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PHOTOVOLTAIC MODULE TECHNOLOGY



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COVER PAGE

*Lamination process of a glass-
glass photovoltaic module at
Module-TEC.*



EFFICIENT, RELIABLE AND ATTRACTIVE PV-MODULES

Fraunhofer ISE offers a wide range of services for product development and material qualification in the field of module technology. With many years of experience, excellently trained scientific staff and advanced research laboratories – including industrial production equipment – we transform innovative ideas into reliable, efficient and competitive solutions. Together with our customers we develop new applications with integrated photovoltaics generating solar electricity from buildings, vehicles and roads.

Our Module Technology Evaluation Center Module-TEC comprises a large variety of interconnection and lamination equipment as well as analysis tools. Partially and fully automated equipment enables development from proof of concept to final products and sampling for testing, demonstration and certification. All our development work is supported by a research network along the entire PV value chain at Fraunhofer ISE. This

includes the Photovoltaic Technology Evaluation Center PV-TEC and the accredited laboratories TestLab PV Modules and CalLab PV Modules for power measurements and reliability tests.

Cell Interconnection

Cell interconnection is a key process in module technology. We offer our customers process qualification on industrial equipment to achieve efficient and reliable products as well as high yields and stable processes.

Our services cover:

- soldering and glueing with electrically conductive adhesives
- ribbon, multi-wire, SmartWire®, shingling, back contact (MWT, IBC)
- full and half cells, including laser separation technologies
- qualification of new cell metallizations
- direct contacting of aluminum
- dedicated processes for HJT, perovskite and tandem cells

Encapsulation

Encapsulation materials protect the solar cells and secure their performance and reliability throughout the service life. They ensure optical transmissivity, electrical insulation and environmental protection.

We offer process and prototype development on industrial equipment including:

- plate-plate, plate-membrane lamination
- glass-backsheet, glass-glass modules
- evaluation of encapsulants and backsheets
- lamination recipe development
- low-temperature lamination suitable for HJT and perovskite (e.g. edge-sealed TPedge modules)
- electroluminescence, gel content and adhesion analysis

Product Development for Integrated Photovoltaics

We develop new material systems, processes and prototypes, in which solar electricity generation is an additional functionality of established structures in the field of building-, vehicle- and road-integrated photovoltaics. We have developed a unique color-coating technology Morpho-Color® based on the Morpho-butterfly effect that allows homogeneous and saturated colors with full design freedom at very low yield losses.

Our expertise in the field of Integrated PV covers:

- customized module design for integration into building roofs and facades, in trucks, cars and roads
- solar cell integration into various composite materials
- light-weight modules
- curved modules for vehicle roof and body integration
- colored and patterned PV modules for building and vehicle integration
- shingle cell interconnection for uniform optical appearance

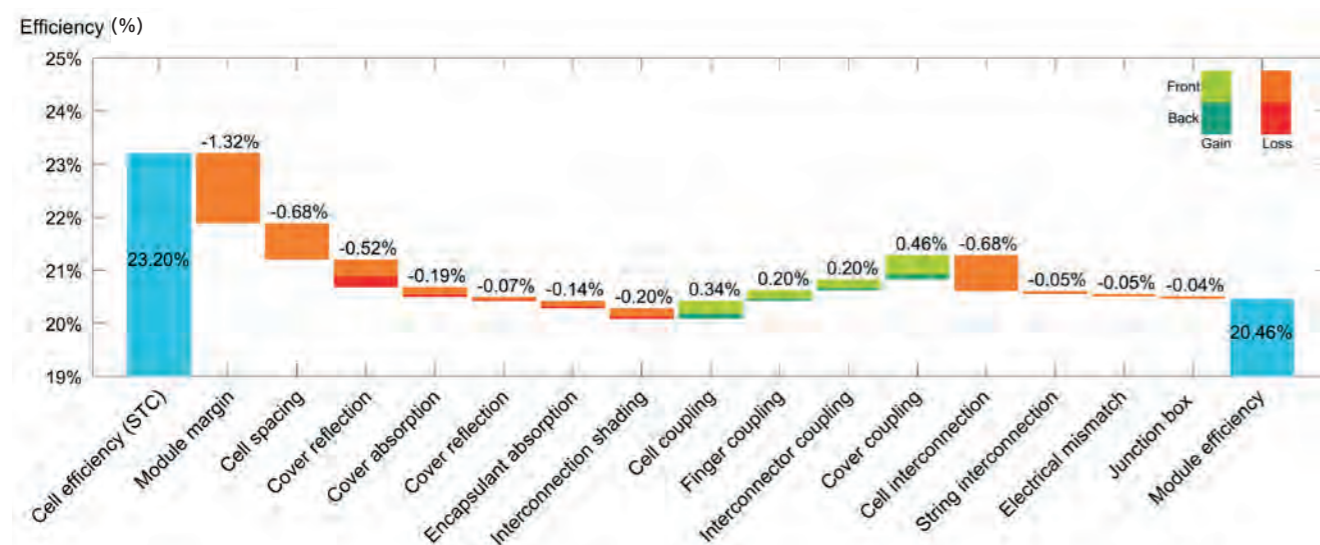
Simulation, Characterization and Reliability Testing

Various services are implemented at Fraunhofer ISE to support the development of new module products:

- Cell-to-Module loss and gain calculations based on our software package SmartCalc.CTM to evaluate and optimize module design for efficiency, power and energy yield in different applications. The software can be obtained at: www.cell-to-module.com
- optical, electrical and mechanical characterization of module materials
- Finite-Element-based simulations (FEM) to evaluate the reliability of module and material designs under mechanical and thermo-mechanical load
- precise power measurements and reliability testing in our accredited laboratories TestLab PV Modules and CalLab PV Modules

Research and Development for Your Needs

Contact us for specific support. We are looking forward to develop solutions for you.



5 Screenshot of SmartCalc.CTM with waterfall-chart, displaying the efficiency gains and losses for a bifacial PV module.

- 1 Engineer operating industrial string equipment.
- 2 Multi wire interconnection of solar cells for increased module efficiency.
- 3 Cell placement in a module stringer.
- 4 Customizable colored modules for building integration.