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Reducing sputter damage-induced recombination losses during deposition of the transparent front-electrode for monolithic perovskite/silicon tandem solar cells

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Highlights

- In perovskite solar cells sputter damage leads to non-radiative recombination losses.
- Sputter damage-induced losses are quantified by light intensity-dependent analysis.
- The effect of sputter damage can be reduced by reducing the sputter power.
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Tin oxide buffer layer-free tandem devices are optically superior.

Abstract

Many research groups work on overcoming the 30% power conversion efficiency (PCE) level for perovskite/silicon tandem solar cells with various approaches. The most common tandem architectures employ a transparent conductive oxide (TCO) front electrode. Due to its fast deposition and up-scalability, sputter deposition is the preferred method for TCO deposition. The sensitive layers of perovskite solar cells are protected from sputter damage by a thermal atomic layer (ALD) deposited tin oxide (SnO_2) buffer layer, which induces parasitic absorption. Here, we propose a method to reveal the impact of sputter damage on SnO_2 buffer layer-free devices. By performing light intensity-dependent current density-voltage (J-V) measurements and thereby reconstructing the single-junction solar cell pseudo J-V characteristics, we could associate sputter damage with trap-assisted non-radiative recombination losses. Additionally, we demonstrate a simple method to minimize sputter damage to the perovskite solar cell to the point where a protective SnO_2 buffer layer is no longer required. By lowering the sputter power density during the TCO deposition, we regained ~13 mV open-circuit voltage and ~3% fill factor of the devices, improving the efficiency from 13.55 to 14.17%. We show that these improvements are linked to a reduction of transport and non-radiative recombination losses. Finally, we fabricated optically superior and sputter damage-free monolithic perovskite/silicon tandem devices without needing a protective SnO_2 buffer layer. By doing so, we increased the tandem device current density by 0.52 mA/cm^2, representing a crucial step toward further optimizing the optical performance of tandem devices.

Previous Next

Keywords

Sputter damage; Perovskite/silicon tandems; Tandems; Transparent conductive oxides; Non-radiative recombination losses; Optical simulation

Data availability

Data will be made available on request.

1 Now at Energy Material and Surface Sciences Unit, Okinawa Institute for Science and Technology Graduate University (OIST), 1919-1, Tancha, Onna Son, Okinawa, 904-0495, Japan

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