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# Improved open-circuit voltage in ZnO/PbS quantum dot heterojunction solar cells through the surface passivation of ZnO nanowires

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## Introduction

Solid state quantum dot solar cells (QDSCs), such as bulk heterojunction PbS/ZnO QDSCs, are attracting much attention owing to their broadband light-harvesting and the potential of high efficiency and low cost. Recent progress has pushed the efficiency of PbS/ZnO QDSCs above 8% through the QD surface passivation.[1] However, the open-circuit voltages ($V_{oc}$) are still lower than theoretical expectations calculated from the corresponding energy levels.[2] One reason could be due to the defects located near the conduction band of ZnO. Here, we proposed a method that an ultra-thin $TiO_2$ layer grown on ZnO surfaces could eliminate the effect of ZnO defects and improve the cell performances.

## Experimental Method

ZnO-PbS bulk heterojunction solar cells (as illustrated in Fig. 1) were fabricated by solution-processed methods.[3] Firstly, ZnO nanowires (ZnO-NWs) were grown by a wet-chemical method on fluorine-doped tin oxide glasses coated with a ZnO compact layer. Then, thin $TiO_2$ layers were coated on ZnO-NWs by a chemical bath deposition (CBD) method. Finally, ZnO-NWs were filled and coated with PbS QDs, followed by the deposition of a gold contact layer.

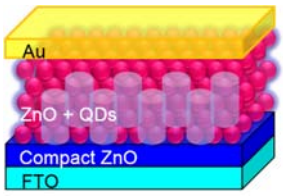


**Fig. 1** Schematic illustration of the structure of ZnO-PbS bulk heterojunction solar cells.

## Results and Discussion

Fig. 2 shows the fluorescence spectra of ZnO-NWs with and without $TiO_2$ coating. The emission intensity at around 600 nm significantly dropped after $TiO_2$ treatment, which was attributed to the decrease of surface defects in ZnO. As shown in Fig. 3, the $V_{oc}$ and efficiency of ZnO/PbS cells were significantly improved by the $TiO_2$ treatment. When higher concentration of $TiO_2$ precursors was applied, the $V_{oc}$ slightly decreased, which could be due to the intrinsic defects within $TiO_2$ layer. Our results indicate the surface passivation can suppress recombination through removing ZnO defects and thus significantly improve the $V_{oc}$ and power convention efficiency.

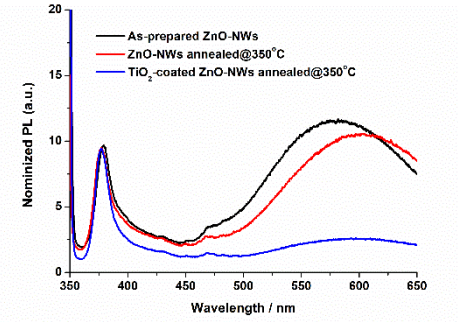


**Fig. 2** Fluorescence spectra of as-prepared ZnO-NWs, and annealed ZnO-NWs with and without $TiO_2$ passivation.

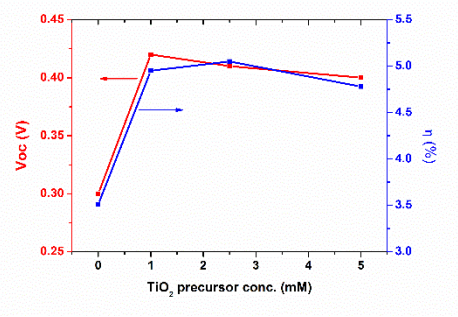


**Fig. 3** The effect of $TiO_2$ passivation on the $V_{oc}$ and efficiency of ZnO/PbS solar cells.

## References

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