Highlights

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Amorphous ZnO/PbS quantum dots heterojunction for efficient responsivity broadband photodetectors

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The integration of lead sulfide quantum dots (QDs) with a high-conductivity material that is compatible with a scalable fabrication is an important route for the applications of QD-based photodetectors. We developed a broadband photodetector by combining amorphous ZnO and PbS QDs, forming a heterojunction structure. The photodetector showed detectivity up to 7.9 × 1012 and 4.1 × 1011 jones under 640 and 1310 nm illumination, respectively. The role of the oxygen background pressure in the electronic structure of ZnO films grown by pulsed laser deposition was found to play an important role in the conductivity associated with the variation of the oxygen vacancy concentration. By increasing the oxygen vacancy concentration, the electron mobility of amorphous ZnO layers dramatically increased and the work function decreased. Combining the energy band alignment with the device performance, we can conclude that the improved the photocurrent of ZnO/PbS heterojunction photodetector with ZnO grown at the lowest oxygen pressure is not only related to its higher carrier mobility but also benefits by the proper energy band alignment. This is a consequence of the upward shifting of the Fermi level due to the donor defects induced by a higher concentration of oxygen vacancies.

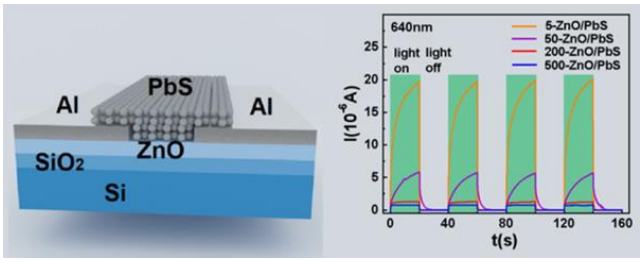

Fig. 1: Schematic structure of the photodetector based on the amorphous ZnO/PbS QD heterojunction (left). Current-time (I-t) curves under 640 nm illumination and at +20 V bias of 5, 50, 200, and 500-ZnO/PbS photodetectors, with ZnO grown at different oxygen pressure, namely 5, 50, 200, and 500 mTorr, respectively.

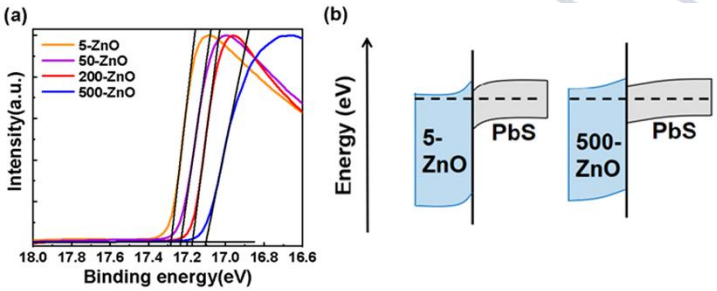

Fig. 2: (a) UPS spectra of 5, 50, 200, and 500-ZnO for high binding energy cut-off. (b) Energy band alignment sketch of the 5-ZnO/PbS (left) and 500-ZnO/PbS QD heterojunctions.