

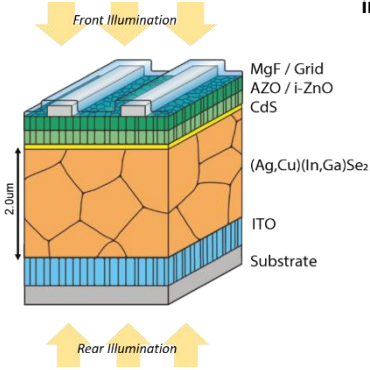
Thin film solar cell research at Empa

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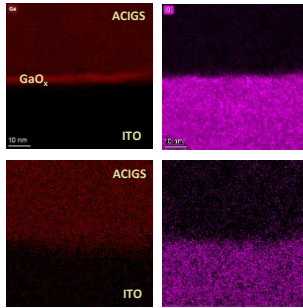


Bifacial CIGS solar cells

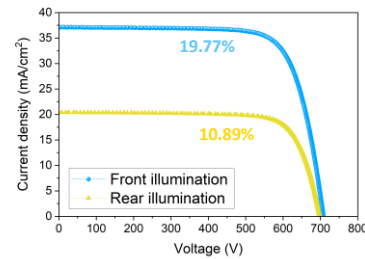
Bifacial device structure



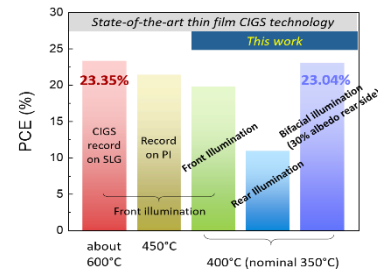
Suppression of detrimental GaO_x interlayer by low-temperature process



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Comparison with state-of-the-art



Summary

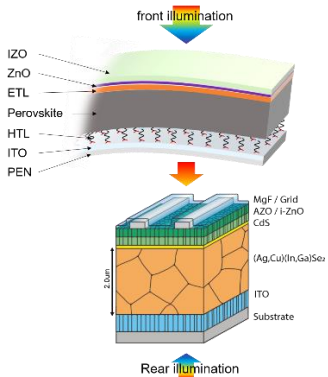
- New low-temperature process overcomes the long-existing hurdles in bifacial CIGS solar cells
- Comparable bifacial device performance with state-of-the-art monofacial devices
- Great potential for building-integrated photovoltaics (BIPV)

Outlook

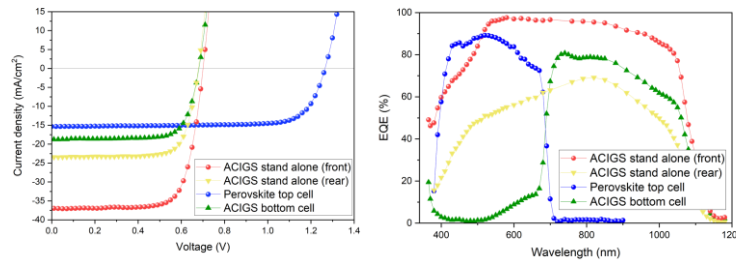
- Realization on light-weight and flexible substrates, e.g. Polyimide

Bifacial Perovskite/CIGS tandem solar cells

Device structure



Bifacial Perovskite/CIGS tandem solar cells



Solar Cells	V _{oc} (V)	J _{sc} (mA/cm²)	FF (%)	PCE (%)	Estimated PCE gain
Perovskite top cell	1.268	15.33	77.9	15.1	
CIGS (stand alone)	0.700	37.00	74.4	19.3	
CIGS bottom cell	0.681	18.70	75.1	9.6	
CIGS rear illumination	0.679	23.40	76.1	12.1	
Perovskite/CIGS 4-terminal bifacial tandems (under 30% albedo)				28.3	9

Summary

- First demonstration of high performance 4T bifacial Perovskite/CIGS tandem solar cells

Outlook

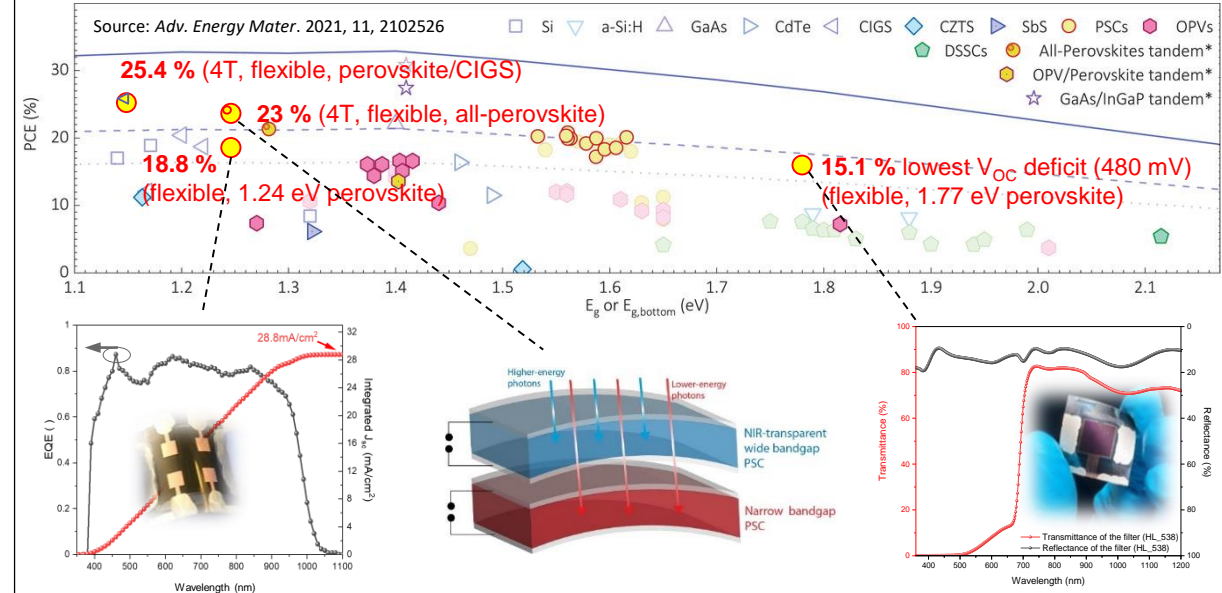
- 2T bifacial Perovskite/CIGS tandem solar cells

Flexible perovskite/CIGS and all-perovskite tandem solar cells

Motivation:

Development of high efficiency flexible tandem solar cells for light weight applications (e.g. wearable electronics, etc.).

Results:



18.8 % efficient narrow bandgap (1.24 eV) perovskite solar cell on flexible substrates

25.4 % efficient flexible perovskite/CIGS 4T tandem solar cell and flexible all-perovskite 4T tandem solar cell with 23 % efficiency

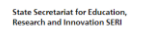
Flexible, wide bandgap (1.77 eV) perovskite solar cell with record low open-circuit voltage deficit (only 480 mV)

Outlook

- Boost efficiency of flexible, thin film 4-terminal tandem solar cells to over 25 %.
- Scale-up flexible tandem solar cells/modules.
- Demonstrate stable and high efficiency thin film tandem solar cells and modules by cost-effective, solution-based methods (slot-die coating).

Acknowledgements

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