Coexisting Photoelectric Storage and Conversion in two-dimensional Materials

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Abstract: Based on two-dimensional (2D) materials, Van derWaals (vdW) heterojunctions, have great potential to develop high-efficiency and ecofriendly nanodevices, which exhibits valuable applications as photodetectors, photovoltaic cells, etc. However, the coexistence of photoelectric storage and conversion in a single device has not been reported until now. Here, we show a simple strategy to construct a vdW *p-n* junction between a WSe2 layer and quasi-2D electron gas. After an optical illumination, the device stores the light-generated carriers for up to seven days, and then releases a very large photocurrent of 2.9 mA with bias voltage applied in darkness; this is referred to as chargeable photoconductivity (CPC), which completely differs from any previously observed photoelectric phenomenon. In normal photoconductivity, the recombination of electron-hole pairs occurs at the end of their lifetime; by contrast, infinite-lifetime photocarriers can be produced and stored in CPC devices without recombination. The photoelectric conversion and storage are completely self-excited during the charging process. The ratio between currents in full- and empty-photocarrier states below the critical temperature reaches as high as 109, with an external quantum efficiency of 93.8% during optical charging. A theoretical model developed to explain the mechanism of this effect is in good agreement with the experimental data. This work paves a path toward the high-efficiency devices for photoelectric storage and conversion.

References

[1] Jiang et al., PHYSICAL REVIEW LETTERS 127 (2021), 217401.

Figures

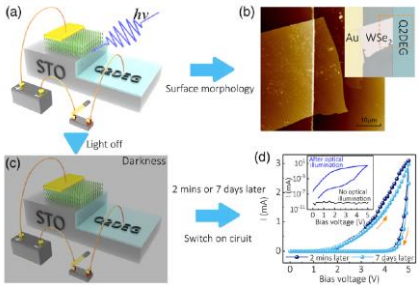

Figure 1: (a) Schematic of WSe2-Q2DEG heterostructure under 405-nm, 16 mW=cm2 optical illumination. te is 6 s, and the circuit is cut off. (b) AFM image showing the surface morphology. Inset: photograph of the device. (c) Device placed in darkness for 2 min or 7 days at 30 K. (d) I-V loops measured in darkness 2 min later and 7 days later, respectively. Inset: I-V curves without and after optical illumination.