Electrodeposition of ZnO for Hybrid Solar Cells

■ Introduction

Hybrid solar cells composed of organic and inorganic semiconductors combine the advantages associated to both material classes. Organic solar cells are flexible, thin, and can be fabricated by solution processing. Inorganic materials have the advantages of high electron mobility and tunable optoelectronic properties.

One of the strategies to improve hybrid organic-inorganic solar cells is the incorporation of nanostructured metal oxides. The nanostructures increase the interfacial surface area between organic and inorganic layers. They also serve as templates to promote the formation of nanocrystalline domains in the organic layer.

Zinc oxide is particularly suited for inverted solar cell architectures due to its optoelectronic properties. However, because of its crystal structure, it grows into various morphologies - some, such as micron-sized flakes as seen in Fig. 1(a), are not suited for hybrid solar cell applications. It is, therefore, essential to understand ZnO growth mechanisms.

This research is concerned with the controlled growth of ZnO nanostructures by electrochemical deposition towards application in hybrid solar cells.

■ Electrocdeposition of ZnO

Compared to vapor phase, vacuum, or high temperature routes, electrochemical deposition is an especially appealing technique because it complements the low-cost fabrication processes characteristic of hybrid solar cells.

In this study, electrochemical deposition is performed in an aqueous solution containing zinc chloride and potassium chloride (KCl). We show that the deposition of a ZnO seed layer on the ITO substrate prior to electrodeposition influences the shape and orientation of the nanorods seen in Fig. 1(b). Furthermore, KCl concentration is observed to have an effect on the growth of micron-sized hexagonal flakes which are detrimental to the thin cross-section of hybrid solar cells.

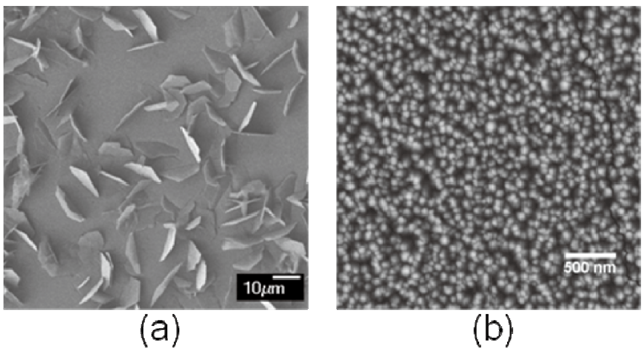

Fig.1 Electrodeposited ZnO films with (a) hexagonal flakes and (b) nanorod array microstructures

■ Electrodeposited ZnO in hybrid solar cells

The resulting films are evaluated on their application in hybrid solar cell devices with a structure of Au/MoO_3/P3HT:PCBM/ZnO/ITO.

Considering the effect of the seed layer and KCl concentration, a homogeneous ZnO film with nanorod array structure was successfully deposited. In a hybrid solar cell, the ZnO nanorod layer had better charge mobility and larger interfacial area compared to a planar ZnO layer. As a result, fill factor and short circuit current are improved as seen in Fig. 2.

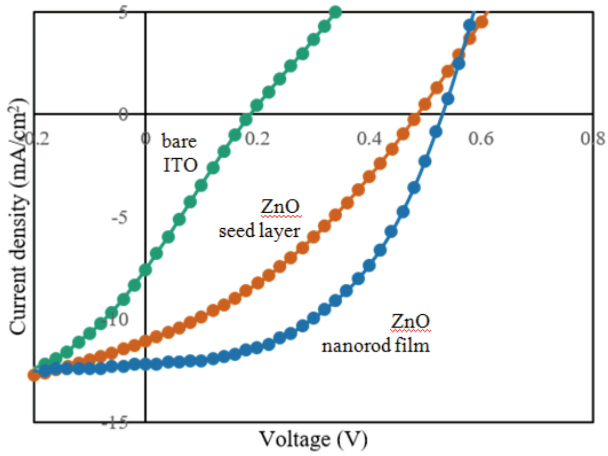

Fig.2 Current density-voltage characteristics of hybrid solar cells fabricated using bare ITO, planar ZnO seed layer film, and ZnO nanorod film.

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