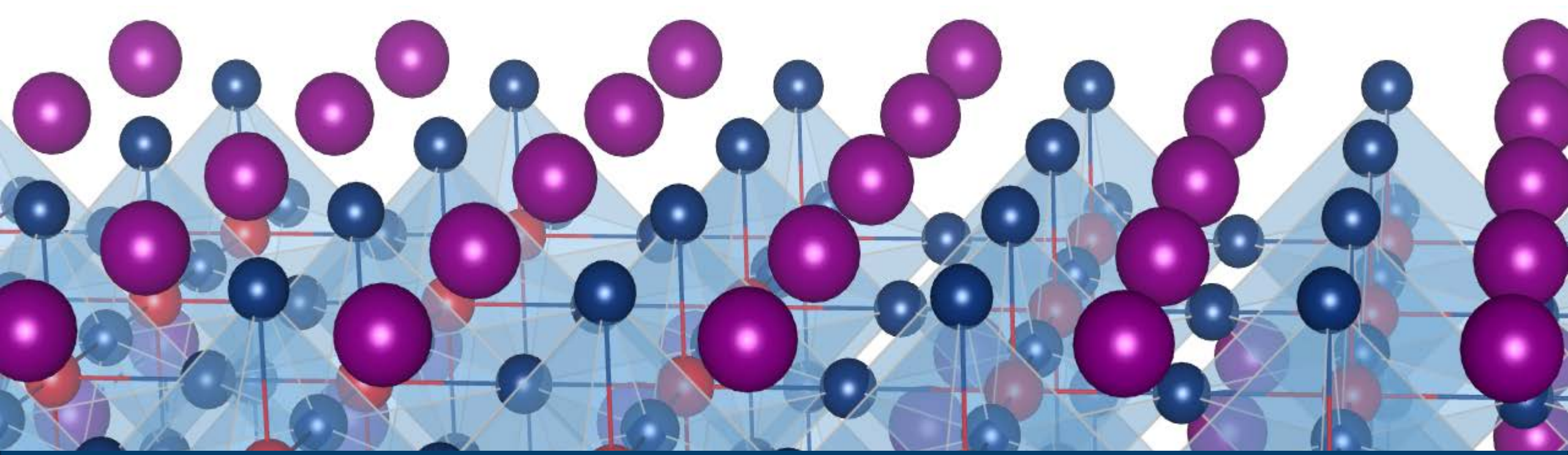

Insights into photovoltaics

Sandheep Ravishankar

IMD-3, Forschungszentrum Jülich

Emmy Noether-Programm

DFG Deutsche Forschungsgemeinschaft

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

JÜLICH Forschungszentrum

Photovoltaics for the clean energy transition

Germany

installed PV capacity: ~100 GWp

PV capacity factor: ~10%

H. Wirth et al., *Fraunhofer ISE*, 2025.

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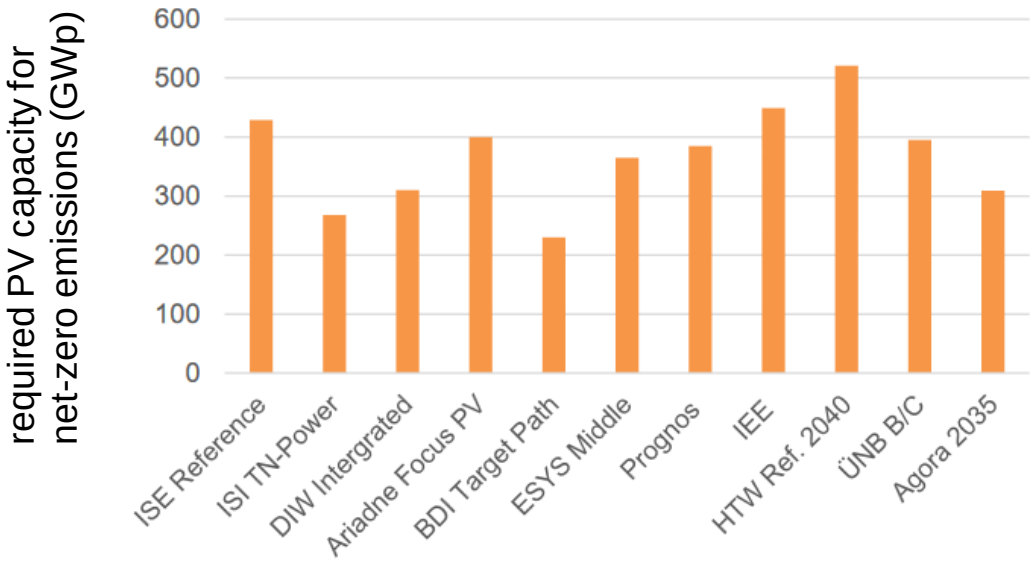

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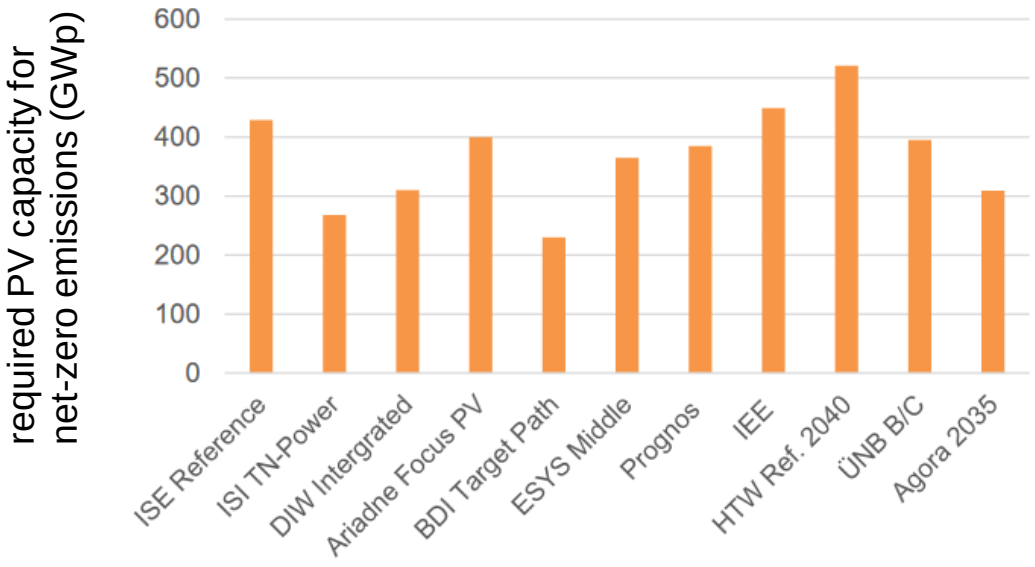
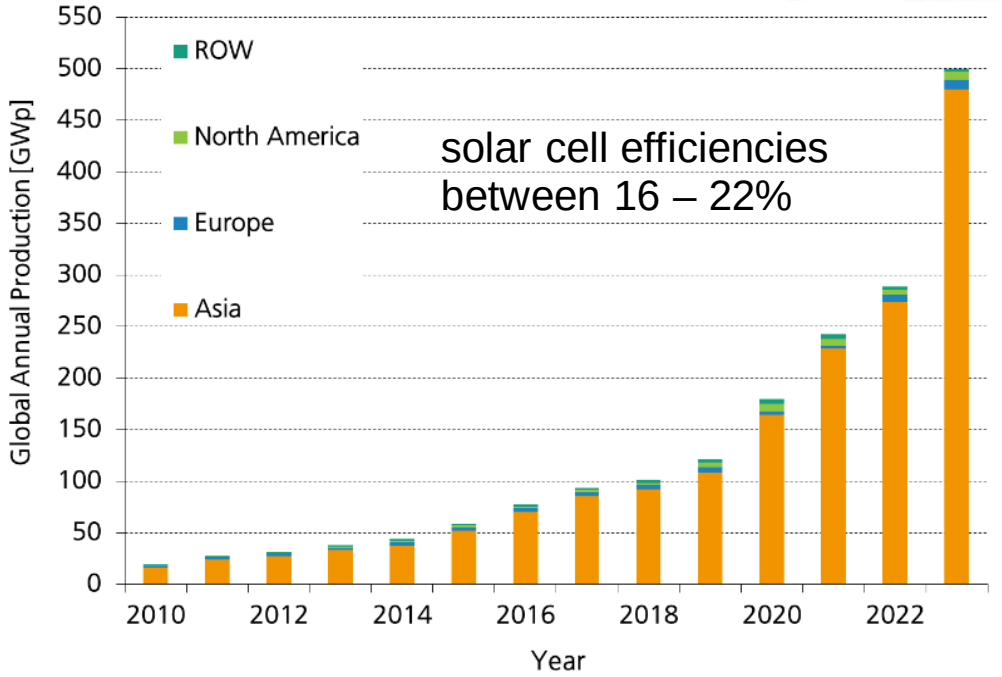


97% of commercial market is silicon wafer-based technology



solar cell efficiencies between 16 – 22%

H. Wirth et al., *Fraunhofer ISE*, 2025 and Fraunhofer photovoltaics report, 2024.

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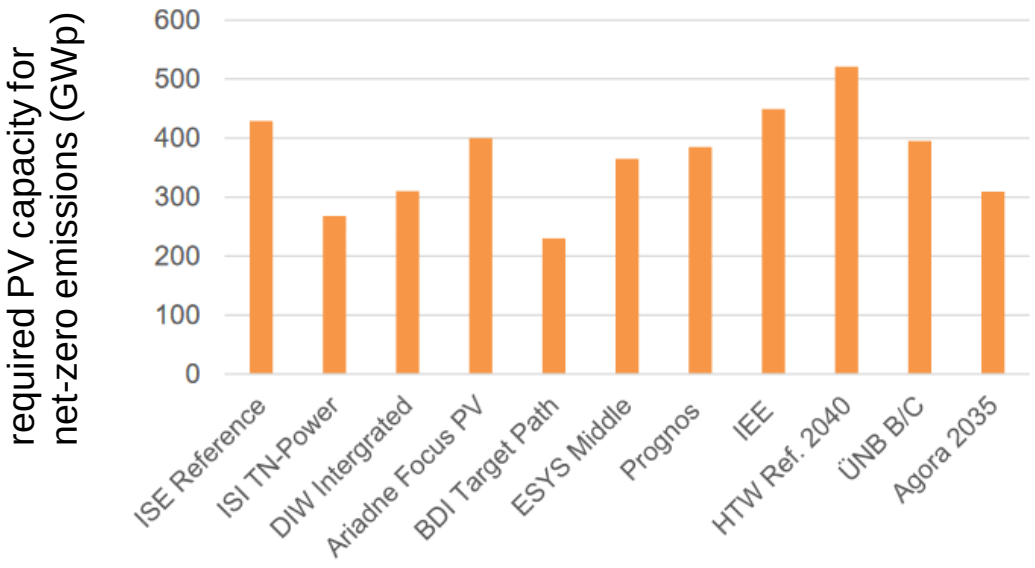

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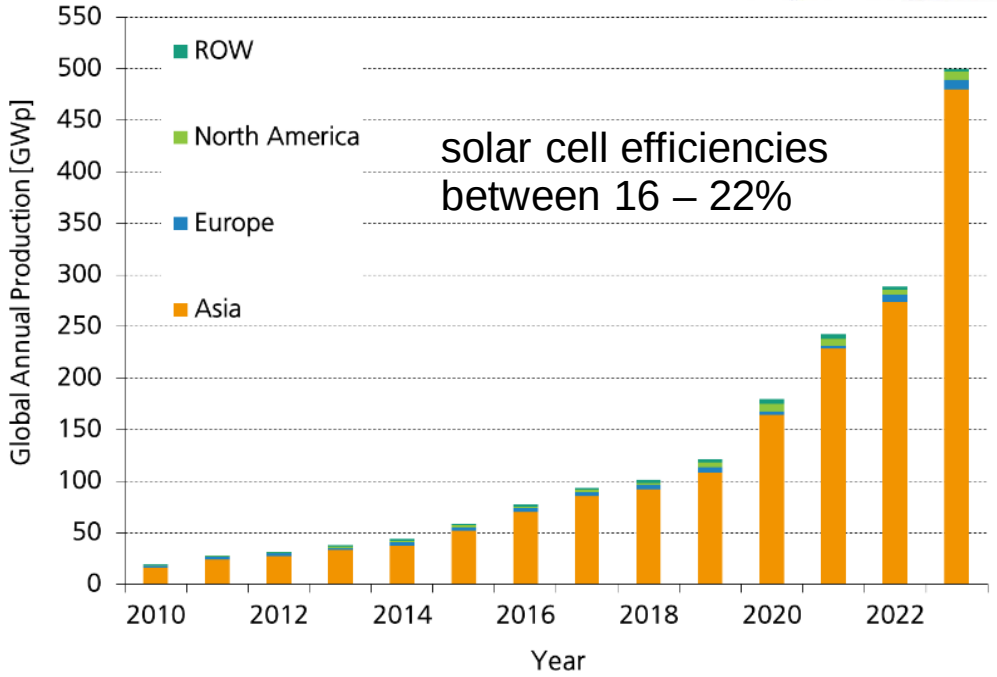
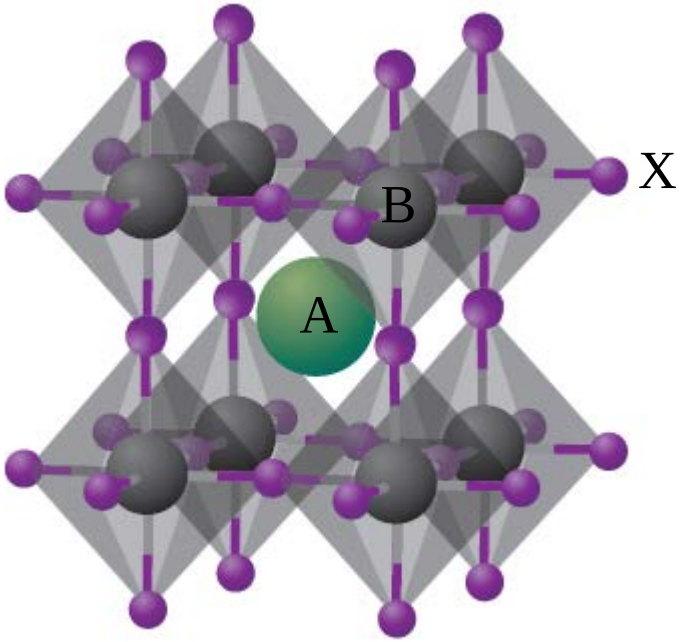


solar cell efficiencies between 16 – 22%

A more efficient PV technology is required for minimising the cost of the over-build

H. Wirth et al., *Fraunhofer ISE*, 2025 and Fraunhofer photovoltaics report, 2024.

Metal halide perovskite solar cells



ABX_3

A – Organic or inorganic cation (MA^+, FA^+, Cs^+)

B – Metal cation (Pb^{2+} or Sn^{2+})

X – Halogen anion (I^-, Br^-, Cl^-)

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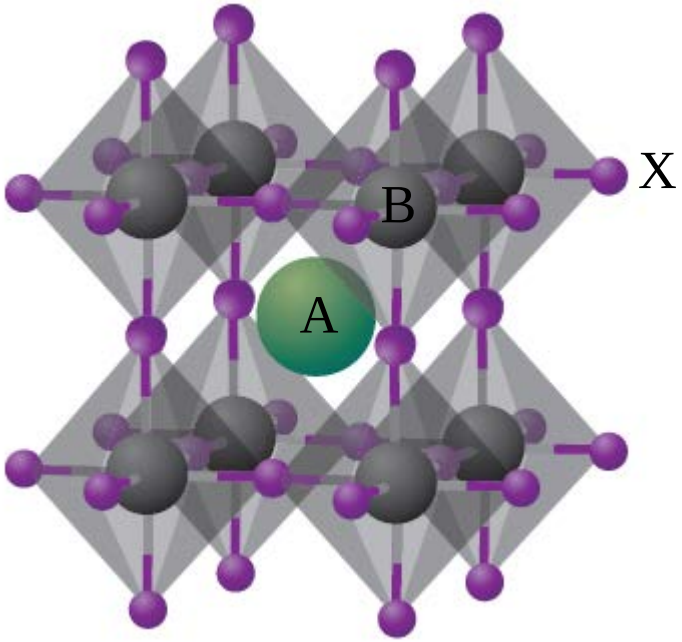

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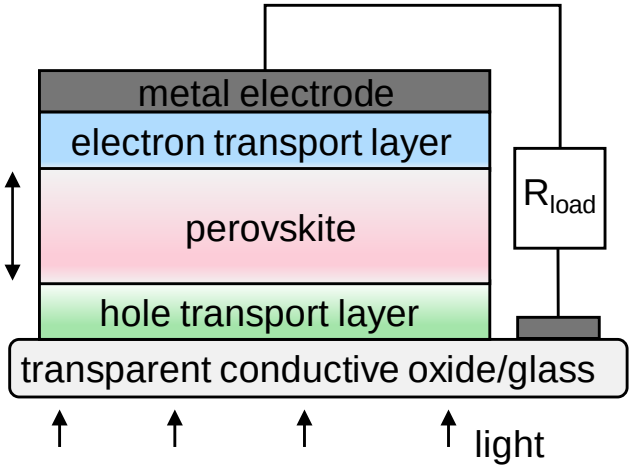
efficient light absorption → 500-1000 nm



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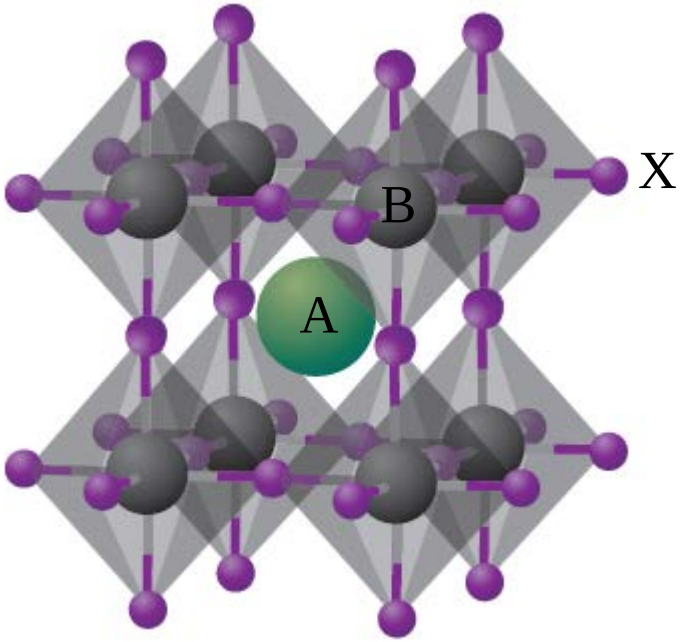

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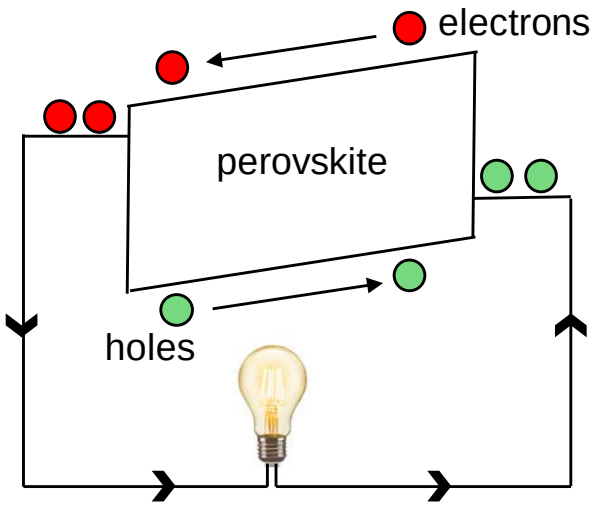
good electronic properties ➡



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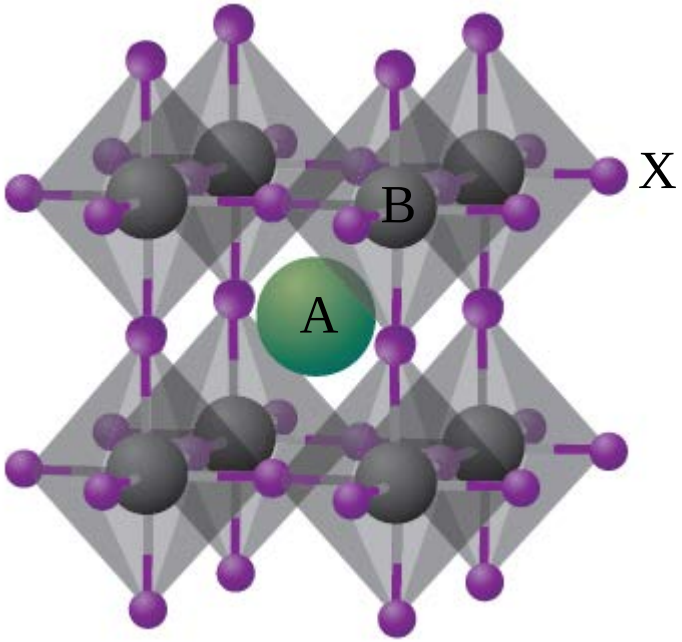

ABX_3

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silicon solar cell fabrication

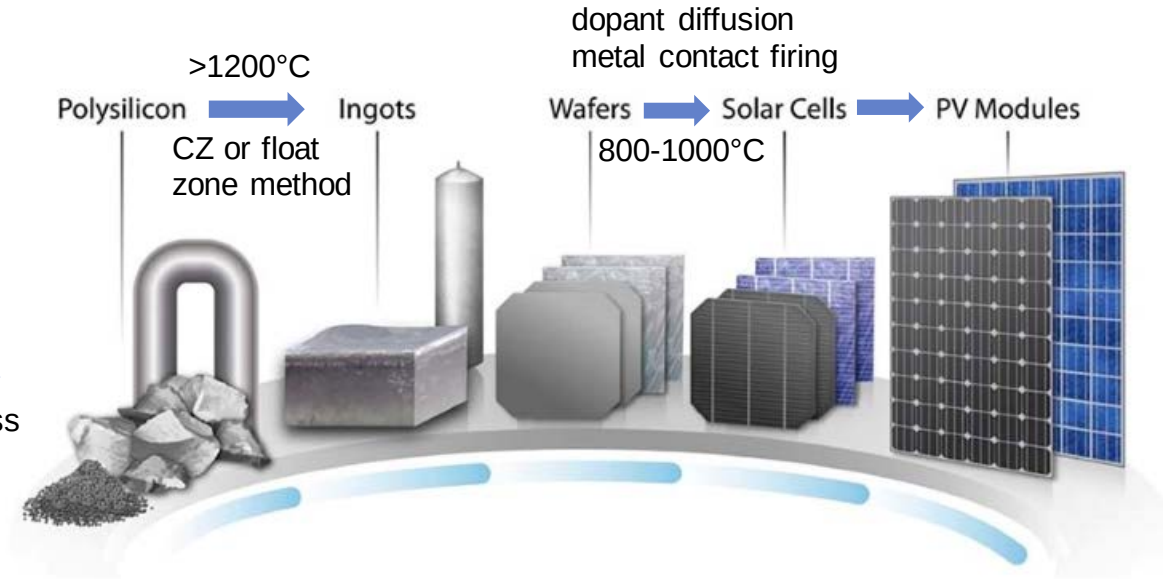
quartz (silicon di-oxide)

1500-2000°C

metallurgical grade silicon

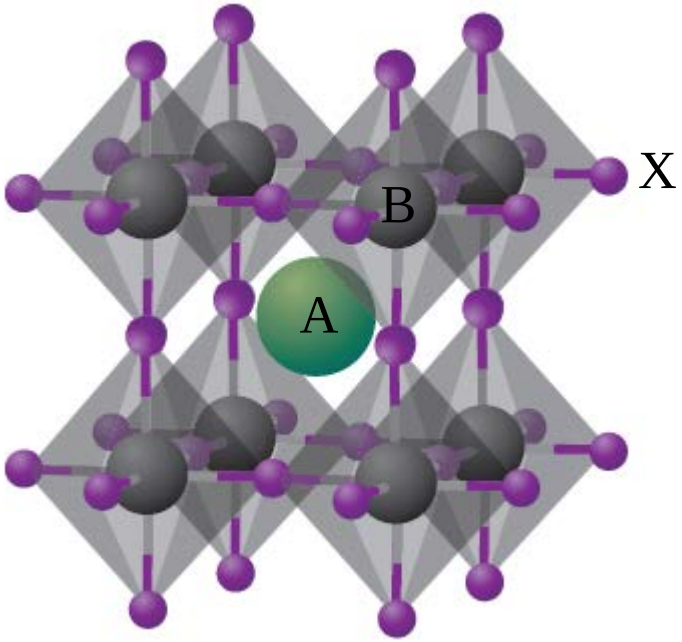
1150°C

Siemens process



https://www.nrel.gov/solar/market-research-analysis/solar-cost-analysis.

Metal halide perovskite solar cells



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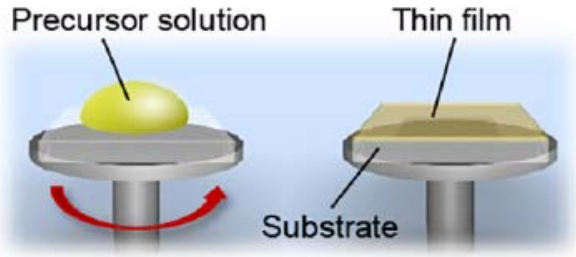
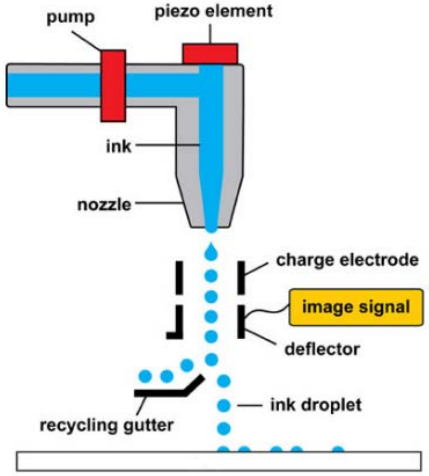
relative ease of fabrication

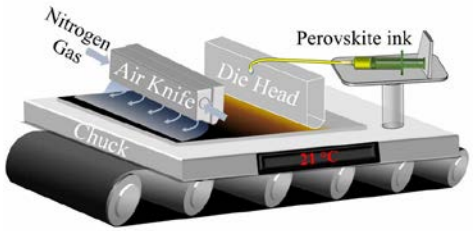
spincoating



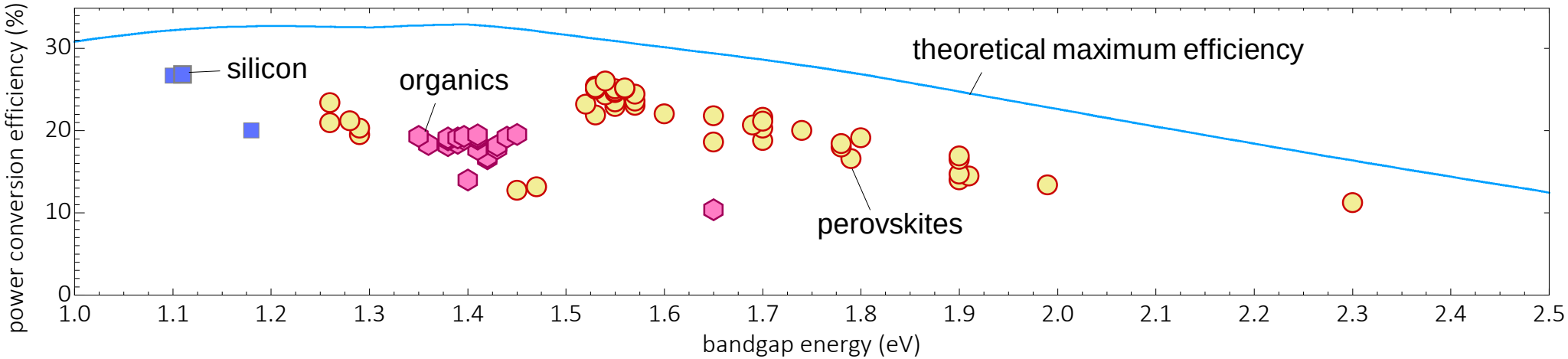
inkjet printing



slot-die coating

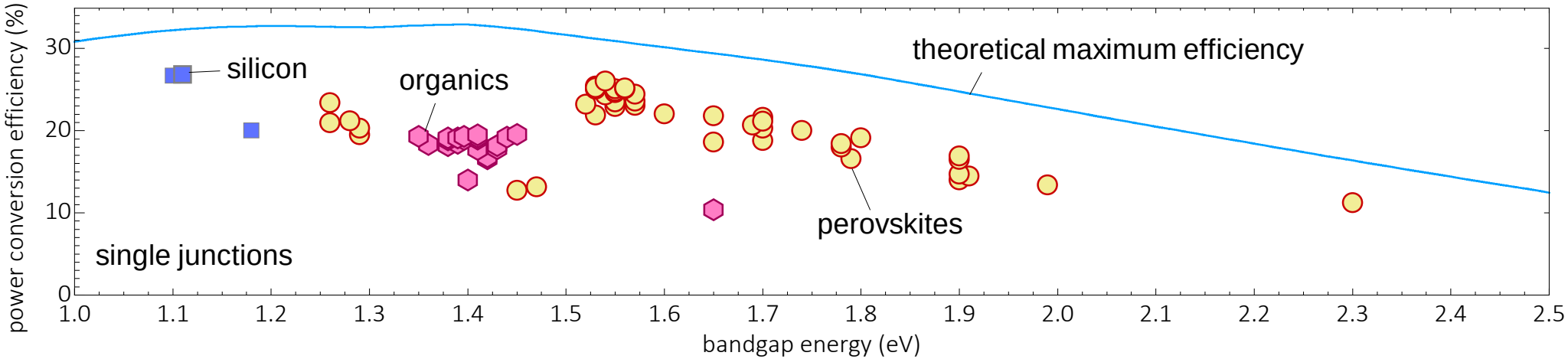


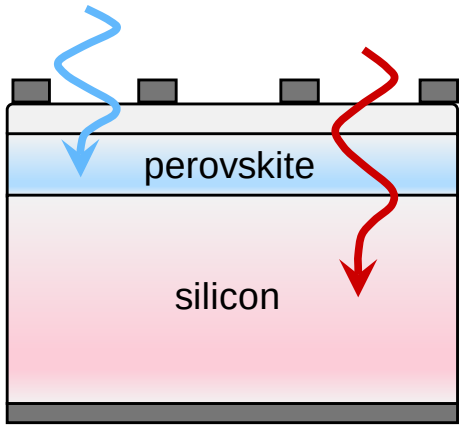
Power conversion efficiency



O. Almora et al., *Advanced energy materials*, 2024, **14**, 2303173.

Power conversion efficiency





perovskite-silicon tandem

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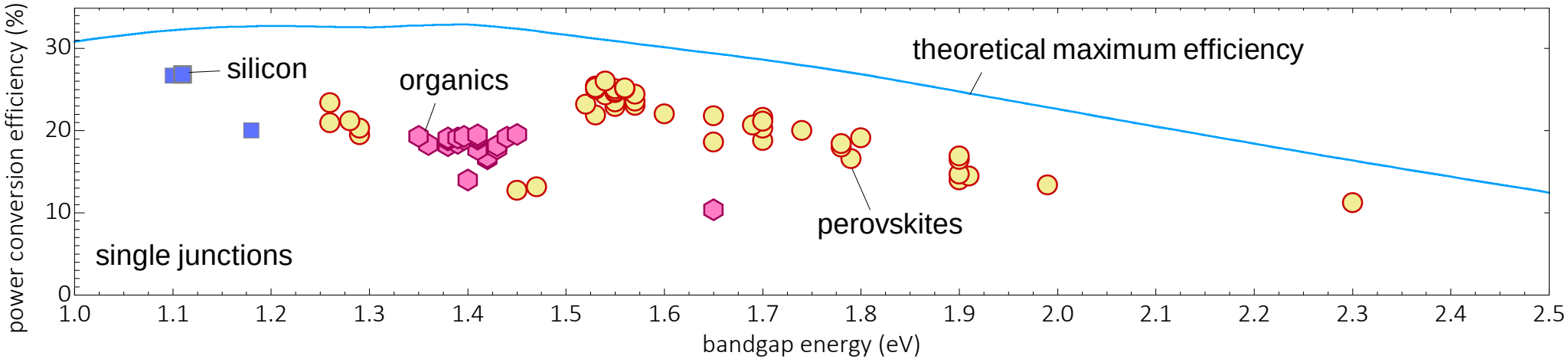

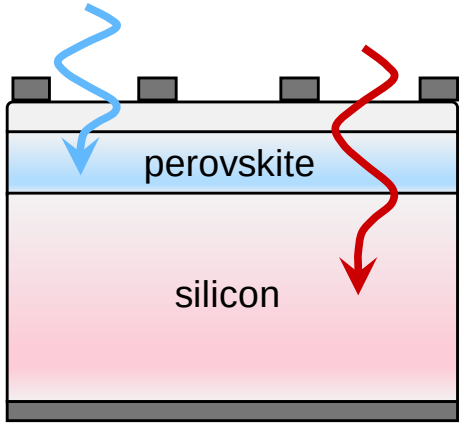

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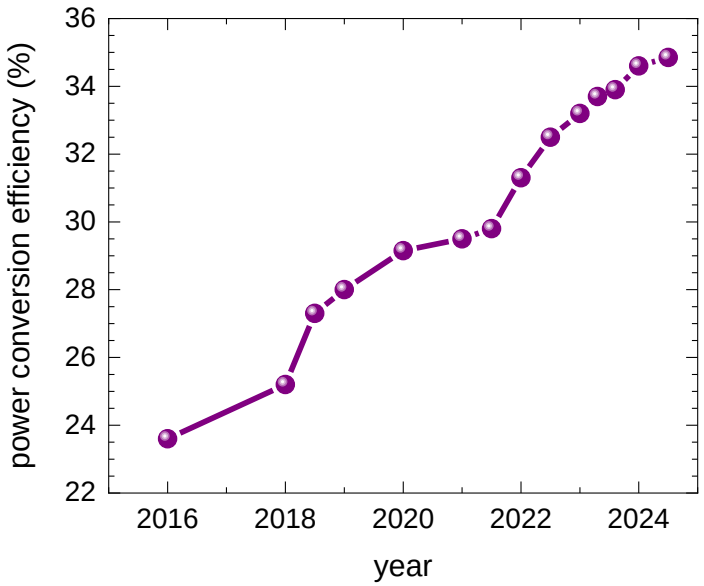

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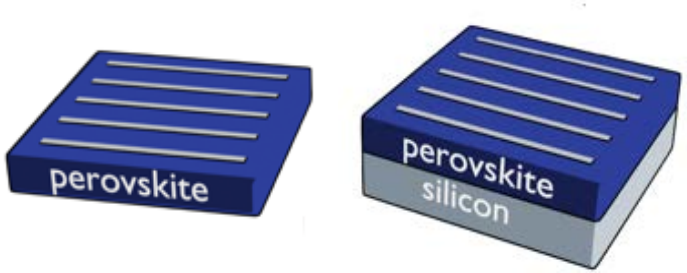
Stability



degradation

temperature humidity light

Perovskite solar cell lifetime less than 1000 hours,
compared to 20 years for silicon solar cells

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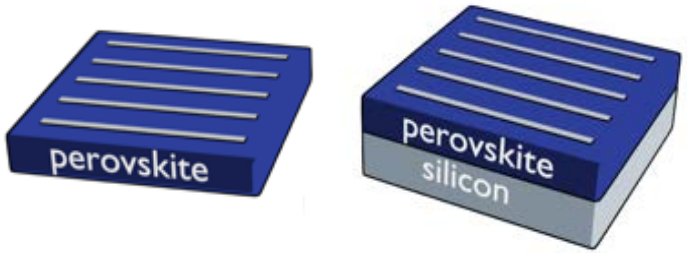

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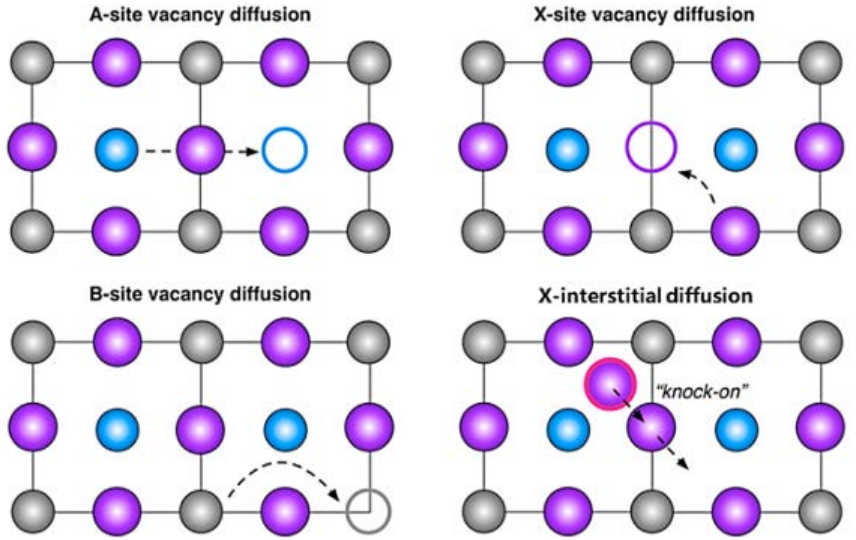
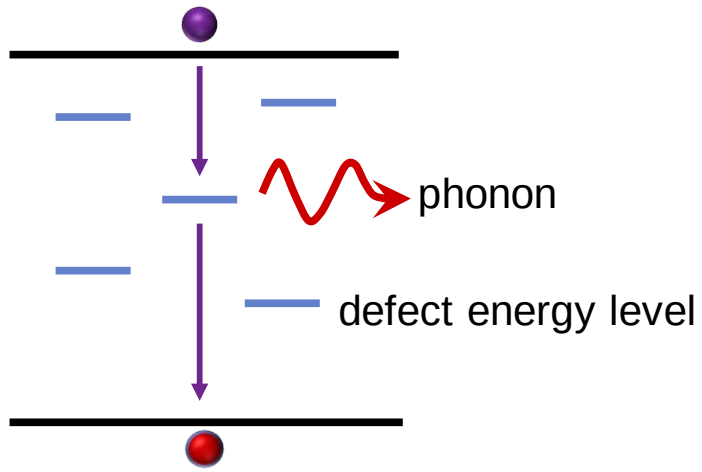
Impact of defects





E. Bi et al., *Trends in chemistry,* 2021.

Open questions

Why are the high efficiencies not clearly correlated with the electronic quality of the perovskite crystal?

How to minimise the impact of defects on the stability?

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