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Controlling the Morphology of ZnO Nanorod Arrays for Hybrid Solar Cells

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For optimal charge collection in organic/inorganic hybrid solar cells, the bulk-heterojunction structure is considered to be ideal because the ordered array of vertically-aligned crystalline nanorods provides a direct charge transport path for carriers dissociated at the donor-acceptor interface. In order to achieve better performing devices, it is essential to control the nanostructure of the inorganic layer. ZnO is a popular choice for the inorganic material and electrochemical deposition is one of the many techniques used to grow it. A wide variation of ZnO nanostructures which includes dendrites, hexagonal platelets, rods, and rosettes can be grown by varying the parameters of deposition [1]. Nanorod arrays have been grown by electrochemical deposition in KCl and $ZnCl_2$ electrolyte baths [2]. However, it is observed that hexagonal platelets also grow along with the nanorod arrays.

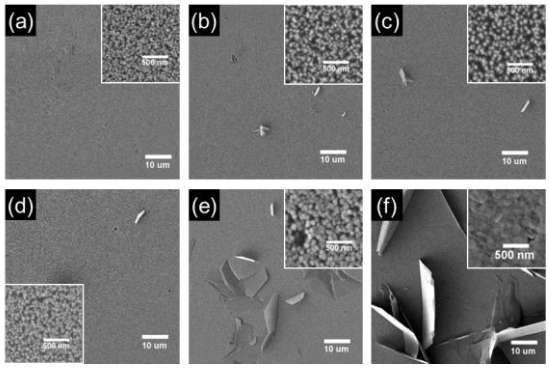

Fig. 1. SEM images of electrochemically deposited ZnO grown in 3mM $ZnCl_2$ with 0.05M KCl (a, b, c) or with 0.1M KCl (d, e, f) for 10 min (a,d), 30 min (b,e), and 60 min (c,f). Insets are zoomed in images to show nanorods.

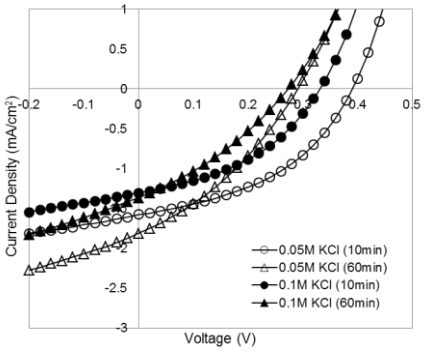

Fig. 2. JV curves of hybrid solar cells fabricated from the electrochemically deposited ZnO.

In this study we show reduced growth of hexagonal platelets during electrochemical deposition of nanorod arrays for hybrid solar cells. ZnO nanorod arrays were grown on ZnO-seeded ITO/glass substrates. The seed layer was deposited by spin-coating a filtered solution of zinc acetate dihydrate and methanol (0.1g/mL) onto ITO substrates followed by baking at 350°C for 30 min. Electrochemical deposition was carried out on a rotating disk electrode (RDE) set-up at -1.0V vs SCE with Zn wire as the counter electrode and in electrolyte baths of KCl (0.05M or 0.1M) and $ZnCl_2$ (3mM or 5mM). The hybrid solar cells were fabricated by spin-coating a solution of P3HT:PCBM (2:1) in chlorobenzene on the ZnO films for the active layer followed by vapor deposition of MoO_3 and Au for the top electrode.

SEM images in Fig. 1 show hexagonal platelets decreasing in number and in size as the concentration of KCl in the electrolyte decreases. The JV cuves in Fig. 2 show that when fabricated into solar cells, for ZnO grown in the same duration, the ZnO grown in a lower concentration of KCl has better performance.

References:

[1] J. Cembero and D. Busquets-Mataix, Thin Solid Films 517, 2859 (2009).

[2] H. El Belghiti, T. Pauporte, and D. Lincot, Phys. Status Solidi A 205, 2360 (2008).