Effect of Mg-doped ZnO nanoparticles on H_2O-oxidized ZnO nanorods-based perovskite solar cells

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Recently, perovskite solar cells (PSCs) have shown exceptional development and emerged as the top alternative for the Si-based photovoltaic technology [1]. Most efficient PSCs are based on compact or mesoporous TiO_2 as electron transporting layer (ETL). However, high temperature sintering is usually required to synthesize TiO_2 which hinders the application of PSCs in flexible substrates. Among metal oxides, ZnO is considered to be a possible alternative for TiO_2 due to its comparable energy levels, higher electron mobility and low temperature processability. In our previous work, we demonstrated that ZnO nanorods (NRs) formed by low temperature H_2O oxidation can be employed as ETL for PSCs [2]. Herein, we present the interfacial modification of H_2O-oxidized ZnO NRs by Mg-doped ZnO (MZO) nanoparticles (NPs). This process will shift the conduction band minimum (CBM) of ZnO towards the LUMO of perovskite to facilitate easier electron injection from the active layer to ETL as shown in Fig. 1.

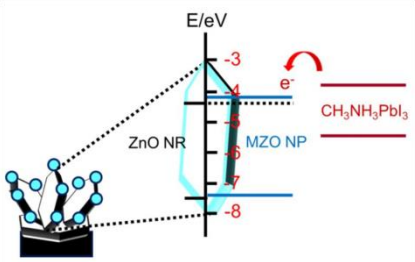

Fig. 1. Energy level diagram of PSCs based on ZnO NRs-MZO NPs.

Firstly, Zn thin films were thermally evaporated on top of a ZnO compact layer. Fig. 2(a) shows ZnO NRs grown by H_2O oxidation of Zn thin films at 90°C for 8h. MZO precursor solutions were prepared from the addition of Mg $(CH_3COO)_2 \cdot 4H_2O$ and 0.25 M $Zn(CH_3COO)_2$ in methanol:H_2O with Mg/(Mg+Zn) (molar ratio) of 5%, 10% and 20%. These solutions were then spin-coated on top of ZnO NRs and heated to 150°C for 1h. Fig. 1(b) shows that the surface of ZnO NRs became visibly rough due to the addition of 5% MZO NPs. All the samples have the same morphology with minimal variation in transparency. Finally, the ITO/ZnO NR-MZO NP samples will be utilized as ETL for PSCs with a configuration of ITO/ZnO-MZO/PCBM/$CH_3NH_3PbI_3$/*spiro*-OMeTAD/Ag.

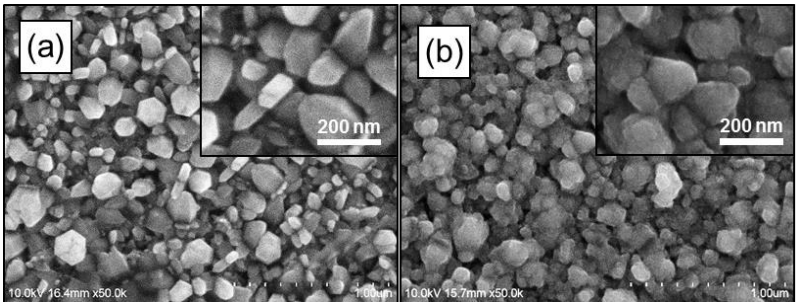

Fig. 2. SEM images of (a) ZnO NRs formed after H_2O oxidation at 90℃ for 8h and (b) ZnO NRs modified by 5% MZO NPs.

References:

[1] NREL Best Research-Cell Photovoltaic Efficiency Chart

[2] C. M. O. Pelicano, H. Yanagi, J. Mater. Chem. C, 2017, DOI: 10.1039/C7TC01934C.