Electrodeposited Al-doped ZnO films for Hybrid Solar Cells

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Using nanostructured inorganics in inverted hybrid solar cells are predicted to improve device performance because it provides increased interfacial areas that act as effective charge transport paths. Zinc oxide (ZnO) has been widely studied as an electron transport layer in these devices because it can be grown in various nanostructures while having appropriate optical and electrical properties. The improved conductivity of ZnO is beneficial to the device and can be achieved by doping ZnO with aluminum.

In this work, we demonstrate the growth of Al-doped ZnO (AZO) films on ITO/glass substrates by electrochemical deposition in a chloride medium and the use of these films in hybrid solar cells. The AZO films were grown in electrolytes containing $ZnCl_2$, $AlCl_3$, and KCl, with a 0.5% Al/Zn ratio. Potentiostatic deposition was carried out for 300 s at -1.0V vs. SCE with a Zn wire counter electrode and ITO/glass substrates seeded with ZnO as the working electrode while the electrolyte was bubbled with oxygen and kept at a constant temperature of 70 °C.

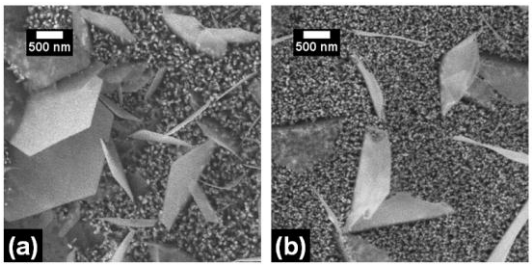

Fig. 1 SEM images of electrodeposited AZO films with (a) 0.05M KCl and (b) 0.025M KCl in the electrolyte.

The AZO films had high optical transmittance, as measured from UV-Vis spectroscopy. Nanorod structures and hexagonal flakes are observed with SEM, as seen in Fig. 1. The nanorods are less than 100 nm in diameter and display some degree of orientation. The micron-sized flakes have nanometer scale thickness and mainly grow perpendicular to the substrate. At higher Al/Zn ratios, interconnected flakes are grown without nanorod structures. EDX measurements confirm the presence of Al in the AZO film, as well as Cl.

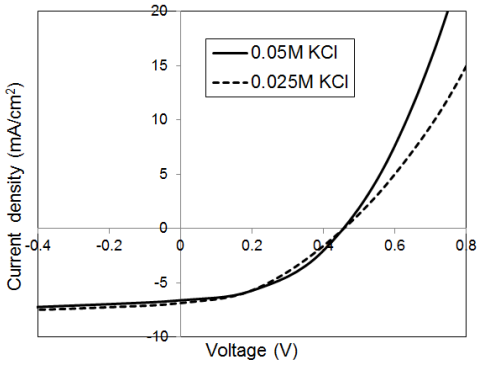

Fig. 2 *J-V* characteristics of hybrid solar cells fabricated with AZO films deposited in electrolytes with (a) 0.05M KCl and (b) 0.025M KCl.

Hybrid organic-inorganic solar cells with Au/MoO_3/P3HT:PCBM/AZO/ZnO seed-layer/ITO/glass structures were fabricated by first coating the AZO films with P3HT:PCBM as the active layer. MoO_3 as a hole-transport layer and Au as a high work function electrode are then deposited by vacuum deposition. The *J-V* characteristics are shown in Fig. 2. The cells had power conversion efficiencies about 1.14%.