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Supporting Information

Research on the Ga_2O_3/$ZnGa_2O_4$ Mixed-phase Films and Solar-blind Photodetectors Prepared Directly by Annealing of Zn Alloying Ga_2O_3 Films

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Raman spectroscopy of as-grown thin films.

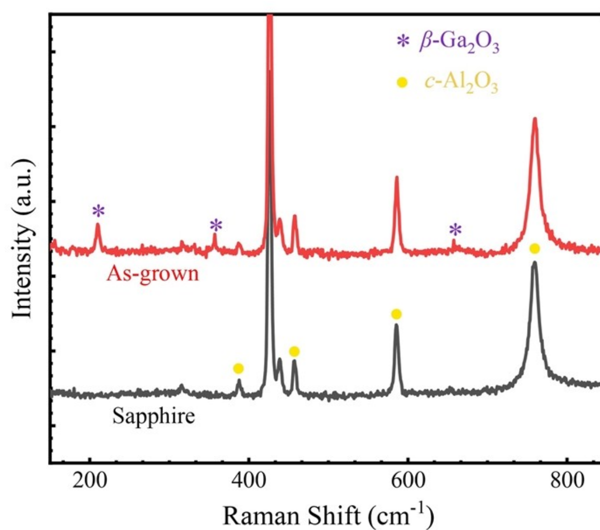


Figure S1 Raman spectrum of the as-grown film, with the Raman characteristic peaks of β-Ga_2O_3 and sapphire substrate marked in the figure.

Physical characterization of the native film (AFM).

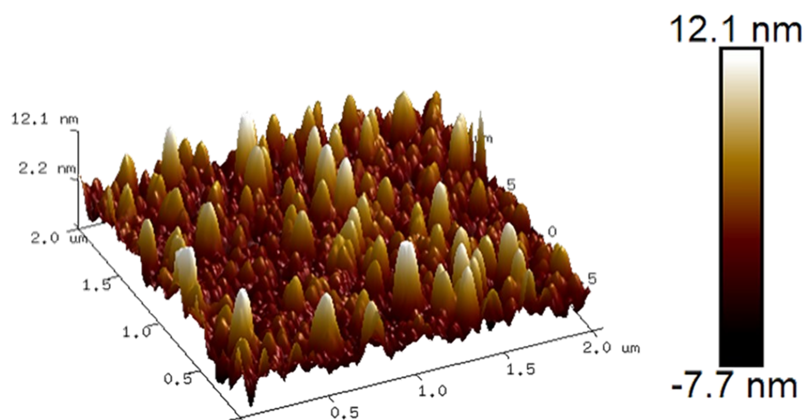


Figure S2 Three-dimensional surface morphology, with RMS roughness used to quantify the surface texture.

Three-dimensional surface morphology of thin films annealed under different conditions.

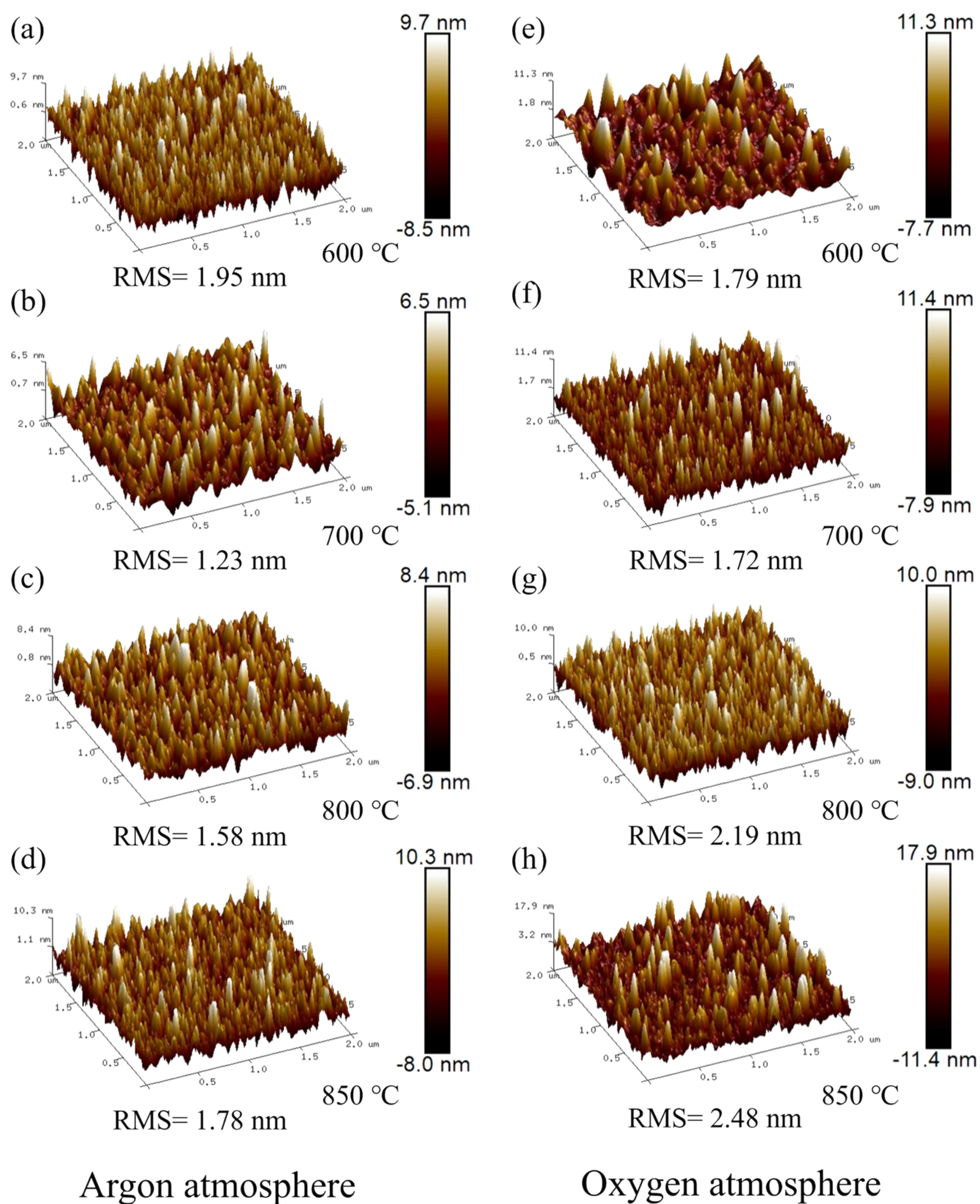


Figure S3 (a-d) The films annealed in an Ar atmosphere. (e-h) The films annealed in an O_2 atmosphere.

Surface SEM image of as-grown films.

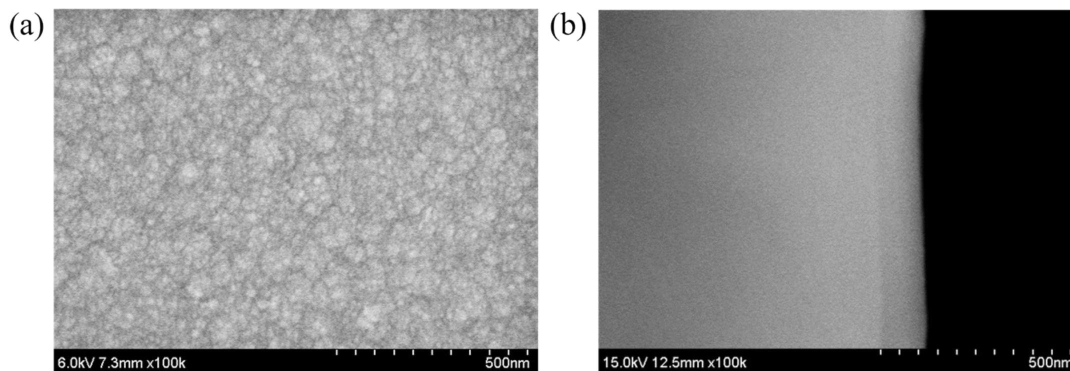
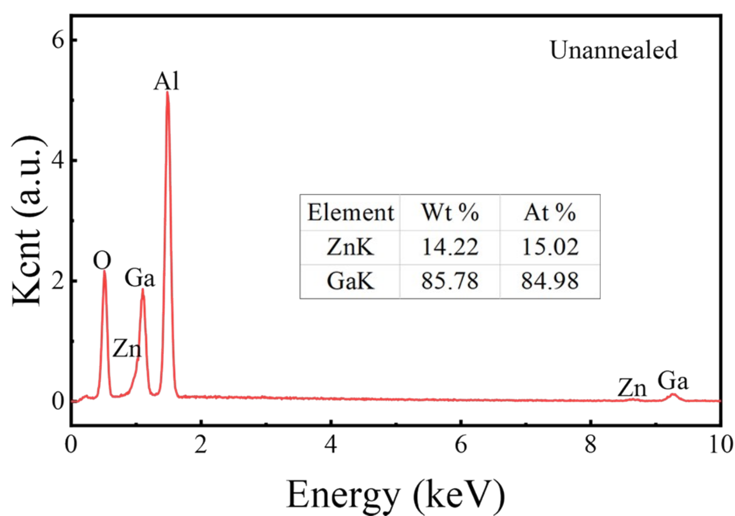


Figure S4 (a) Surface SEM image of as-grown films at a magnification of 100 k, with a 500 nm scale bar at the bottom left, corresponding to 10 divisions. (b) Cross-sectional SEM image, also at 100 k magnification, showing a film thickness of approximately 110 nm.

Physical characterization of the as-grown films (EDS).



Element	Wt %	At %
ZnK	14.22	15.02
GaK	85.78	84.98

Figure S5 EDS analysis and elemental composition. A 15 kV electron beam was used to irradiate the film surface.

Zinc and gallium ratios in the films after annealing under various conditions.

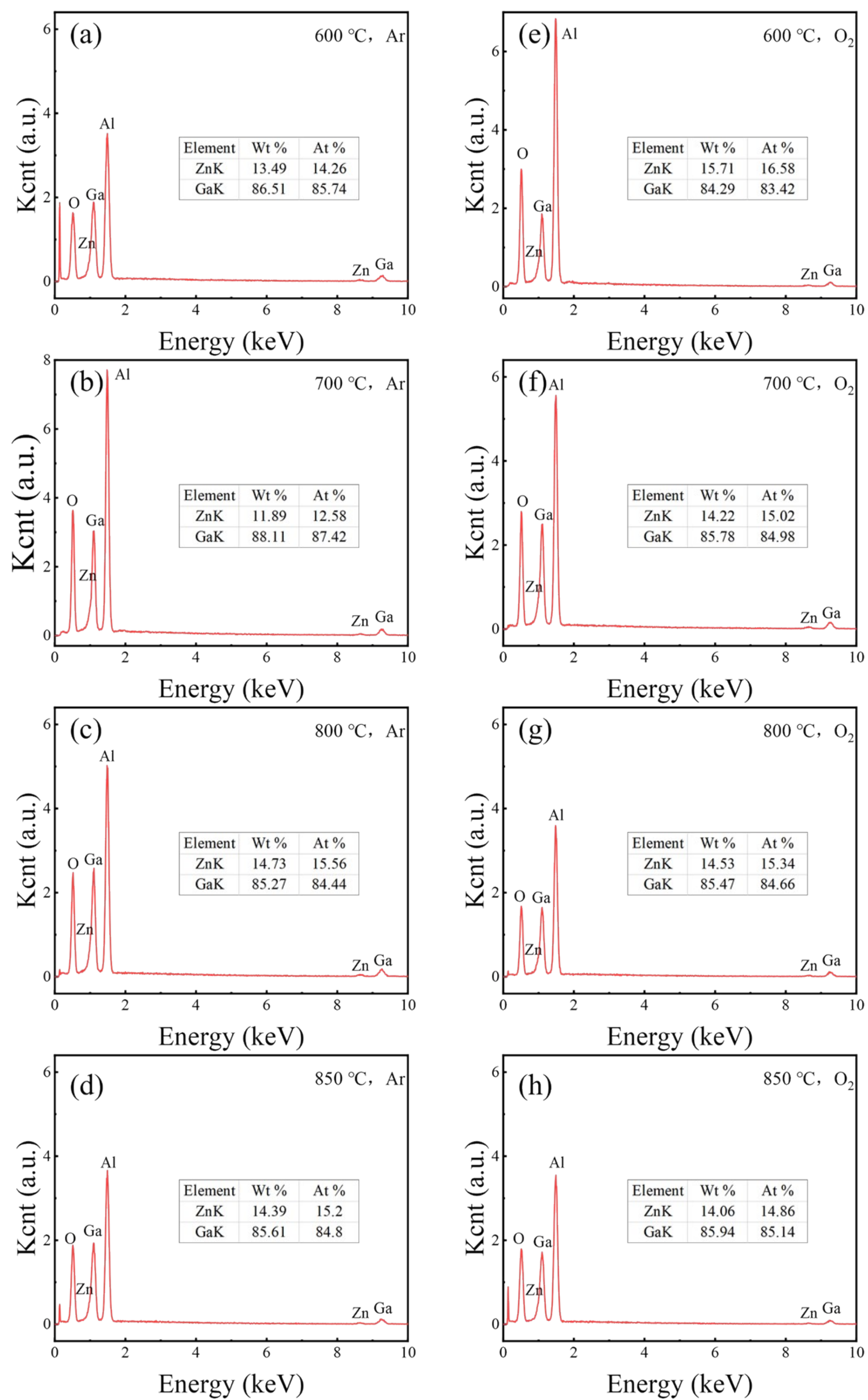


Figure S6 (a-d) Correspond to an Ar atmosphere. (e-h) Correspond to an O_2 atmosphere. The table lists the weight percentages (Wt %) and atomic percentages (At %) of Zn and Ga, respectively.

Fine spectra of Zn 2p and Ga 2p.

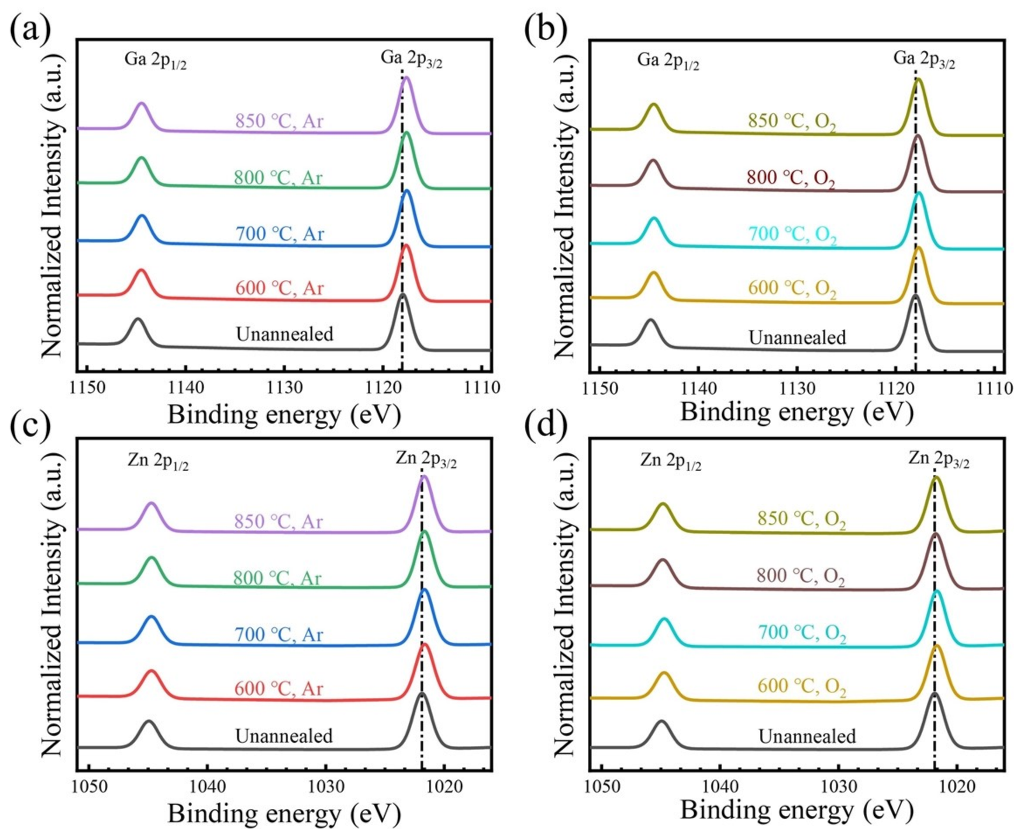


Figure S7 High-resolution XPS core-level spectra of Ga 2p and Zn 2p. (a) Ga 2p spectra of thin films annealed in Ar atmosphere; (b) Ga 2p spectra of thin films annealed in O_2 atmosphere; (c) Zn 2p spectra of thin films annealed in Ar atmosphere; (d) Zn 2p spectra of thin films annealed in O_2 atmosphere.

The low-frequency noise characteristics of device.

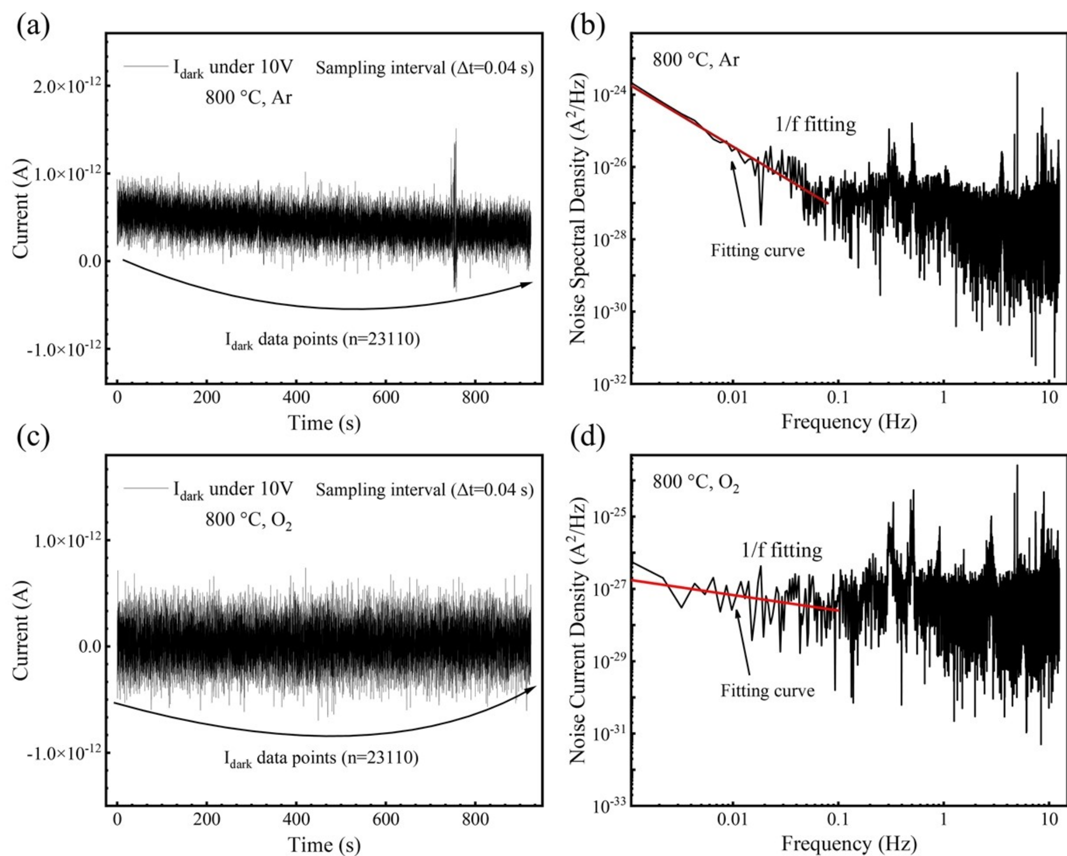


Figure S8 (a) Long-term measurement of I-t in a dark environment for the device (800 °C, Ar); (b) Fitting of the noise spectral density curve for the device (800 °C, Ar); (c) Long-term measurement of I-t in a dark environment for the device (800 °C, O_2); (d) Fitting of the noise spectral density curve for the device (800 °C, O_2).

Table S1 Comparison of the detector performance of films subjected to annealing under different atmospheres and temperatures.

Processing conditions	Dark current (pA)	Responsivity (A/W)	Decay time (ms)	UV-vis rejection ratio
600 °C, Ar	0.542	129.78	1.72	7.47×10^{4}
700 °C, Ar	0.443	619.87	1.10	9.03×10^{4}
800 °C, Ar	0.137	2058.54	2.90	3.39×10^{5}
850 °C, Ar	0.177	1635.09	7.72	2.86×10^{5}
600 °C, O_2	0.20	65.35	0.92	5.06×10^{4}
700 °C, O_2	0.252	425.86	0.52	3.60×10^{5}
800 °C, O_2	0.453	2364.01	2.32	4.75×10^{5}
850 °C, O_2	0.208	841.15	6.84	2.47×10^{5}

Note: A bias voltage of 10 V was applied to each device during the measurements.