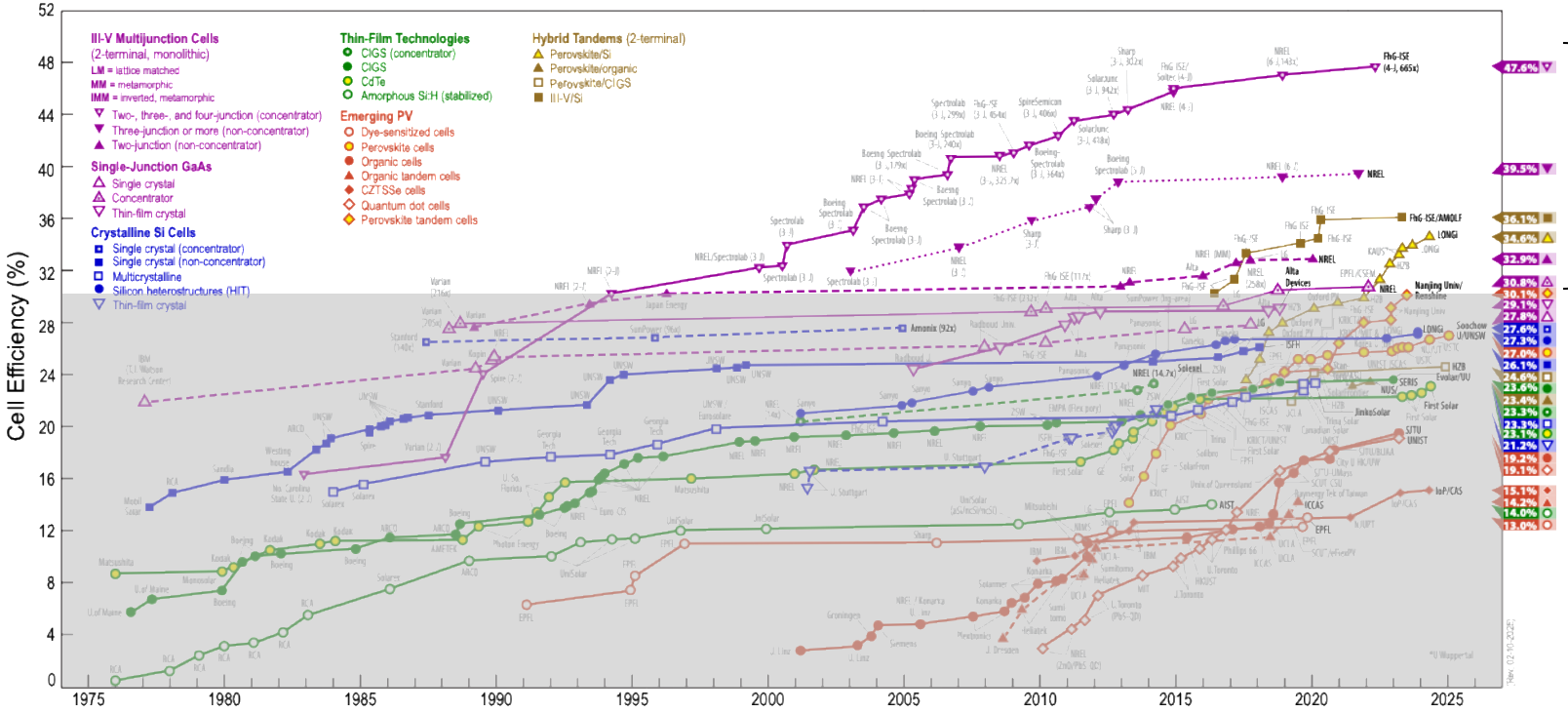
Tandem Solar Cells

Emily Warren
Senior Scientist and Group Manager
NREL

Photo by Josh Bauer / Bryan Bechtold, NREL 82067

Tandem solar cells enable disruptive applications

- Currently ~99% of all terrestrial PV is based on single junction solar cells
- Tandems (2 or more junctions) enable > 30% efficiency – leveraging for balance of system cost



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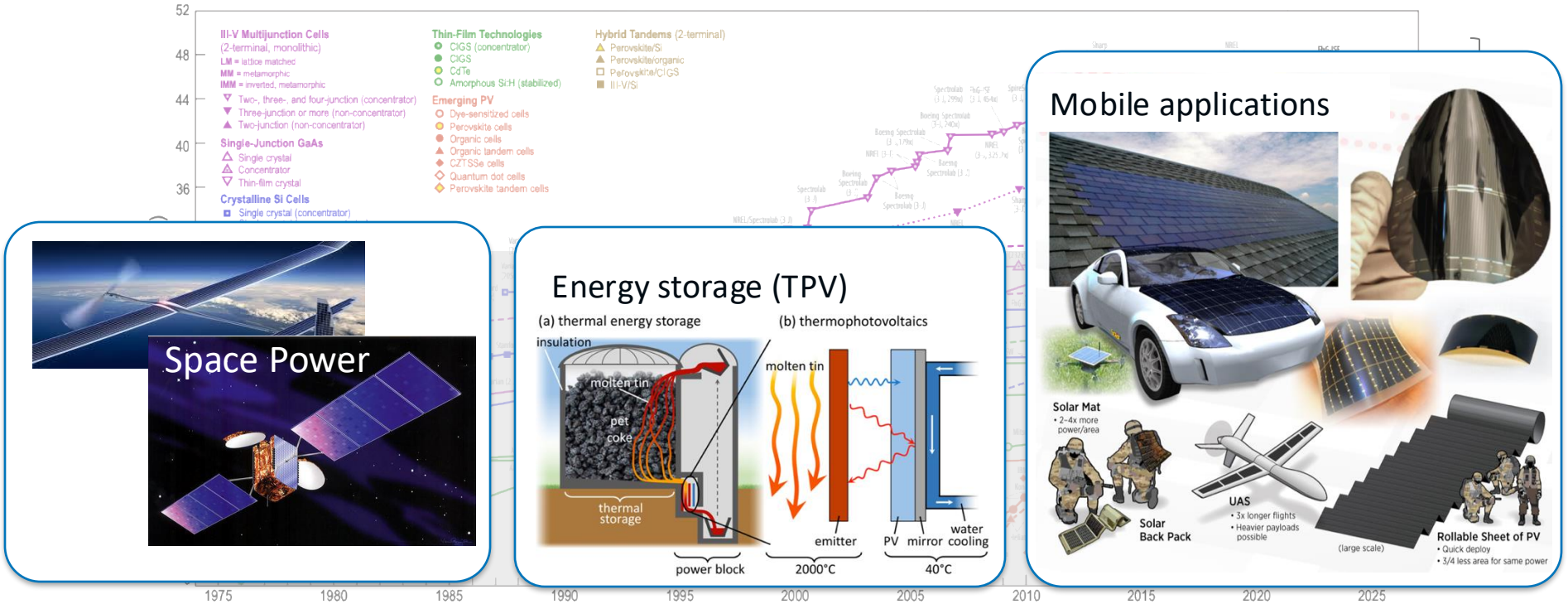
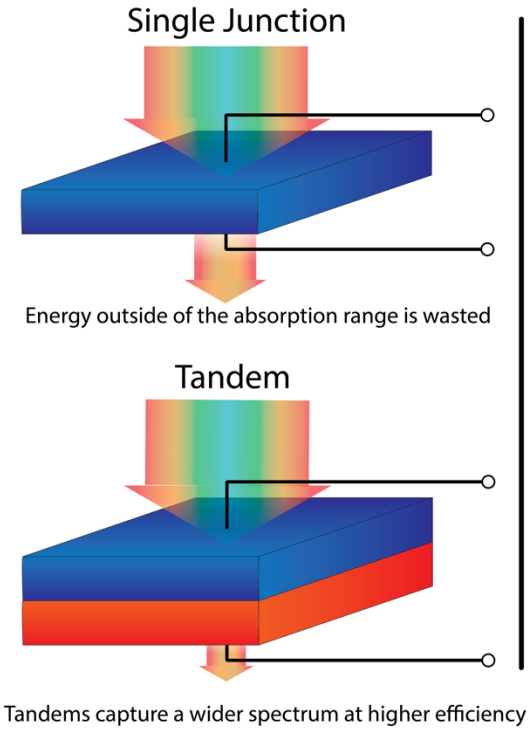
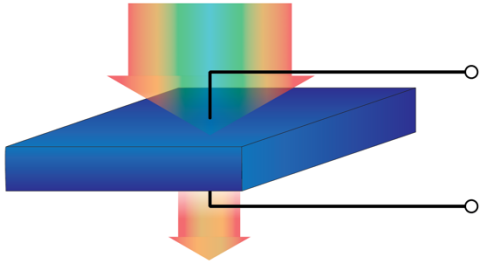


Tandems are possible – what configuration is best?



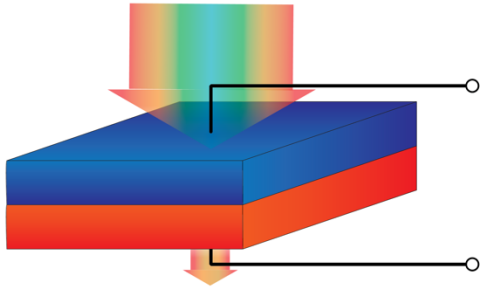
Tandems are possible – what configuration is best?

Single Junction



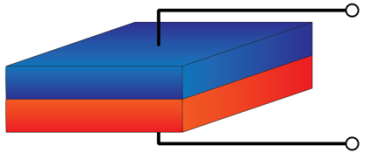
Energy outside of the absorption range is wasted

Tandem

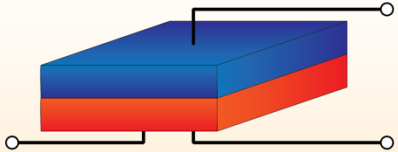


Tandems capture a wider spectrum at higher efficiency

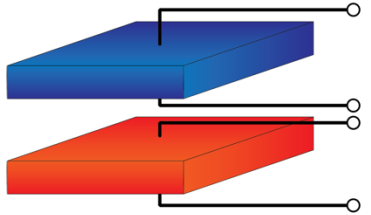
2-Terminal



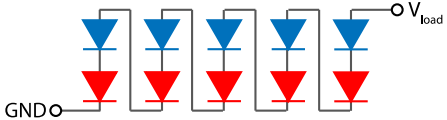
3-Terminal



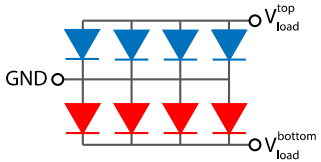
4-Terminal



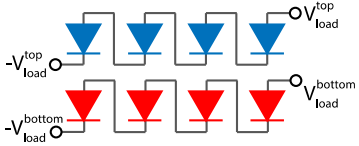
2T series-connected



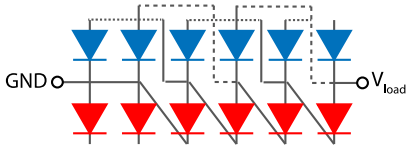
3T parallel-connected



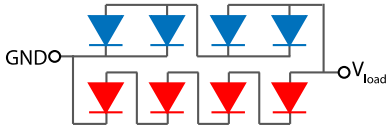
4T two loads



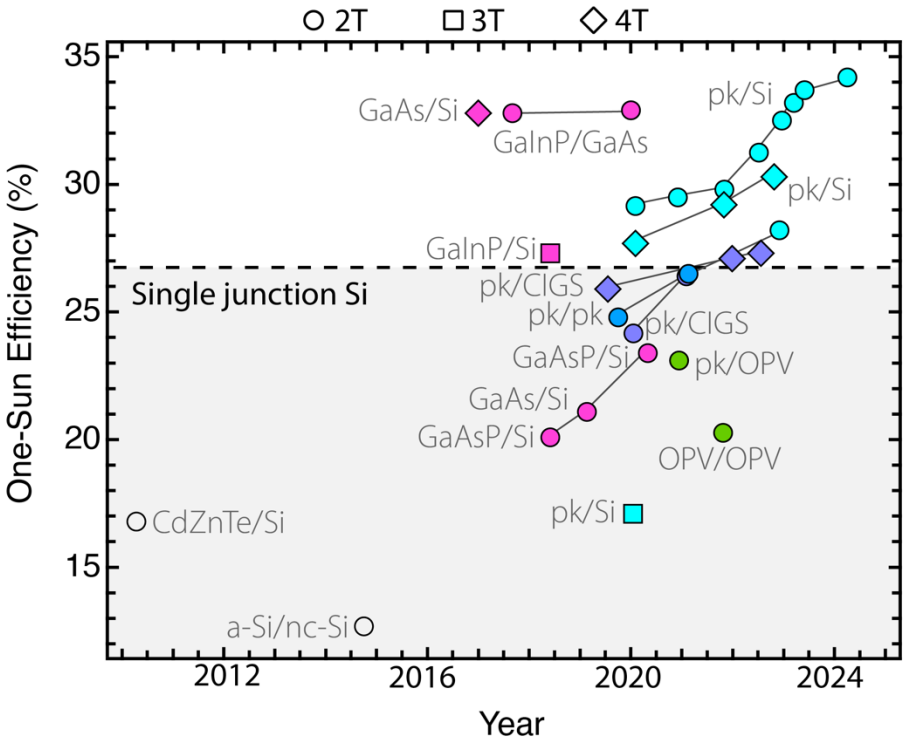
3T voltage-matched



4T voltage-matched



Tandem PV Efficiency: Cell level demonstrations



Tandem PV demonstrations show promise

- Multiple materials and configurations have achieved over 30% efficiency
    - Current 2J tandem record: **34.6%** for metal-halide perovskite/Si tandems
- Most current investments in perovskite-based tandems, due to potential for high efficiency and low cost

A Roadmap for Tandem PV Technology

Joule

CellPress
OPEN ACCESS

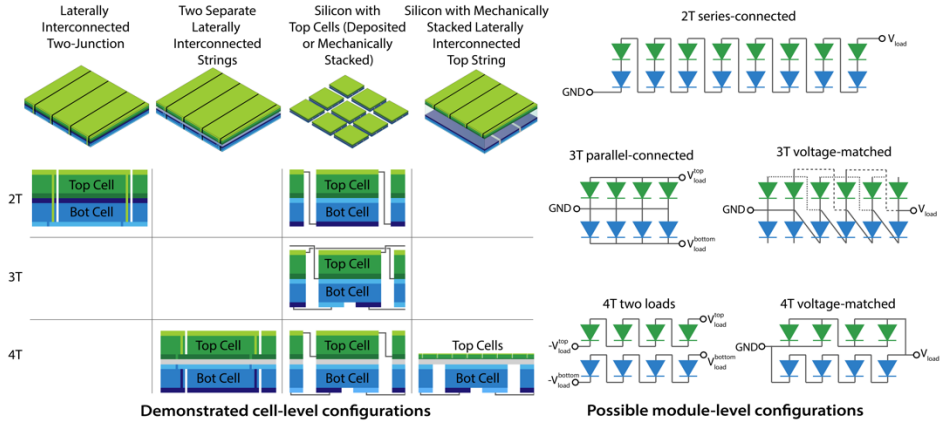
Review

A roadmap for tandem photovoltaics

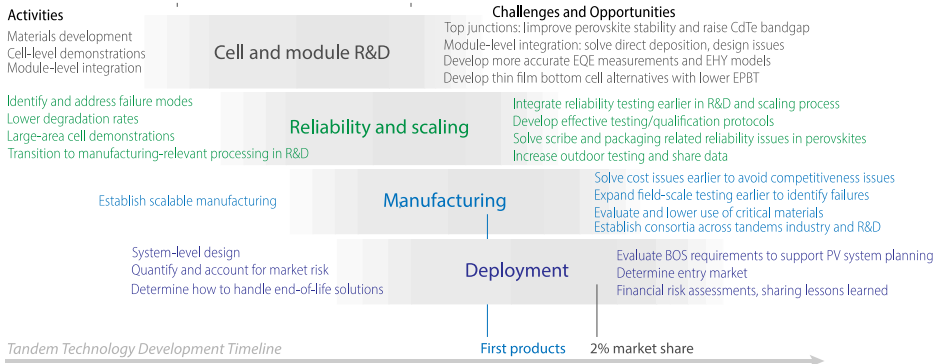
Kirstin Alberi,[1,*] Joseph J. Berry,[1,2,3] Jacob J. Cordell,[1] Daniel J. Friedman,[1] John F. Geisz,[1] Ahmad R. Kirmani,[1,4] Bryon W. Larson,[1] William E. McMahon,[1] Lorelle M. Mansfield,[1] Paul F. Ndione,[1] Michael Owen-Bellini,[1] Axel F. Palmstrom,[1] Matthew O. Reese,[1] Samantha B. Reese,[1] Myles A. Steiner,[1] Adele C. Tamboli,[1] San Theingi,[1] and Emily L. Warren[1]

The intent of this roadmap is to bolster the collective effort to develop tandem PV by providing a comprehensive view of the pathway to commercialization and the high-level challenges that must be overcome along the way.

Part I: Foundational knowledge



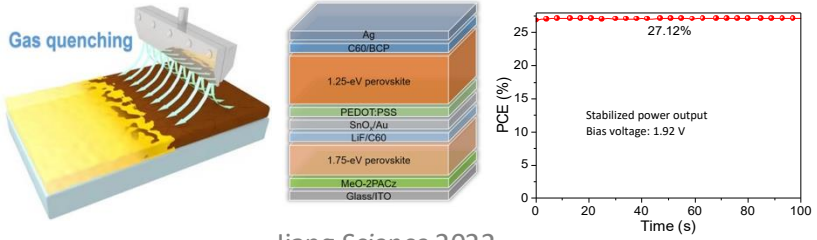
Part II: A roadmap for future development



K. Alberi *et al. Joule*, 2024, doi: 10.1016/j.joule.2024.01.017.

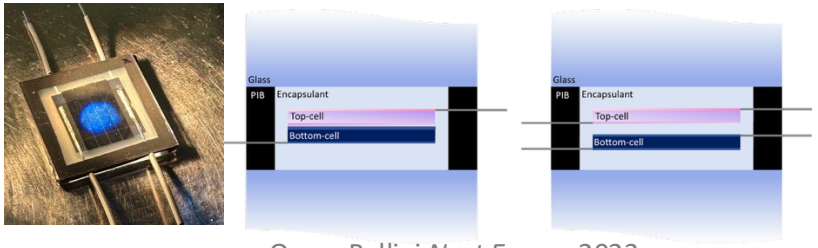
Tandems research at NREL

Material fundamentals, tandem cells



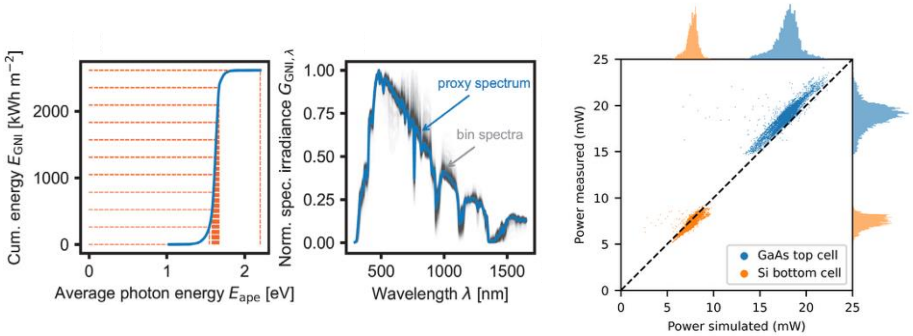
Jiang *Science* 2022

Tandem module demonstrations



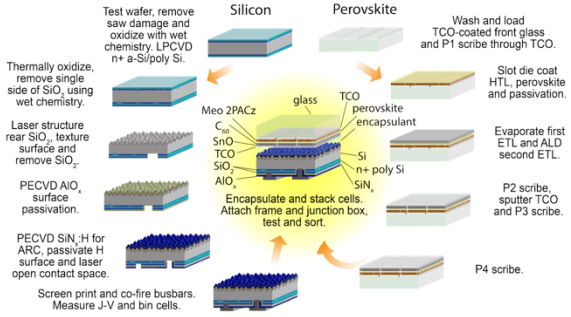
Owen-Bellini *Next Energy* 2023

Energy yield modeling



Witteck *SRRL* 2023, Martin *submitted* 2024

Technoeconomic analysis



Cordell *Joule* 2024