Solar Energy Materials and Solar Cells 202 (2019) 110078

Contents lists available at ScienceDirect

Solar Energy Materials and Solar Cells

journal homepage: www.elsevier.com/locate/solmat

Energy harvesting performance of bifacial and semitransparent amorphous silicon thin-film solar cells with front and rear transparent conducting oxide contacts

Jun-Sik Cho[a,b,*], Yeong Hun Seo[a,c], Bo-Hun Choi[c,**], Ara Cho[a,b], Ahreum Lee[a], Min Jeong Shin[a], Kihwan Kim[a,b], Seung Kyu Ahn[a], Joo Hyung Park[a], Jinsu Yoo[a,b], Donghyeop Shin[a], Inyoung Jeong[a], Jihye Gwak[a,b]

[a] *Photovoltaics Laboratory, Korea Institute of Energy Research, 152 Gajeong-ro, Yuseong-gu, Daejeon, 34129, South Korea*
[b] *Department of Renewable Energy Engineering, Korea University of Science and Technology (UST), 217 Gajeong-ro, Yuseong-gu, Daejeon, 34113, South Korea*
[c] *Department of Materials Physics, Dong-A University, 840 Saha-gu, Busan, 604-714, South Korea*

ARTICLE INFO

Keywords:
Solar cell
Energy harvesting
Thin-film
Hydrogenated amorphous silicon
Semitransparent
Bifacial

ABSTRACT

Bifacial and semitransparent hydrogenated amorphous silicon (a-Si:H) thin-film solar cells were prepared with front and rear transparent conducting oxide (TCO) contacts using a plasma-enhanced chemical vapor deposition process. Increased power conversion efficiencies (PCEs) and average visible transmissions (AVTs) in the visible wavelength range were realized in the cases of the bifacial and semitransparent solar cells based on the optimization of the device designs, such as front TCO contacts, intrinsic a-Si:H absorbers (i-a-Si:H), p-type hydrogenated nanocrystalline silicon carbide, and n-type hydrogenated nanocrystalline silicon layers. The dependencies of the performance parameters of the solar cells on the illumination direction and intensity were also investigated systematically. As the film thickness of the i-a-Si:H absorber layers increased from 150 nm to 450 nm, the PCEs of the solar cells respectively increased in the ranges of 6.01–7.50% and 5.25–6.25% when front and rear illuminations were used for a standard light intensity of 100 mW/cm^2, while the AVTs decreased from 22.76% to 15.67% irrespective of illumination direction. The best PCEs of the bifacial and semitransparent solar cells that were fabricated with the use of optimal conditions were respectively equal to 7.94% and 6.20% when front and rear illumination conditions were used. The corresponding AVT was equal to 14.34%. The performance parameters of bifacial and semitransparent a-Si:H solar cells at varying illumination intensities in the range of 10–100 mW/cm^2 were also investigated, and yielded consistent PCE values in the range of 6.39–6.62% with front illumination, and 4.95–5.15% with rear illumination.

1. Introduction

Photovoltaics (PV) are expected to play an increasingly important role in the global effort to reduce the use of fossil fuels, such as oil, natural gas and coal, and the amount of green-house gas emission [1,2]. Among PV applications, building-integrated PV (BIPV) is a practical, innovative, and promising technology, for urban energy systems that require increased energy consumption but lack the required space for installation. They can be designed to replace building materials including rooftops, skylights, windows, and facades, and to convert part of the impinging sunlight into electricity, while transmitting the remaining solar irradiance into the enclosed building volume where it can be availed for indoor lighting [3]. Bifacial solar cells with semitransparent properties have primary advantages over conventional solar cells using opaque metal contacts. They can use radiation illumination either at the front or at the rear sides of a solar device or at both, thereby resulting in a potentially higher energy yield. The bifacial properties make the solar cells very promising for their integration in a building environment, whereby vertical architectural elements are illuminated from different sides during the day, and albedo constitutes an important component of the overall illumination [4]. They also provide an aesthetic appearance and improved visual performance.

The power conversion efficiency (PCE) and average visible transmission (AVT) of the bifacial and semitransparent solar cells need to be

* Corresponding author. Photovoltaics Laboratory, Korea Institute of Energy Research, 152 Gajeong-ro, Yuseong-gu, Daejeon, 34129, South Korea.
** Corresponding author. Department of Materials Physics, Dong-A University, 840 Saha-gu, Busan, 604-714, South Korea.
E-mail addresses: jscho@kier.re.kr (J.-S. Cho), adamchoi@dau.ac.kr (B.-H. Choi).

https://doi.org/10.1016/j.solmat.2019.110078
Received 5 June 2019; Received in revised form 19 July 2019; Accepted 23 July 2019
Available online 20 August 2019
0927-0248/