TCF-18-15677 Final Report: Commercializing Perovskite/CIGS Tandems

Lorelle M. Mansfield

National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Technical Report
NREL/TP-5K00-95929
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NOTICE

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Commercializing Perovskite/CIGS Tandems

TCF-18-15677

PROJECT INFORMATION

TCF Tracking Number: TCF-18-15677
Project Start Date: 4/1/2019 Project End Date: 6/30/2022
Point(s) of Contact at DOE: Inna Kozinsky
Prime Lab: NREL
Principal Investigator name(s): Lorelle Mansfield

Project Partner(s): Please include any partner lab(s), cost-share partner(s), etc. that participated on the project.

Partner	Agreement Type	Point of Contact
Ascent Solar Technologies, Inc. (AST)	NDA	Lawrence Woods, Director of Research and Development, LWoods@ascentsolar.com

FUNDING TABLE

Year or Budget Period	Federal Funding		Cost-Share	
	Planned	Actual	Planned	Actual
2019	$ 85,765	$ 40,006	$101,423	$XXX,XXX
2020	$ 14,235	$ 22,996	$XXX,XXX	$XXX,XXX
2021	$XXX,XXX	$ 4,179	$XXX,XXX	$XXX,XXX
2022	$XXX,XXX	$ 3,594	$XXX,XXX	$XXX,XXX
Total	**$100,000**	**$ 70,775**	**$101,423**	**$XXX,XXX**

TYPE OF COST-SHARE *(select all that apply)*

☐ Cash
☒ In-Kind

Cost share was provided in the form of CIGS bottom cells and staff time from AST.

SOURCE OF TCF BASE FUNDING *(select all that apply to indicate which DOE Program(s)/ Program Office(s) funded this project.)*

☐	**Office of Cybersecurity, Energy Security, and Emergency Response (CESER)**
☐	**Office of Fossil Energy and Carbon Management (FECM)**
☐	**Office of Nuclear Energy (NE)**
☐	**Office of Electricity (OE)**
☐	**Office of Clean Energy Demonstration (OCED)**

Office of Energy Efficiency and Renewable Energy (EERE)	
☐	Advanced Manufacturing Office (not for projects funded in FY24 and after) (AMO)
☐	Advanced Materials and Manufacturing Technologies Office (AMMTO)
☐	Bioenergy Technologies Office (BETO)
☐	Building Technologies Office (BTO)
☐	Hydrogen and Fuel Cell Technologies Office (previously Fuel Cell Technologies) (HFTO)
☐	EERE Grid Integration Program (EGI)
☐	Geothermal Technologies Office (GTO)
☐	Industrial Efficiency and Decarbonization Office (IEDO)
☒	Solar Energy Technologies Office (SETO)
☐	Vehicle Technologies Office (VTO)
☐	Water Power Technologies Office (WPTO)
☐	Wind Energy Technologies Office (WETO)

PROJECT SCOPE AND OBJECTIVE

In this project we plan to transfer NREL wide-bandgap perovskite knowhow to AST for use as the top cell in the tandem device and co-develop a durable transparent interconnect for a monolithic top-to-bottom cell connection. At the projects end, we plan to demonstrate monolithic tandem devices with higher efficiency than single cell counterparts. Tandem devices will have perovskite top cell and AST CIGS bottom cell.

BENEFIT TO DOE MISSION

Ascent Solar Technologies (AST) is a manufacturer of lightweight and flexible Cu(In,Ga)Se_2 (CIGS) solar photovoltaic modules that specializes in solar technology for portable power, building-integrated photovoltaics (BIPV), and aerospace environments. Halide perovskite (HP)/CIGS tandems are a particularly interesting combination for creating low-cost, high-efficiency modules. Especially compelling is the low deposition temperature of the HP device processing that enables their use on temperature-sensitive bottom cells and flexible substrates, enabling low-cost monolithic (two-terminal) tandem module constructions in light-weight flexible solar modules. The higher power per unit area and low-cost characteristics make them particularly suited for portable power, limited-area BIPV applications, and AST's space and near-space photovoltaic applications. The time is right to commercialize the technology in the U.S.

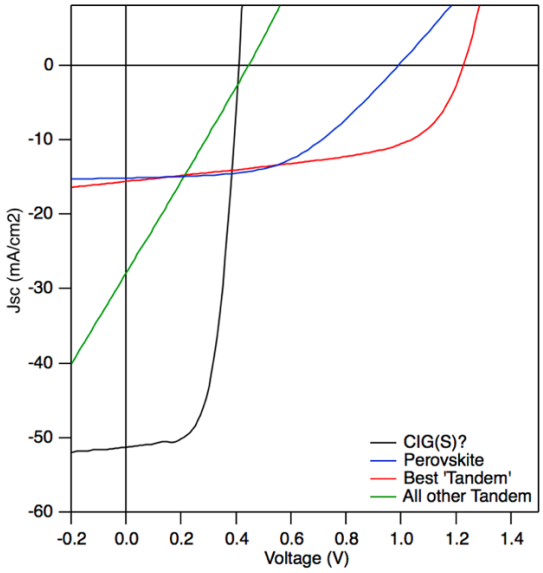
GENERATED TECHNICAL DATA AND REPORTS

Nothing was released to the public.

TECHNICAL METRICS

Using the table below, please describe the technical metrics the project proposed to achieve. Include a brief description of the metric, the proposed target including units, and the achieved value including units. When possible, metrics should be specific, measurable, achievable, relevant, and time-bound (SMART).

SMART Metric Name and Description	Targeted Value	Achieved Value
MS1: Demonstrate HP device top cell with Eff. > 10%. Inverted HP device on flexible substrate.	Eff. > 10%.	18.2% inverted HP device on glass.
MS2: Demonstrate open-circuit voltage addition in monolithic tandem. Tandem devices with perovskite top cell and AST CIGS bottom cell.	Click to enter targeted value	CIGS device Voc = 0.41V Perovskite Voc = 0.99 Tandem Voc = 1.22
MS3: Demonstrate monolithic tandem devices with higher efficiency than single cell counterparts. Tandem devices with perovskite top cell and AST CIGS bottom cell.	Click to enter targeted value	Not achieved: NREL HP: 7.6% AST CIGS: 13.0% Tandem: 10.8 %



COMMERCIALIZATION ADVANCEMENTS

MARKET ADVANCEMENTS

Although AST had financial difficulty during this project, they continue to participate in the lightweight PV market which has expanded to include Aerospace, Defense & Emergency power, and Agrivoltaics.

COMMERCIALIZATION ACHIEVEMENTS AND SUCCESS STORIES

Because AST was shut down for a while during this project, there is nothing to report.

CONCLUSION

PATH FORWARD

At the time that this project was abandoned, AST's future was uncertain. As of 2025, they have regrouped and refocused on their single-junction CIGS products. They still include perovskites on their website information and perhaps they will pursue perovskite/CIGS tandems as a step in their technology roadmap.

LESSONS LEARNED

Lessons around cost share: AST provided in kind cost share of materials and staff labor. However, they did not report these contributions to us. In the future NREL could be more demanding to get the cost-share information.

Lessons around project scope: The project scope was ambitious for the short time that was proposed.

Technical lessons learned: A smoother CIGS bottom cell is needed to allow high quality perovskite deposition on top for tandem devices.