Microwave-Assisted H_2O Oxidation-Derived Nanostructured Zinc Oxide Films as Electron-Transporting Layer for Solar Cells

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Perovskite solar cells (PSCs) have developed rapidly due to the superb photovoltaic (PV) properties of perovskites as well as the excellent charge-transporting materials utilized for efficient charge separation. Thus, the strategic design and the resulting materials properties for charge transport are crucial for PV performance. Previously, we developed nanostructured ZnO films via a novel low-temperature H_2O oxidation as electron-transporting layers (ETL) for PSCs [1]. However, H_2O oxidation using a conventional hot-plate heating is time consuming and inefficient leading to non-uniform reactions. In this study, we integrated microwave technology with H_2O oxidation method to accelerate the formation of ZnO nanostructures (NSs). Microwave-assisted synthesis can not only shorten the processing time but also increase product yields and enhance product purity.

Herein, vacuum-deposited Zn thin films were immersed in a beaker filled with pure H_2O and placed inside the microwave oven. The influence of the irradiation time was studied by applying a microwave power of 500 W. ZnO nanorods (NRs) with uneven growth length were obtained after 30 min of microwave exposure, as shown in Fig. 1a. Then after 1 h, uniform NRs evolved having the same morphology as conventional H_2O-oxidized ZnO NRs formed after 8 h. Increasing the irradiation time to 90 min led to the formation of shorter NRs. It can also be observed that the overall film became smoother. This could be due to the dissolution and redeposition of ZnO molecules in between the NRs. Moreover, longer irradiation of 2 h resulted in the development of nanoparticles (NPs) which are seen to be deposited on top of the NRs. Raman spectra of these ZnO NSs showed intense E_2-mode peaks verifying their high-quality wurtzite crystal structure. Finally, all the samples are found to be highly transparent (~ 80%), indicating that they can be applied as ETL for PSCs.

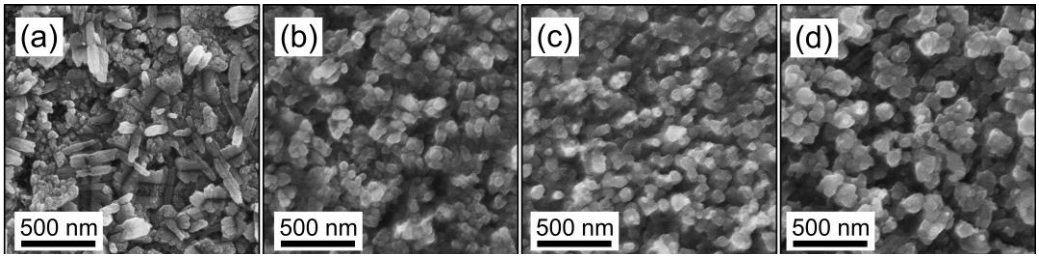

Fig. 1. SEM images of ZnO NSs formed via microwave-assisted H_2O oxidation for (a) 30, (b) 60, (c) 90, and (d) 120 min.

[1] NREL Best Research-Cell Photovoltaic Efficiency Chart

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