TEAMUP: Tandems for Efficient and Advanced Modules using Ultrastable Perovskites

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New consortium assembles PV pioneers to make a step change toward commercially competitive next generation perovskite-silicon tandem solar modules.

Pioneers in perovskite-silicon tandems from academic, Industrial and Federal laboratories target >28%-efficient multijunction modules with stable, long-term operation in field conditions capable of providing electricity below $0.02/kWhr, factors critical for a just transition to a clean energy economy.

Tandem perovskite-silicon devices have the potential to boost the efficiency beyond current commercial silicon solar cells by several percent without a substantial increase in weight or size. Furthermore, they can be integrated with today's silicon modules and use 5-6 x less silver per W of power generated than silicon cells. However, a key to commercializing this technology is the use of device design and materials that mitigate degradation and improve stability and longevity, the focus of this new consortium.

APRIL 20 2023 [BOULDER, CO] – The Tandems for Efficient and Advanced Modules using Ultrastable Perovskites, or TEAMUP, project is a PV consortium that aims to achieve >28% efficiency perovskite-silicon multijunction modules with stable operation under real-world conditions. The team is comprised of researchers from world-class research labs and leading US companies, and will distribute $9M of federal funding from the U.S Department of Energy Solar Energy Technologies Office (SETO) to bring together teams of researchers from across 4 academic institutions, 3 companies and 1 National Lab to address the issues in perovskite solar cell devices that limit their durability, scale-up, and efficiency. Led by Prof. Michael McGehee at the University of Colorado Boulder, this collaboration includes members from Northwestern University, Arizona State University, UC Merced, the National Renewable Energy Laboratory, Swift Solar, Tandem PV and Beyond Silicon. This project will, through innovative device design and materials selection, develop stable tandem perovskites that will demonstrate the real-world feasibility and commercial viability of perovskite-based PV products. Bringing these more efficient and affordable solar harvesting technologies to market is critical to accelerating a just transition to renewable energy.

Currently there is not a consensus on the most effective approaches for improving the stability and longevity of tandem cells and TEAMUP will create a unique innovation ecosystem in which researchers can openly share the advantages and disadvantages of each approach, accelerating understanding and iteration across the field. Specifically, while there are many approaches to the deployment of perovskites to harvest solar energy, TEAMUP will pursue perovskite-silicon tandems, since these are the most promising method to reach a GW/y market size on an acceptable timescale. The TEAMUP consortium is intentionally pursuing two approaches: monolithic and mechanically stacked tandems, as well as vapor and solution processing of perovskite materials. The key to the long-term, real-world operation of these solar modules is the mitigation and prevention of degradation. By working together, researchers in TEAMUP will develop processes and materials that mitigate degradation which are applicable across the different perovskite deposition techniques and module designs. Advances in these areas are anticipated to be broadly applicable across the perovskite industry.

Mike McGehee, the lead investigator from CU Boulder says “We have an extraordinary team who bring many different types of expertise to the Consortium and I look forward to seeing what we can accomplish”. Colin Bailie, Founder and CEO of Tandem PV comments on the collaborative nature of this project “Tandem PV and Swift Solar have long sought to work directly together and with the broader US research community on common research topics that can be solved more quickly as a group. We are excited by the opportunity to work on the same team and not as competitors”.

Recent results and analyses indicate the possibility of producing monolithic 2T tandem cells with 33% efficiency and mechanically stacked tandems with 31% efficiency. However, understanding of module stability to a level that would convince investors and customers of performance for >25 years is a challenge that requires the innovation and collaboration only possible through the TEAMUP consortium.

Key degradation mechanisms that impact the stability of tandem perovskites have been identified as the focus of this consortium, including the prevention of halide oxidation through protective barrier layers, the development of more stable organic molecules in self-assembled monolayers for passivation of perovskite surfaces and minimization of damage associated with scribe lines.

Research in TEAMUP will be structured in a two-stage iterative process, innovation followed by thorough testing. For the innovation stage the teams will adopt a multifaceted approach, including the optimization of the perovskite composition and deposition, refinement of the contacts, and iteration on module design and fabrication. To effectively understand the impact of innovation in these areas on the stability of the tandem cells, TEAMUP has built out a comprehensive testing program, that will form the second stage. In the first step unpackaged cells will be aged on 2.5 x 2.5 cm substrates under 1-sun at 65 ^{o}C in an inert atmosphere, after which an advanced suite of characterization tools will be used to understand the degradation processes. The results of these analyses will be used to forecast performance in the field and inform future design decisions. The standard 1000 hour 85 ^{o}C damp heat test will be the second stage of testing to demonstrate that the packaged cells keep the moisture out. In the final stage, packaged cells will be subjected to outdoor testing under a range of conditions.

Combining the data and experience from the design and testing of these tandem cells will enable TEAMUP to build detailed forecast models capable of describing performance in real world conditions over a 25 year period, a critical tool in taking this technology to a commercial product.

The importance of this technology was highlighted by Colin Bailie “Perovskite-silicon tandems represent not only the opportunity to make solar more affordable for more communities in the US, but also a unique opportunity to return the United States to a position of leadership in solar manufacturing and develop a domestic manufacturing base around this new technology. TEAMUP’s success will ensure perovskite-silicon tandems are in a strong technological position as companies prepare for mass production”. Tomas Leijtens, Co-Founder and CTO of Swift Solar agrees “We’re excited to work with this diverse team to tackle the most pressing stability and performance challenges as we scale up perovskite solar technology. This consortium should help accelerate perovskite tandem commercialization in the US”.

TEAMUP was selected as a part of the SETO Fiscal Year 2022 Photovoltaics (PV) funding program, an effort to reduce costs and supply chain vulnerabilities, further develop durable and recyclable solar technologies, and advance perovskite PV technologies toward commercialization. TEAMUP is one of several projects that will improve coordination amongst researchers through collaborative, multi-

stakeholder efforts to increase the understanding of perovskite module performance and develop processes to achieve stability and larger device areas.

Understanding and solving the degradation mechanisms that negatively impact stability in tandem perovskites is essential to demonstrating their feasibility to future investors and customers. By adopting an approach that is agnostic to both perovskite processing and device design, TEAMUP will develop solutions that can be applied across a wide cross-section of the perovskite industry.

About TEAMUP
TEAMUP brings together perovskite pioneers from Academic, Industrial and Federal laboratories to improve the robustness of tandem perovskite-silicon solar modules and realize commercially competitive perovskite-based solar energy harvesting technologies.

About the Solar Energy Technologies Office
The U.S. Department of Energy Solar Energy Technologies Office supports research and development across the solar energy spectrum to drive innovation, lower costs, and support an equitable transition to a decarbonized economy. Learn more at energy.gov/solar-office.

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