Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.
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Supporting Information

Anion-cation synergistic doping strategy on Ga_2O_3 scaffold for improving electron extraction and transport in $CH_3NH_3PbCl_3$-based photodetector

Shuo Liu,[a] Shujie Jiao,*[a] Hongliang Lu,[a] Yue Zhao,[a] Yimin Jin,[a] Song Yang,[a] Dongbo Wang,[a] Shiyong Gao,[a] Jinzhong Wang[a] and Liancheng Zhao[a,b]

[a] *School of materials science and engineering, Harbin Institute of Technology, Harbin, 150001, China*.

[b] *School of Materials Science and Engineering, Shanghai Jiao Tong University, Shanghai, 200000, China*

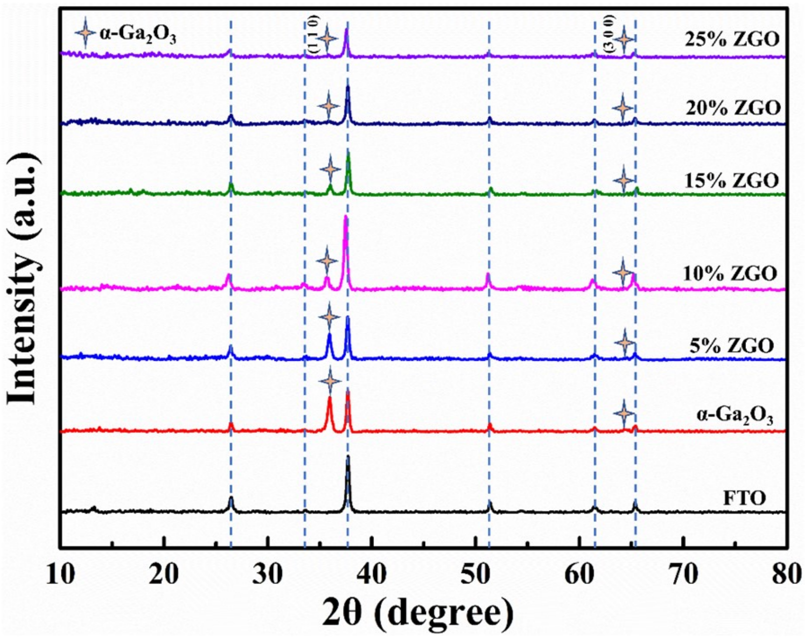

Fig. S1 XRD pattern of 5%-25% $Zn(Ac)_2$-doping α-Ga_2O_3 nanorods, and FTO substrate as well as pristine α-Ga_2O_3 nanorods for comparison.

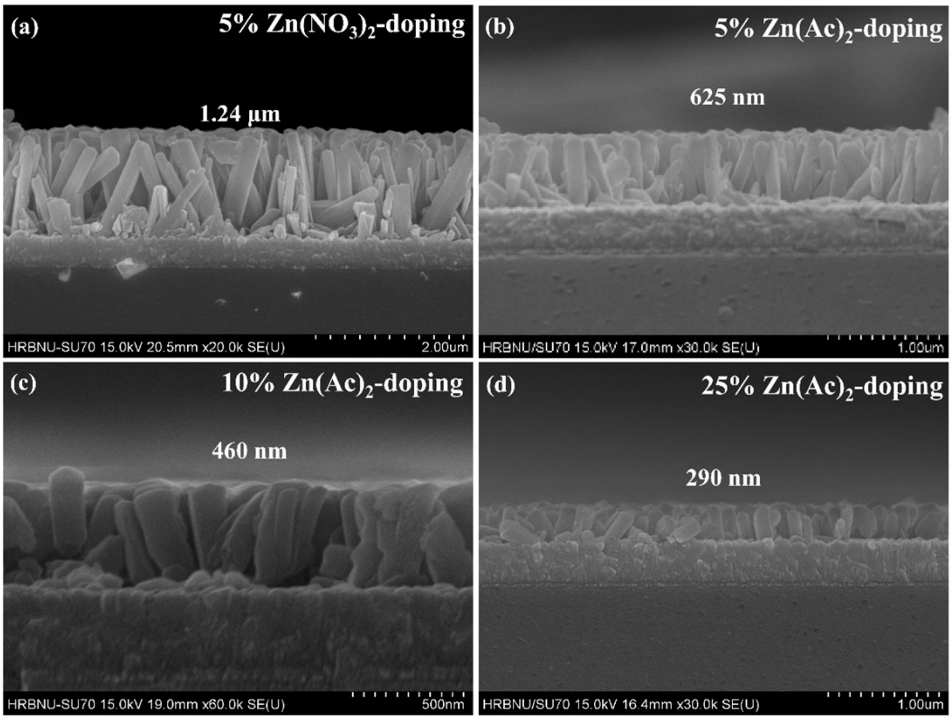

Fig. S2 (a) Cross-sectional SEM image of ZGO nanorods with 5% $Zn(NO_3)_2$-doping. (b)-(d) Cross-sectional SEM images of ZGO nanorods with 5%,10%, 25% $Zn(Ac)_2$-doping, respectively.

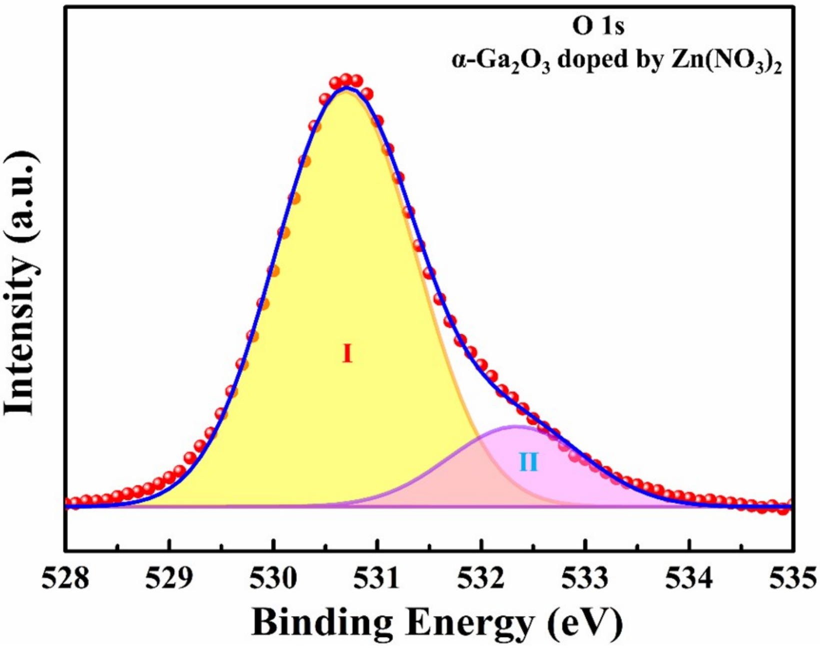

Fig. S3 XPS core-level spectrum of O 1s in the α-Ga_2O_3 nanorods doped by 5% $Zn(NO_3)_2$.

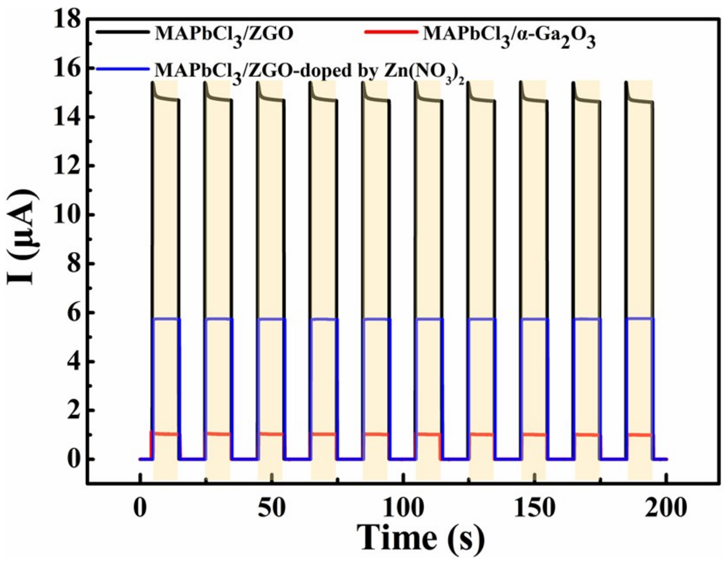

Fig. S4 I-t curves of the polycrystalline $MAPbCl_3/\alpha\text{-}Ga_2O_3$, polycrystalline $MAPbCl_3$/ZGO, and polycrystalline $MAPbCl_3$/ZGO-doped by $Zn(NO_3)_2$ devices.

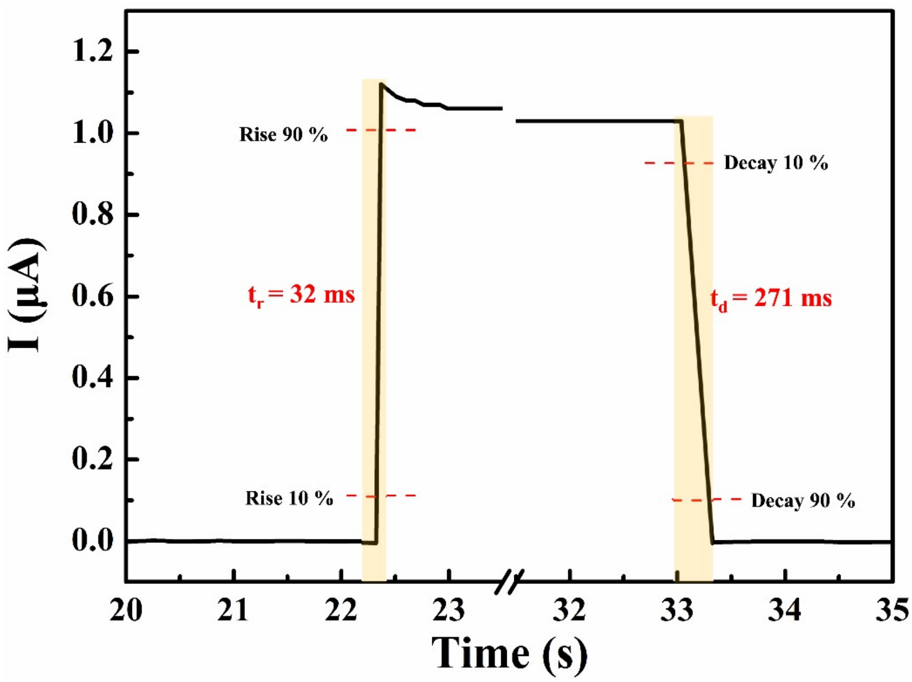

Fig. S5 Response time of the polycrystalline $MAPbCl_3/\alpha\text{-}Ga_2O_3$ device.

In the SCLC curves, the dark current is almost linearly dependent on the applied voltage in the low voltage region, indicating an Ohmic region. Then, the current increases quickly in the intermediate voltage region, reflecting the trap-filling limited (TFL) region. This is relevant to the complete filling of the trap states by the injected charge carriers. At higher bias, the current shows a quadratic dependence ($I \propto V^2$) fitting with the Mott-Gurney law:

$$J_d = \frac{9\varepsilon\varepsilon_0 \mu V^2}{8L^3}$$

where J_d is the current density, V is the applied voltage, L is the thickness of the perovskite, ε is the relative dielectric constant of $MAPbCl_3$ and ε_0 is the vacuum permittivity. The quadratic dependence region is defined as SCLC region, where the carrier mobility is determined. To investigate the electron mobility, the electron-only devices are prepared respectively in the polycrystalline $MAPbCl_3$/α-Ga_2O_3 device and $MAPbCl_3$/ZGO device. According to the above equation, the electron mobilities are determined to be 4.95×10^{-3} cm^2 V^{-1} S^{-1} in the polycrystalline $MAPbCl_3$/α-Ga_2O_3 device. The corresponding value is 6.12×10^{-3} cm^2 V^{-1} S^{-1} in the $MAPbCl_3$/ZGO device， which is slightly increased than the pristine device.

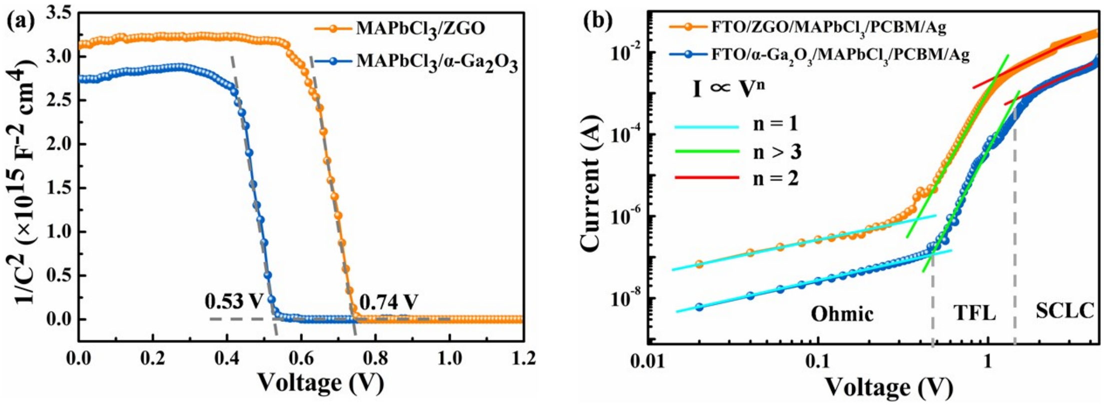

Fig. S6 (a) Mott-Schottky curves and (b) SCLC curves of the polycrystalline $MAPbCl_3$/α-Ga_2O_3 device and polycrystalline $MAPbCl_3$/ZGO device.

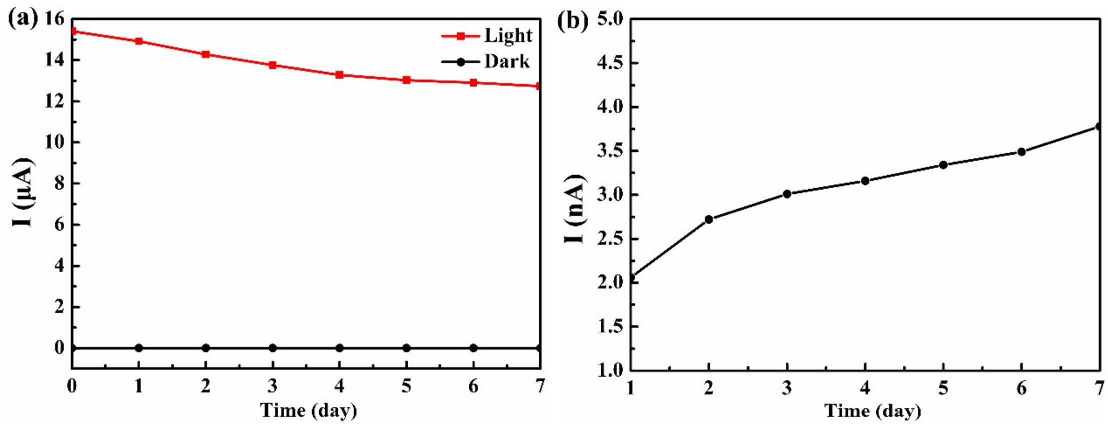

Fig. S7 (a) Stability test with the polycrystalline $MAPbCl_3$/ZGO photodetector stored in air at a temperature of 25℃ and a humidity of 20-30%. (b) The changes of dark current in an enlarged image.

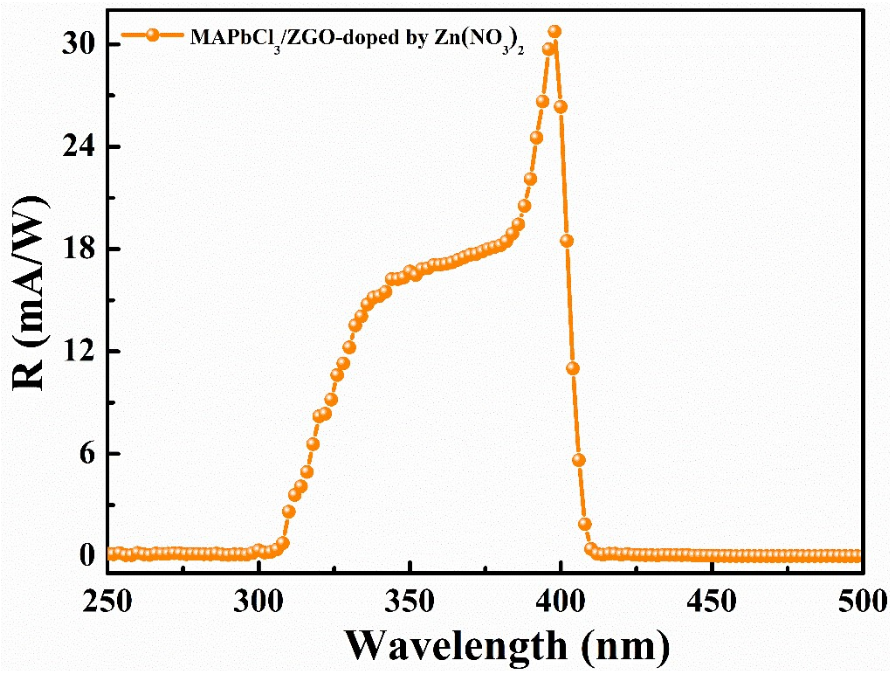

Fig. S8 Responsivity of the polycrystalline $MAPbCl_3$/ZGO (doped by $Zn(NO_3)_2$) device under zero bias.

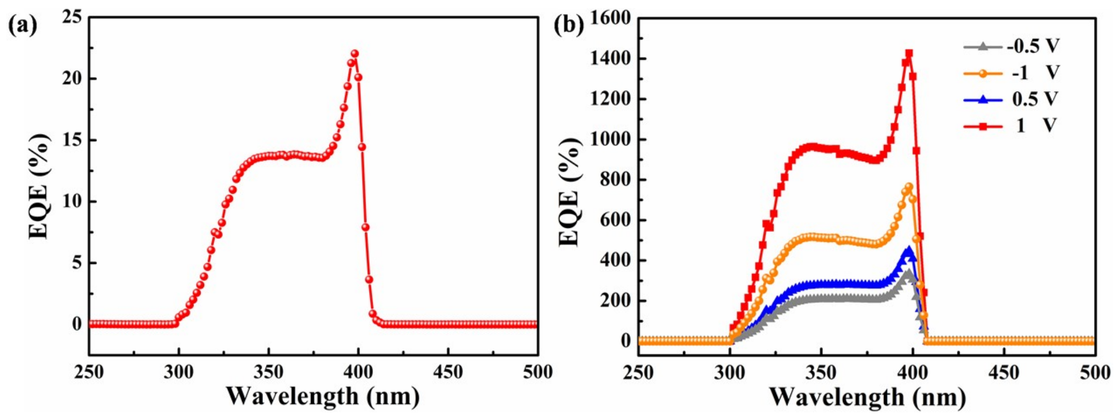

Fig. S9 EQE of the polycrystalline $MAPbCl_3$/ZGO device under (a)zero bias, and (b) -1 V, -0.5 V, 0.5 V, 1V.