

Photovoltaic Cell Complementary Module

Article Overview

A complementary photovoltaic module integrates advanced cell designs, such as tandem or steric-complementary perovskite-silicon cells, into optimized modules to maximize efficiency, stability, and energy yield.

Tandem and Complementary Cell Designs

Modern PV modules increasingly use tandem solar cells, where two or more layers of different materials are stacked to capture a broader spectrum of sunlight. For example, perovskite-silicon tandem cells combine a perovskite top layer with a silicon bottom layer, achieving certified efficiencies above 32% while enhancing long-term stability through steric-complementary interface designs. This approach optimizes molecular fit in the perovskite lattice, improving charge transport and protecting the absorber from environmental stressors by combining small, flexible cations with large, rigid cations to neutralize defects and form a robust protective layer .

Cell-to-Module (CTM) Ratio

When individual PV cells are assembled into a module, the cell-to-module (CTM) power ratio quantifies the efficiency loss or gain from the integration process. Optical losses occur due to reflection and absorption in the glass and encapsulant, while electrical losses arise from Joule heating in interconnections. Conversely, optical gains can be achieved through back reflections from the backsheet, metallization, and cell spacing. Optimizing these factors allows modules to approach or even exceed the nominal efficiency of individual cells, with advanced designs targeting CTM ratios over 100% by reducing losses and enhancing optical coupling

Article Content

Jul 10, 2026

Complementary Switching-Based Reconfigurable Strategy for Hotspot ...

Abstract: In the domain of Photovoltaic (PV) power generation, the occurrence of hotspot phenomena is prevalent due

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Photovoltaic module

Photovoltaic module Photovoltaic modules are made up of a mosaic of solar cells. Here is a description of their main features and of

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Crystalline Silicon Photovoltaics Research

The U.S. Department of Energy (DOE) Solar Energy Technologies Office (SETO) supports crystalline silicon photovoltaic (PV)

Jun 02, 2026

A roadmap for tandem photovoltaics

It includes information about how devices and modules are configured, progress in cell-level efficiencies, a discussion

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Perovskite-silicon tandem solar cell with steric

Researchers in China developed a monolithic perovskite-silicon tandem solar cell using a

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An Introduction to Photovoltaic Modules

Introduction to Solar PV Modules To understand the basics of photovoltaics, we must first come to the building block of solar panels

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Photovoltaic Modules

1 Introduction Photovoltaic modules (PV modules) are supposed to have a lifetime of more than 20 years under various

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Silicon-Based Tandem Solar Cells and Modules

We cover the entire value chain from technology development and analysis of cells and modules through

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Recent Facts about Photovoltaics in Germany

In Europe, there are small module production facilities, however, hardly any cell or wafer production. A slump in trade with China

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APPROVED LIST OF MODELS AND MANUFACTURERS (ALMM)

Application Form for applying for enlistment in ALMM (Approved List of Models and Manufacturers) for Solar

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Tandem technology for higher PV performance | TNO

A tandem panel consists of a combination of solar cells. This delivers a higher PV yield. Discover how we

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Enhanced photovoltaic panel defect detection via adaptive complementary ...

This module is seamlessly integrated into YOLOv5 for detecting defects on photovoltaic panels, aiming primarily to

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Latest Solar Panel Technology — Clean Energy Reviews

Perovskite solar cells operate similarly to traditional silicon-based solar cells, converting sunlight into electricity

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Photovoltaic Module: Definition, Importance, Uses and Types

Photovoltaic modules, or solar modules, are devices that gather energy from the sun and convert it into electrical power

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World's most efficient solar module: Shingle Matrix technology meets ...

The shingle-matrix approach represents a fundamental departure from traditional photovoltaic module construction, in

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Solar Modules Guide 2025: Types, Efficiency

Solar modules represent the cornerstone of modern renewable energy systems,

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Perovskite solar cell

Perovskite materials can also be combined with other photovoltaic technologies in tandem architectures, with perovskite-silicon two

Feb 20, 2026

Best Research-Cell Efficiency Chart | Photovoltaic Research | NLR

Best Research-Cell Efficiency Chart NLR maintains a chart of the highest confirmed conversion efficiencies for

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Tandem cell or tandem module?

At Intersolar Europe in Munich, several companies presented their concepts for high

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Pathways toward commercial perovskite/silicon tandem photovoltaics ...

To overcome these limitations and harness the full potential of photovoltaics, perovskite/silicon dual-junction tandem

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Solar Photovoltaic Cell Basics

There are a variety of different semiconductor materials used in solar photovoltaic cells. Learn more about

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Photovoltaics and electricity

Solar photovoltaic (PV) cells, PV modules (panels), and solar PV arrays for electricity generation.

Oct 16, 2025

Perovskite tandem solar modules: 2026 landscape | PatSnap

Perovskite tandem solar modules have broken the 33% efficiency barrier in certified lab conditions—combining

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Cell to module (CTM) losses

Cell to module (CTM) losses The encapsulation of solar cells into a photovoltaic module introduces some optical loss mechanisms as

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C2DEM-YOLO: improved YOLOv8 for defect detection of photovoltaic cell ...

Photovoltaic (PV) cell modules are the core components of PV power generation systems, and defects in these

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Solar Photovoltaic Technology Basics

Solar Photovoltaic Technology Basics What is photovoltaic (PV) technology and how does it work? PV

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A comprehensive evaluation of solar cell technologies, associated loss ...

In-depth assessments of cutting-edge solar cell technologies, emerging materials, loss mechanisms, and performance

Mar 27, 2026

Fraunhofer ISE Achieves Record Efficiencies for

Scientists at the Fraunhofer Institute for Solar Energy Systems ISE have succeeded in

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The Complete Guide to Photovoltaic (PV) Modules

Contact Us July 22nd, 2024 The Complete Guide to Photovoltaic (PV) Modules Solar cells, commercially referred to as photovoltaic

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Degradation and Failure Modes in New Photovoltaic Cell and Module ...

February 2025 This detailed analysis by Task 13, provides essential insights into the reliability and performance of cutting-edge

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A Perovskite Photovoltaic Mini-Module-CsPbBr₃

The mini-module fabricated by interconnecting three solar cells in series was used to supply enough voltage (>1.5 V) to

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Parameter extraction of photovoltaic cell/module models using

These findings confirm that reformulating the objective function using the secant method constitutes an effective and

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A roadmap for tandem photovoltaics: Joule

Increasing solar cell efficiencies will aid widespread deployment, and combining existing PV technologies into tandem

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Photovoltaics: Materials, Cells and Modules

We are developing the next generations of sustainable silicon solar cells and modules, along the entire

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Photovoltaic systems

The voltage of a solar cell does not depend strongly on the solar irradiance but depends primarily on the cell temperature. PV

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27%-efficiency silicon heterojunction cell with 98.6% cell-to-module ...

The module has 75 units of FBC cells in total with smart-wire zero-busbar interconnections as the stringing

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Photovoltaic system

Photovoltaic cell electrical output is extremely sensitive to shading (the so-called "Christmas light effect").

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PV Cells 101: A Primer on the Solar Photovoltaic Cell

Part 1 of the PV Cells 101 primer explains how a solar cell turns sunlight into electricity and why silicon is the

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