be expressed as follow:[6]

$$\delta_{\max} \approx \left(\frac{h_1 + h_2}{r} \right)$$

In our study, the range of bending strain applied to a-Ga_2O_3/ZnO heterojunction is calculated from 0.164% to -0.164%, which respectively represents the maximum tensile strain and compressive strain.

Note S2: The *I-V* curves of ZnO and a-Ga_2O_3 based devices under different strains.

To expound whether piezoresistive effect or piezotronic effect plays a dominant role in the a-Ga_2O_3/ZnO film heterojunction when external strains are applied, two pairs of ITO electrodes are deposited onto the a-Ga_2O_3 and ZnO film, respectively. The schematic structures of ITO/ZnO/ITO and ITO/a-Ga_2O_3/ITO devices are displayed in the inset of Fig. S2a and S2b, respectively. The almost linear dark *I*-V curves of the devices under different strains indicate that the ITO electrodes form Ohmic contacts with both a-Ga_2O_3 and ZnO film, and the piezoresistive effects have little impact on the resistance of the device from -0.164% compressive strain to 0.164% tensile strain. Therefore, the strain regulating *J-V* curves presented in Fig. 1(d) is mainly due to the effective adjustment by the piezoelectric polarization charges generated at the a-Ga_2O_3/ZnO hetero-interface.

References

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