INVITED LECTURE

Progress and Challenges in Perovskite Photovoltaics

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Description:

Perovskite solar cells and perovskite-based tandem solar cells have rapidly developed in the last decade, to a current record power conversion efficiency (PCE) of 26.1% and 33.7% [1], respectively and several research groups overcoming 30% PCE of the tandem cells. The stability has similarly improved, with best devices now reaching undiminished performance after more than 1000 hours. Such progress has been enabled by development of a novel set of measurement techniques that serve the purpose of single and tandem solar cell detailed characterization and optimization. In this contribution, we will review the current state-of-the-art solar cell and discuss the potential further improvements. Challenges of operation in outdoor conditions with focus on long-term stability and issues related to encapsulation and packaging will be pointed out.

Requirements of high performance, excellent stability and possibility of tandem integration have turned the focus on p-i-n (inverted) perovskite architecture. This architecture avoids the SPIRO-OMeTAD that is unstable at elevated temperatures and at the same time the arhitecture benefits from the self-assembly molecules (SAM) that form almost lossless interface with perovskite [2]. The other interface can be treated with thin ALD deposited oxide layers, further improving performance. Both aspects will be in detail presented together with the advanced long-term maximum power point operation in custom white LED setup that is designed specifically for stability testing of single-junction devices.

For stability analysis of monolithic, 2-terminal tandem devices, however, higher spectral requirements due to series connection of the two subcells are necessary. Consequently, long-term analysis of tandems is rare in the literature. For that purpose, a novel setup for advanced characterization of tandem solar cells, based on a bichromatic LED light source [3] has been developed and will be presented. Two spectrally independent LED arrays are used to independently bias individual subcells. Blue LEDs with a central wavelength of $\lambda = 470$ nm are used to bias the top cell, while IR LEDs ($\lambda = 940$ nm) bias the bottom cell. This enables accurate long-term testing of tandems as well as possibility to characterize individual subcells non-destructively through e.g. light intensity dependent I-V measurements and extracting one-diode model parameters for each subcell. With this method, we are able to reconstruct tandem J-V and disentangle it into subcell J-Vs. Its application on state-of-the-art perovskite/silicon tandem solar cells will be demonstrated The developed BCLED tool can therefore be used for subcell sensitive analysis and also long-term stability testing due to longevity of LEDs.