Special Issue: “Advanced Thin Film Materials for Photovoltaic Applications”

DHARMADASA, I. <http://orcid.org/0000-0001-7988-669X>

Citation:

DHARMADASA, I. (2020). Special Issue: “Advanced Thin Film Materials for Photovoltaic Applications”. Coatings, 10 (6), e562. [Article]

coatings

Editorial

Special Issue: "Advanced Thin Film Materials for Photovoltaic Applications"

Imyhamy I. Dharmadasa

Materials and Engineering Research Institute, Sheffield Hallam University, Sheffield S1 1WB, UK;
Dharme@shu.ac.uk

Received: 10 June 2020; Accepted: 11 June 2020; Published: 13 June 2020

Abstract: Photovoltaic (PV) technology is rapidly entering the energy market, providing clean energy for sustainable development in society, reducing air pollution. In order to accelerate the use of PV solar energy, both an improvement in conversion efficiency and reduction in manufacturing cost should be carried out continuously in the future. This can be achieved by the use of advanced thin film materials produced by low-cost growth techniques in novel device architectures. This effort intends to provide the latest research results on thin film photovoltaic solar energy materials in one place. This Special Issue presents the growth and characterisation of several PV solar energy materials using low-cost techniques to utilise in new device structures after optimisation. This will therefore provide specialists in the field with useful references and new insights into the subject. It is hoped that this common platform will serve as a stepping-stone for further development of this highly important field.

Keywords: thin films; perovskite; SnS/SnS_2; CdS/CdTe; CIGS; silicon; electroplating of semiconductors; photovoltaics

---

In the past, photovoltaic device development was mainly based on simple p-n homo- or hetero-junction type structures. However, these devices utilise only a fraction of the solar spectrum, and the rest is lost during the PV process. In order to harvest all photons from UV, Visible and IR regions, and add the contributions from "impurity PV effect" and "impact ionisation", graded bandgap multi-layer devices were designed [1]. These designs were experimentally tested using well known semiconductors (GaAs/AlGaAs), and their validity was proven by achieving V_{oc}~1.175 V and FF~0.86 [2]. After this validation, the new device architectures were fabricated using low-cost electroplated materials, and has achieved 15.3% efficiency to date. A monograph has been published [3] on this subject and the search for low-cost, advanced thin film materials is essential for the development of next-generation PV devices based on graded band-gap multi-layer solar cells.

This Special Issue consists of ten fully refereed scientific publications: seven open access articles [4–10] and three open access review articles [11–13]. The seven articles provide information on perovskite, SnS/SnS_2, CdTe, CIGS, silicon and transparent conducting oxide (SnO_2) materials used in solar cell development. One of these articles is a featured paper on electrodeposition of CdTe [7]. Out of the three review articles, one summarises the $CdTe_{(1-x)}Se_x$ thin films in solar cell applications [11]. The second review focuses on the encapsulation of organic and perovskite solar cells [12]. The third paper is a feature review of the electroplating of semiconductor materials for applications in large area electronic devices [13].

Among the research articles, Nishi et al. [4] present their latest work on $CH_3NH_3PbI_3$ perovskite material deposited under normal atmospheric conditions. These authors present devices with efficiencies ~14.3% and a stability up to four weeks, with the efficiency reducing only to 13.4%. This work shows the improvement in stability in the right direction. The next article by Gedi et al. [5] presents the results of eco-friendly SnS and SnS_2 thin films' growth and characterisation using chemical solution process. They report uniform and well-adhered layers with band gaps of 1.28 and 2.92 eV values, suitable for PV applications. Opyrchal et al. [6] report the photoluminescence study on the effect of Cu on the front side illumination of CdTe/CdS solar cells. The work focuses on the PL transitions close to the bandgap of CdTe. Ojo and Dharmadasa [7] present the results of electroplated CdTe material grown for use in CdS/CdTe solar cells. This article focuses on a case study of the temperature-dependent properties of electroplated CdTe thin films. Lorbada et al. [8], in their research article, provides a deep insight into the electronic properties of CIGS modules with monolithic interconnects. Chen et al. [9] present their results on enhancement of the potential-induced degradation resistance of crystalline silicon solar cells via anti-reflection coatings deposited by industrial PECVD method. The last research article by Ren et al. [10] presents the use of spin-coated SnO_2 thin films to cover cracks in the TiO_2 hole blocking layer used in perovskite solar cells. This process has improved the conversion efficiency of their solar cell structure.

The first review article by Lingg et al. [11] describes the properties of $CdTe_{(1-x)}Se_x$ thin films used in solar cell applications. First Solar Company has achieved ~22% efficient CdS/CdTe-based devices by incorporating Se in the CdTe layer. Hence, this comprehensive review is useful for researchers in this field to learn the properties of $CdTe_{(1-x)}Se_x$ alloy. The addition of Se in front of the solar cell creates a graded bandgap structure, enhancing the device performance. The second review paper by Uddin et al. [12] on the encapsulation of organic and perovskite solar cells is really important in order to improve the stability and lifetime of these types of solar cells. Although the highest thin film solar cell efficiencies of ~23% are reported for perovskite solar cells, their instability is a real concern at present. Hence, this encapsulation work is timely and useful for the researchers in this area. The last paper by Ojo and Dharmadasa [13] is a review paper on low-cost and high quality materials growth technique. This paper describes the electroplating of semiconductor materials for applications in large-area electronics such as PV solar panels and display devices. This will be an ideal paper for new researchers who intend to enter this area of research activities.

Finally, I would like to express my appreciation to all of the contributors to this Special Issue. They have positively responded to this call and their contributions are highly appreciated. Thanks are also due to the Coatings administration team for their efficient and excellent service, and for producing this professional publication.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Dharmadasa, I.M. Third generation multi-layer tandem solar cells for achieving high conversion efficiencies. *Sol. Energy Mater. Sol. Cells* **2005**, *85*, 293–300. [CrossRef]
2. Dharmadasa, I.M.; Roberts, J.S.; Hill, G. Third generation multilayer graded bandgap solar cells for achieving high conversion efficiencies—II. *Sol. Energy Mater. Sol. Cells* **2005**, *88*, 413–422. [CrossRef]
3. Ojo, A.A.; Cranton, W.M.; Dharmadasa, I.M. *Next Generation Multi-Layer Graded Bandgap Solar Cells*; Springer: Berlin/Heidelberg, Germany, 2018.
4. Nishi, K.; Oku, T.; Kishimoto, T.; Ueoka, N.; Suzuki, A. Photovoltaic Characteristics of $CH_3NH_3PbI_3$ Perovskite Solar Cells Added with Ethylammonium Bromide and Formamidinium Iodide. *Coatings* **2020**, *10*, 410. [CrossRef]
5. Gedi, S.; Reddy, V.R.M.; Alhammadi, S.; Moon, D.; Seo, Y.; Kotte, T.R.R.; Park, C.; Kim, W.K. Effect of Thioacetamide Concentration on the Preparation of Single-Phase SnS and SnS_2 Thin Films for Optoelectronic Applications. *Coatings* **2019**, *9*, 632. [CrossRef]
6. Opyrchal, H.; Chen, D.; Cheng, Z.; Chin, K.K. PL Study on the Effect of Cu on the Front Side Luminescence of CdTe/CdS Solar Cells. *Coatings* **2019**, *9*, 435. [CrossRef]
7. Ojo, A.A.; Dharmadasa, I.M. Factors Affecting Electroplated Semiconductor Material Properties: The Case Study of Deposition Temperature on Cadmium Telluride. *Coatings* **2019**, *9*, 370. [CrossRef]

8. Lorbada, R.V.; Walter, T.; Marrón, D.F.; Lavrenko, T.; Mücke, D. A Deep Insight into the Electronic Properties of CIGS Modules with Monolithic Interconnects Based on 2D Simulations with TCAD. *Coatings* **2019**, *9*, 128. [CrossRef]
9. Chen, T.-C.; Kuo, T.-W.; Lin, Y.-L.; Ku, C.-H.; Yang, Z.-P.; Yu, I.-S. Enhancement for Potential-Induced Degradation Resistance of Crystalline Silicon Solar Cells via Anti-Reflection Coating by Industrial PECVD Methods. *Coatings* **2018**, *8*, 418. [CrossRef]
10. Ren, H.; Zou, X.; Cheng, J.; Ling, T.; Bai, X.; Chen, D. Facile Solution Spin-Coating SnO_2 Thin Film Covering Cracks of TiO_2 Hole Blocking Layer for Perovskite Solar Cells. *Coatings* **2018**, *8*, 314. [CrossRef]
11. Lingg, M.; Buecheler, S.; Tiwari, A.N. Review of $CdTe_{1-x}Se_x$ Thin Films in Solar Cell Applications. *Coatings* **2019**, *9*, 520. [CrossRef]
12. Uddin, A.; Upama, M.B.; Yi, H.; Duan, L. Encapsulation of Organic and Perovskite Solar Cells: A Review. *Coatings* **2019**, *9*, 65. [CrossRef]
13. Ojo, A.A.; Dharmadasa, I.M. Electroplating of Semiconductor Materials for Applications in Large Area Electronics: A Review. *Coatings* **2018**, *8*, 262. [CrossRef]