Selective band offset three terminal tandem materials

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Abstract

A new arrival in the field of high efficiency concepts is the three terminal selective band offset barrier tandem solar cell (3T-SBOB [1]). This design reaches tandem efficiencies technologically simpler devices using novel physical transport processes. This paper presents design studies in order to demonstrate practical devices.

The tandem designs consist of silicon interdigitated back contact (IBC) bottom solar cell [2], an SBOB layer, and finally a perovskite (PSC) top cell. The SBOB enables independent quasi-Fermi level separations to develop under illumination, and ensures the 3T-SBOB can reach efficiencies equivalent to four terminal solar cells.

Numerical process modelling and opto-electronic modelling of the elements of the 3T-SBOB is reported. The first step consists of modelling an n-type IBC with a focus on planar front surfaces in light of modifications to the surface required by the subsequent growth of the SBOB and PSC.

The second step consists of a review of PSC materials with suitable affinities, bandgaps, and complex refractive indices proposed at this design stage. Of these, hole transport layer (HTM) materials proposed include both low cost organics [3] and recent high efficiency PTAA [4] materials. Electon transport layer (ETL) materials include SnO2 [5] and PC(71)BM[6].

The performance of 3T-SBOB structures is presented and discussed including the critical topic of interfaces, together with considerations of alternate materials proposed by materials modelling for future investigation.

This paper presents these preliminary materials studies and resulting device structures which will be evaluated in H2020 Solar-ERANET project BOBTANDEM[7].

References

[1] Z. Djebbour *et al*., *"Bandgap engineered smart three-terminal solar cell: New perspectives towards very high efficiencies in the silicon world"*, Prog Photovolt Res Appl. 27, **4** pp. 306-315 (2019); http://dx.doi.org/10.1002/pip.3096

[2] A. Halm, V.D. Mihailetchi, et al., "*The Zebra Cell Concept - Large Area n-Type Interdigitated Back Contact Solar Cells and One-Cell Modules Fabricated Using Standard Industrial Processing Equipment*", 27th EU-PVSEC (2012) http://dx.doi.org/10.4229/27thEUPVSEC2012-2AO.2.1

[3] R. Shang, et al., "*Disodium Benzodipyrrole Sulfonate as Neutral Hole- Transporting Materials for Perovskite Solar Cells*", J. Am. Chem. Soc., (2018), 140, 5018-5022.

[4] Yang et al., Science. 2017;356:1376–1379. http://dx.doi.org/10.1126/science.aan2301

[5] Alex M. Ganose and David O. Scanlon, "*Band gap and work function tailoring of SnO2 for improved transparent conducting ability in photovoltaics*", . Mater. Chem. C, 2016, 4, 1467 (2016)

[6] Eric T. Hoke et al., "*The Role of Electron Affinity in Determining Whether Fullerenes Catalyze or Inhibit Photooxidation of Polymers for Solar Cells*", Adv. Energy Mater. (2012), 2, 1351–1357

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