Asymmetric Contact Enabled Self-Powered Flexible Photodetector on Formamidinium-Based Perovskite with 2D MXene Electrode

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Self-powered photodetectors (PDs) are essential for next-generation optoelectronic applications, including wearable electronics, optical communication, wireless sensing, and biomedical imaging. Hybrid lead halide perovskites have emerged as promising candidates for high-performance PDs due to their excellent optoelectronic properties and low-temperature solution processability. Meanwhile, two-dimensional $Ti_3C_2T_x$ MXene has attracted significant interest as an additive, charge-transport layer, and electrode material owing to its high conductivity and tunable work function. Here, we report a highly sensitive visible-light PD based on a formamidinium-cesium perovskite (PE) thin film integrated with asymmetric MXene (MX) and silver (Ag) electrodes possessing distinct work functions. This asymmetric electrode configuration induces a strong built-in electric field, effectively promoting charge carrier separation and unidirectional charge transport under illumination. The device achieves a high photoresponsivity of 2.58 A W^{-1} and a detectivity of 1.01×10^{13} Jones under biased operation. Notably, under self-powered conditions, it delivers a responsivity of 160 mA W^{-1}, a detectivity of 2.63×10^{12} Jones, and an external quantum efficiency of 49%. Furthermore, a flexible PD is demonstrated, exhibiting excellent photoresponse stability and mechanical robustness under repeated bending cycles. Density functional theory calculations reveal efficient charge transport across the local Schottky junction, while ultraviolet photoelectron spectroscopy explains the interfacial band alignment and charge transfer dynamics at the MX-PE and PE-Ag interfaces. Combining high sensitivity, self-powered operation, mechanical flexibility, and a simple device architecture, this work highlights a promising strategy for next-generation low-power photodetection systems.

References

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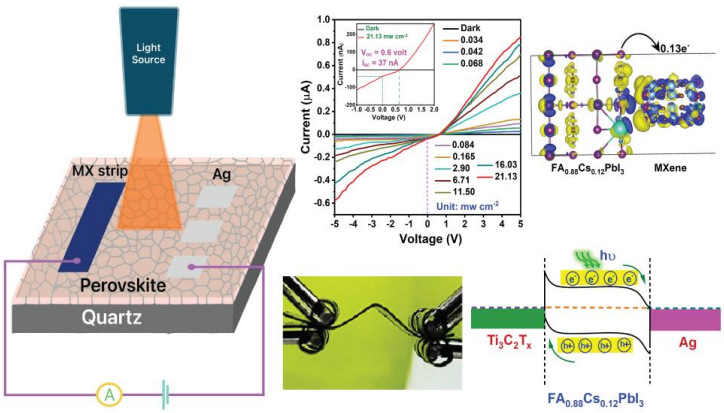
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