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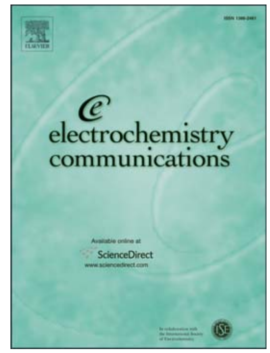

Electrochemical Routes to Earth-Abundant Photovoltaics: A Minireview

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Electrochemical Routes to Earth-Abundant Photovoltaics: A Minireview

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Abstract

Electrodeposition has considerable potential for application in the fabrication of low cost thin film solar cells. The expected demand for earth-abundant replacements for the rare, toxic or expensive materials currently used in thin film solar cells has stimulated research into electrochemical preparation of the different component layers (absorber, buffer, window) in the emerging area of earth-abundant photovoltaics. Recent progress in this rapidly developing area is reviewed with particular emphasis on the kesterites Cu_2ZnSnS_4 and $Cu_2ZnSnSe_4$.

Keywords

CIGS, CZTS, CZTSe, electrodeposition, kesterites, photovoltaics, zinc oxide

Introduction

The growth of installed photovoltaics (PV) is following an exponential increase that will lead to generation capacities of several terawatts by 2050.[1] The dominant PV technology at present is, of course, based on silicon, but the contribution of thin film PV technologies such as cadmium telluride (CdTe) and copper indium(gallium) diselenide (CIGS) is increasing rapidly. However, at some point, limitations associated with the availability of raw materials and with the toxicity of the compounds are likely to restrict further growth of these technologies.[1] Thin film PV is attractive because less energy is required to manufacture the absorbing material than in the case of silicon, leading to shorter energy payback times. The future expansion of thin film PV to meet the proposed terawatt targets should however be feasible, provided that thin film absorbers containing earth-abundant and non-toxic elements can be found to replace CdTe and CIGS. At the same time, new low capital cost methods of fabricating thin film PV are increasingly being explored. It is in this context that electrodeposition is being considered as a scalable low cost route to earth-abundant PV.

Electroplating is used on a large scale in the steel industry and elsewhere to produce layers of metals and alloys such as nickel, nickel-zinc, chromium, copper and brass. The extension of electrodeposition to the large scale fabrication of semiconductor layers for PV has proved successful in the case of CdTe, which was deposited on CdS-coated fluorine-doped tin oxide glass in the BP Apollo® process for the fabrication of large area CdS|CdTe solar modules that achieved power conversion efficiencies of over 10%.[2] Electrodeposition has also been used to prepare several other chalcogenides such as ZnSe and $CuInSe_2$ as well as ZnO.[3] This brief review focusses on the more recent application of electrodeposition to fabricate