

**Project title:** “Three-Terminal Tandem Perovskite Solar Cells: Towards Superior Efficiency and Durability”

Perovskite solar cells are revolutionizing solar technology with their exceptional ability to convert sunlight into electricity. These advanced cells have achieved a record efficiency of 26.7%, but traditional single-junction designs are limited to 33%. To surpass this limit, tandem solar cells, which combine two layers of materials to absorb a broader spectrum of light, have been developed. These tandem cells stack wide-bandgap and narrow-bandgap solar cells to capture more of the solar spectrum. The two most common architectures for tandem solar cells are two-terminal (2T) and four-terminal (4T) configurations. The 2T configuration connects solar cells in series, offering higher efficiency and scalability. In contrast, the 4T configuration stacks cells mechanically with separate circuits, which can lead to optical losses. While the theoretical efficiency of 2T tandem solar cells can reach ~46%, current designs are limited by their inability to study the performance of individual subcells.

This project focuses on three-terminal (3T) tandem solar cells, an innovative design that adds a middle electrode to the 2T configuration. This addition allows for independent study and further optimization of each subcells, leading to higher efficiency of the tandem solar cells. By combining wide-bandgap and narrow-bandgap perovskite solar cells, the project aims to achieve a power conversion efficiency of 28%, advancing beyond current single-junction performance levels.

Key innovations include optimizing the perovskite solar cells, designing advanced connection layers between subcells in order to minimize energy losses, and also enhancing the cells' long-term durability through rigorous testing. The development of robust encapsulation techniques and the application of accelerated aging tests will ensure reliable performance over an extended lifespan. To support these efforts, optical and electrical modeling will be employed to identify and reduce parasitic losses, analyze defect dynamics, and provide targeted solutions for improvement studied solar cells. These diagnostic tools will enable a data-driven approach to advancing 3T tandem solar cell technology.

By integrating cutting-edge materials, innovative design, and comprehensive testing, this project aims to establish 3T tandem solar cells as a transformative technology for a sustainable energy future.