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Novel design for fast, sensitive high-energy photon detector

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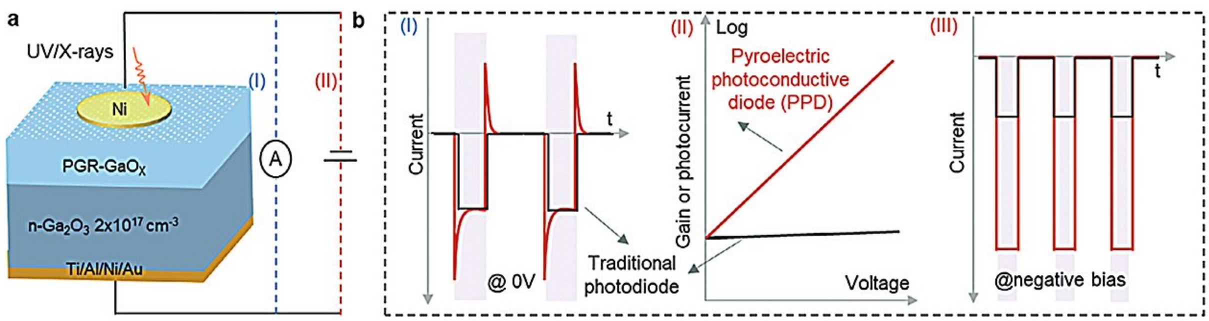

Schematic of the PPD based on PGR-GaOX film and its photoresponse compared to traditional photodiode. Credit: Prof. Long Shibing's team

Prof. Long Shibing and his team from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) have proposed a novel strategy for a high-energy photon detector with high sensitivity and response speed by coupling the interface pyroelectric effect with the photoconductive effect based on polycrystal Ga-rich GaO_x (PGR-GaO_x) Schottky photodiode.

Their work is published in *Advanced Materials*.

High-energy photon detectors (from deep ultraviolet (DUV) to X-rays) are crucial for various fields, including national security, medicine, industrial science and so on. However, current semiconductor materials such as Si and α-Se suffer from large leakage currents and low X-ray absorption coefficients, making it difficult to meet the demands of high-performance detection.

In contrast, wide bandgap (WBG) semiconductor GaO has shown great potential in high-energy photon detection. But the unavoidable deep energy level traps and the lack of effective device structure design of GaO have made it challenging to achieve high-energy photon detectors with high sensitivity and high response speed based on WBG semiconductor.

To address these challenges, Prof. Long Shibing's team designed a pyroelectric photoconductive diode (PPD) based on PGR-GaO_x for the first time. By coupling the interface pyroelectric effect with the photoconductive effect, the detection performance was significantly enhanced.

The PPD exhibits high sensitivity to both DUV and X-ray, with responsivities up to 10^4 A W^{-1} and 10^5 μC Gy_{air}^{-1} cm^{-2}, respectively, which are over 100 times higher than previous detectors made from similar materials. In addition, the interface pyroelectric effect induced by polar symmetry in the depletion region of PGR-GaO_x can greatly improve the response speed of the detector by 10^5 times, reaching up to 0.1 ms.

Compared to traditional photodiodes, the PPD in self-powered mode generates higher gain at the moment of light switching due to the pyroelectric field. Moreover, the PPD can operate in bias mode, where the gain is highly dependent on the bias voltage. Ultra-high gain can be achieved by increasing the bias voltage.

PPD has great potential for applications in imaging enhancement systems with low energy consumption and high sensitivity. This work not only demonstrates that GaO_x is a highly promising high-energy photon detector material, but also provides new strategies for realizing high-performance high-energy photon detectors.

More information: Xiaohu Hou et al, Pyroelectric Photoconductive Diode for Highly Sensitive and Fast DUV Detection, *Advanced Materials* (2024). DOI: 10.1002/adma.202314249

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