# Accelerated Growth of Novel Nanostructured Zinc Oxide Films via Microwave-Assisted $H_2O$ Oxidation for Solar Cell Applications

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Perovskite solar cells (PSCs) have advanced rapidly due to their superb photovoltaic (PV) properties along with the excellent charge-transporting materials used for charge separation. Thus, the strategic design of novel materials for charge transport is crucial for PV performance. Previously, we developed ZnO films via a novel low-temperature $H_2O$ oxidation as electron-transporting layer (ETL) for PSCs [1]. However, $H_2O$ oxidation using a conventional hot-plate heating is time consuming. In this study, we integrated microwave technology with $H_2O$ oxidation (M-WO) to accelerate the growth of ZnO. Microwave-assisted synthesis can not only shorten the processing time but also increase product yields and enhance product purity. Herein, glass/ITO/Zn thin film samples were immersed in a beaker filled with pure $H_2O$ and placed inside the microwave oven. The effect of irradiation time was examined by applying a microwave power at 500 W for 0.5-2 h. Fig. 1(a) shows the resulting nanostructures (NSs) after M-WO process. Flat-topped ZnO nanorods (NRs) developed immediately after 30 min. Then after 1 h, the flat-topped NRs evolved to pointed NRs. Increasing the irradiation time to 1.5 h initiated the formation of some nanotubes (NTs), possibly due to the natural selective etching along the (001) plane of ZnO crystal. Finally, all the existing NRs were converted to NTs creating honeycomb-like structures after 2 h. The HRTEM and NBD pattern of a single flat-topped ZnO NR is shown in Fig. 1(b). It can be seen that the NR is highly crystalline with a lattice spacing of about 0.28 nm, corresponding to the (100) spacing of ZnO crystal lattice. In order to evaluate the overall applicability of the ZnO films in practical devices, we examined their ETL capability with perovskite films via steady-state PL analysis (Fig. 1(c)). The perovskite emission is clearly quenched when in contact with the ZnO films, signifying electron transfer. These preliminary results revealed the great potential of our ZnO films as ETL not only to perovskite solar cells but also to other photovoltaic and optoelectronic devices.

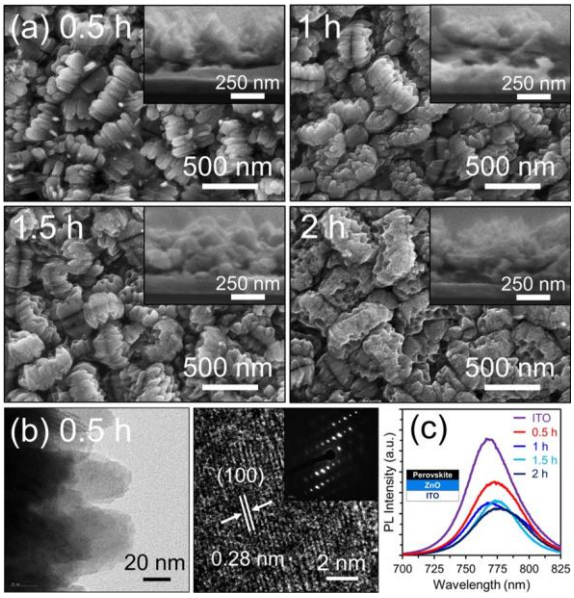


Fig. 1 (a) SEM images of ZnO NSs formed via M-WO under different oxidation times. (b) HRTEM and NBD pattern of 0.5 h-ZnO sample. (c) Steady-state PL of ZnO-perovskite samples.

[1] NREL Best Research-Cell Photovoltaic Efficiency Chart

[2] C. M. Pelicano, H. Yanagi, J. Mater. Chem. C 2017, 5, 8059-8070

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